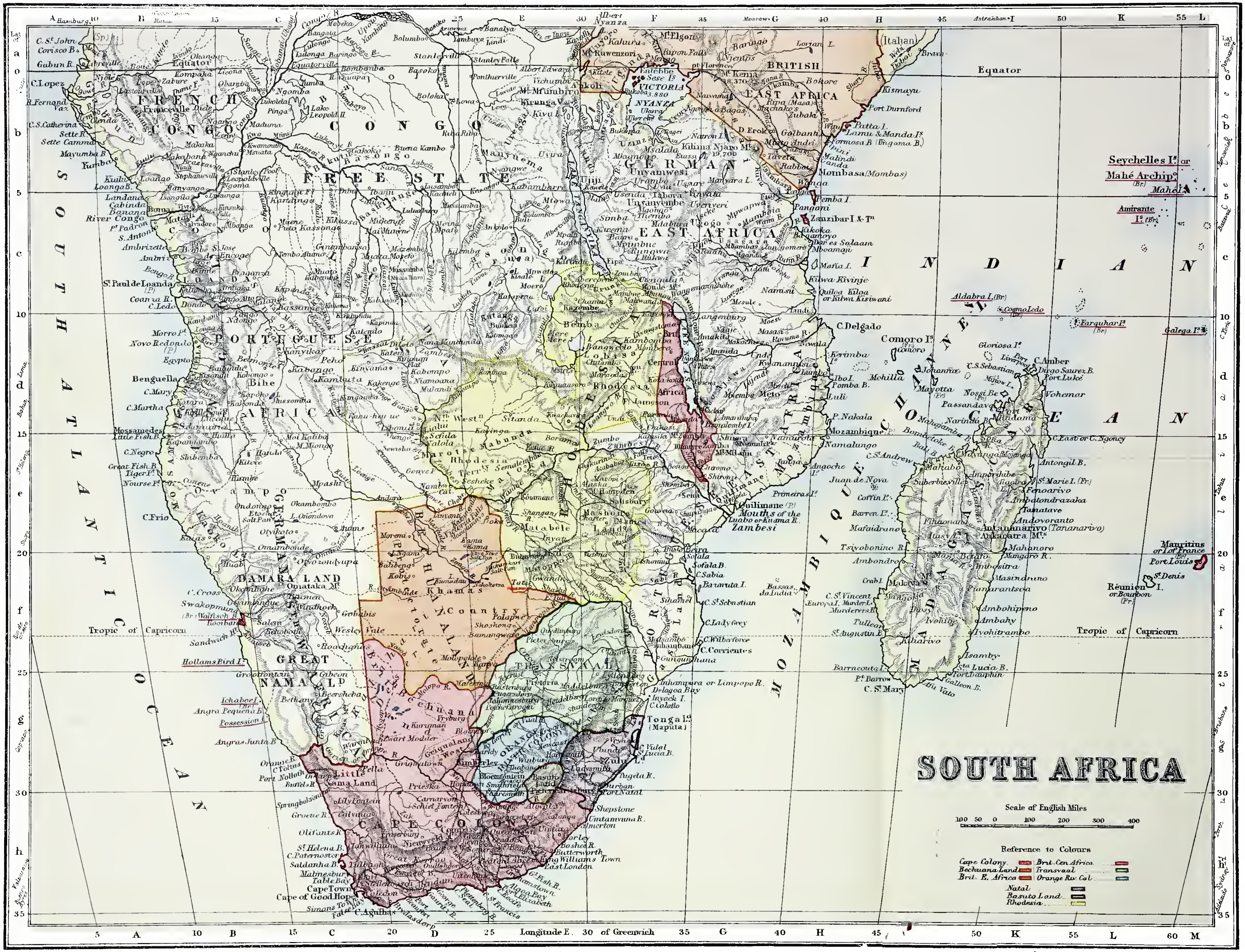
SCIENCE . . .

IN . . .

SOUTH AFRICA.


SOUTH AFRICA
Scale of English Miles
100 50 0 100 200 300 400
Reference to Colours
Cape Colony
Bechuana Land
Brit. E. Africa
Brit. Cen. Africa
Transvaal
Orange Riv. Col.
Natal
Basuto Land
Rhodesia
SOUTH ATLANTIC OCEAN
INDIAN OCEAN
MOZAMBIQUE CHANNEL
FRENCH CONGO
CONGO FREE STATE
PORTUGUESE WEST AFRICA
GERMAN EAST AFRICA
BRITISH EAST AFRICA
GREAT NAMA LAND
DAMARA LAND
MADAGASCAR
Equator
Tropic of Capricorn
Longitude E. 30 of Greenwich

From

Charles W. Howard
Assist. Entomologist,
Pretoria
S. Africa

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PREFACE

At a meeting of the Council of the South African Association for the Advancement of Science, held on the 26th February, 1904, Sir David Gill, K.C.B., F.R.S., etc., being in the chair, it was resolved that a Handbook on scientific work and progress in South Africa be prepared on the occasion of the visit of the British Association to South Africa in 1905.

As to the general plan of the work, while the aim has been to give a review of the various departments of scientific enquiry, these are not strictly limited by purely theoretical considerations, and considerable latitude has been allowed to the various writers, some of whom have preferred to treat their subjects historically or from a practical point of view. Any lack of uniformity, however, which this entails will, it is considered, be more than compensated for by the results of individualistic treatment. In order, however, to give a certain unity and continuity, the various subjects have been classified according to the arrangement found in the Contents.

Two Editors were appointed by the Colonial Governments on the recommendation of the Council of the South African Association for the Advancement of Science, one to be mainly responsible for the general editing, and the other for that of the scientific matter of the work.

The cost of the production of the book has been defrayed by the various South African Governments, which have invariably shown an enlightened appreciation of the value of scientific work.

The plates illustrating the paper on Diamond Mining in Kimberley have been generously presented by the author, Mr. Gardner Williams.

The work on the part of the contributors, who are all actual workers in South Africa, has been entirely voluntary, and the ready co-operation of the various writers has lightened in no small degree the task of the Editors, who desire to express their grateful acknowledgments.

THE EDITORS.

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INTRODUCTION.

THE Meeting of the British Association to be held in South Africa in 1905 is an event of no ordinary interest. Never before has the Southern Hemisphere been visited by a large body of men eminent in every department of science.

It is impossible to imagine that such a visit can be made without a powerful stimulus to the thought and imagination of the many minds of trained receptivity among our guests. Many have no doubt primarily undertaken the journey by way of relaxation and change of scene, but some must find, in the widely different aspects of Nature which they will encounter, suggestions for new lines of research,—suggestions which we may hope will be followed by future visits, in circumstances which give time and opportunity for fuller study. Apart from the Study of Nature, there must necessarily be problems connected with social and economic life, which to other minds present even more absorbing interest.

Under our very eyes certain races of mankind are disappearing—the pure Bushman is nearly extinct, and the Hottentot is daily diminishing in numbers; whilst other native races, no longer warring against each other, are rapidly multiplying, and have to face conditions of life entirely different from those of their ancestors. Amongst the white races also the conditions of life are rapidly changing. The isolated farmer, whose chief ambition was to watch the increase of his flocks and herds and to be removed as far as possible from the sight of his neighbour's smoke, whose ideas were limited, and whose education was almost nil, is rapidly being replaced by sons and daughters intent on education, and with ideas and ambitions far beyond those of their fathers.

The rapid increase of the white population, due in the first instance to the discovery of the diamond fields and many fold enhanced by that of the gold fields, has created a condition of things which forms a most interesting study. Take, for example, the case of Johannesburg. Its gold industry greatly differs from that of the "new rushes" of other parts of the world. The pursuit of that industry, in the form which it necessarily assumes there, involves the employment on a large scale of men of culture and high scientific training, of men who are comparatively rich and in large proportion accustomed to, or aiming at, a kind of life previously almost unknown in South Africa. Thus rapidly—almost in a decade—has arisen a city of 100,000 inhabitants, demanding schools, colleges, libraries, museums, hospitals, water supply, drainage, facilities of travel, amusements, and all the luxuries and conveniences of life, such as in Europe are only to be found in cities having a growth of centuries. Imperfectly as it has been possible to meet these demands, the attempts to do so in an adequate manner offer a most interesting study in sociology and economics.

Not alone in cities do like difficulties occur. It is obvious that out of the conditions previously mentioned, serious problems in national education must arise both in relation to whites and natives. Our fiscal questions, the industries most suitable for the country and the application of scientific methods in their pursuit, offer a wide field of problems, and it is to be hoped that some of our visitors may give valuable contribution towards their solution.

It is, however, in the cause of pure science that we look for the greatest impulse, sympathy and aid. Few countries owe more to science than does South Africa. What would be the possibilities of mining in the Rand without the methods of deep level working and the economic extraction of gold from low grade ores which science has placed at her disposal? Science has rescued our vineyards from the ravages of phylloxera, has kept in check the insect pests of our fruit industry, has thrown a flood of light on the cause and cure of animal diseases, has developed our fisheries, and made possible that rapid opening up of the country which renders its resources of value, and in a thousand ways has administered to the amenities of life. But in an imperfectly developed country the conditions of life must tend chiefly towards what men call practical ends. This does not mean—as it is too often understood to mean—that science itself is a non-practical thing. When the struggle of life is keen men do not stop to investigate scientific principles for themselves, and have only time to borrow the results of scientific discovery by others for their own immediate ends. This has certainly hitherto been the case in South Africa. We can point to but an honoured few who in the past have done good original scientific research. But, with the recent importation of men of trained scientific capacity, as Professors in our colleges, or Government experts, and now with a few sons of the soil who have been trained by them, there is evidence of a marked increase in true scientific work, and a hopeful prospect of more.

With this explanation and this apology, we venture to offer the present volume, by South African writers, to our guests. It may serve as an index to what has been done, it may even be useful in the way of suggestion to those of our visitors who have come to South Africa earnestly bent on adding to the store of human knowledge.

DAVID GILL.

SECTION I.—PHYSICAL.

I. SOUTH AFRICA: AN OUTLINE OF ITS PHYSICAL GEOGRAPHY.

By H. C. Schunke Hollway, F.R.G.S., F.S.A., Government Land Surveyor, Cape Colony and Transvaal.

It has been truly said that "the gifts of Nature, her land, her waters and her skies, determine the character of the race's work." It is evident, then, that to students of South African history, politics and economics, a general knowledge of the geographical position of the land, of its surface-relief and climate, and of the rest of the physical conditions contingent on these, is indispensable.

To obtain an accurate and comprehensive view of the physical structure of the country we must take account of existing natural boundaries; we shall then find that South Africa forms a compact and well-defined orographical region.

The boundaries to the north, as variously accepted, are arbitrary, and from the geographical point of view inconvenient. Some geographers take the Limpopo as northern limit, others the Zambesi, whereas in truth the only natural boundary of South Africa which can be recognised is the great Congo-Zambesi divide. To clearly bring out the contours of this magnificent belt of Highland, stretching like a bridge from east to west across the continent of Africa, from within a short distance of the Atlantic Ocean to the north end of Lake Nyassa, and also in order to include the northernmost border of British Territory administered from the South and reached by southern doorways, it has been considered best for the purposes of this description to adopt the 8th parallel of S.L. as the northern limit of Southern Peninsular Africa. Here we have a sub-continent, which extends over 26 degrees of latitude, and measures in its widest part, from east to west, nearly 2,000 miles, covering an extent equal to European Russia, Germany and France combined.

Such a vast country, three-fourths within the tropics, one-fourth only in the temperate zone, facing the sea east and west—to windward and leeward—must present many and remarkable contrasts of climate and physical surroundings. To the white man, as far as the portion situated in the tropics is concerned, the question of climate must be supreme; he realises that a bracing, invigorating atmosphere—at least during part of the year—is essential to hard and sustained work, he is therefore compelled to seek the more favoured spots, where a high elevation offers a climate which does not relax or enfeeble his physical energies.

In the country extending from the Transvaal Highveldt to the Zambesi it is found that the level of 3,000 feet represents the limit below which Europeans cannot safely settle; north of the Zambesi, however, this limit is higher, and should not be taken at less than 4,000 feet. The consideration of the vertical as well as the horizontal distribution of the land becomes thus a matter of great importance, and we find that, for economic reasons, as also because they give us most clearly the main feature-lines of the country, the contour-lines of 3,000 feet and 4,000 feet are the most valuable. It will be found convenient to call the land at an elevation between 3,000 and 4,000 feet *upland*, and the land rising above 4,000 feet *highland*. The 3,000 feet line gives us the outline of the South African upland *massif*, a vast table-land mainly built up of primary, metamorphic and old sedimentary rocks, little disturbed since palæozoic times, in extent 1,615,000 square miles, or two-thirds of the area of South Africa. At the northern or widest side it measures 1,400 miles across, thence it gradually narrows towards the south, its eastern and western sides keeping more or less parallel to the coast lines, until it measures at its southern front about 400 miles in width. Its greatest length from south to north is over 1,700 miles. The belt of land remaining between the upland and the sea varies in width from 50 to 300 miles.

Along its border the widely extended table-land rises into high plateaux and intermittent mountain ranges which form the water-parting between the uplands and the coastal belt.

These highland plateaux with their mountains constitute the dominant features in the physiography of South Africa; they reach an elevation of from 4,000 to 8,000 feet, and there are culminating ridges and peaks which climb to over 10,000. Most of these plateaux have great potentialities, and if we, moreover, consider that their total extent is 533,900 square miles, or equal to the size of the British Islands, France, Germany and Holland combined, we realise how kind Nature has been in thus enabling the white man to colonise right into the heart of Tropical Africa. From the data, such as are at present available, we obtain 2,600 feet as the mean altitude of South Africa. It is not, however, pretended that this is a strictly accurate result; nevertheless it cannot be far from the truth.

The highland plateaux resting on the great upland *massif* are as follows :—

		sq. miles.
1.	The South-Eastern (Cape-Orange) Highland ..	187,200
2.	The Rhodesian (Matabele-Mashona) Plateau ..	23,000
3.	The Shire Highlands (Zomba and Mlanje) ..	600
4.	The Namili Plateau (east of Mlanje) .. .. .. And other small outliers.	200

		sq. miles.
5.	The Livingstone Nyasa Highland	9,200
6.	The Angoni Plateau	8,000
7.	The Nyika Plateau	16,700
8.	The Nyasa-Tanganyika Plateau	17,000
9.	The Great Divide (Congo-Zambesi) Plateau ..	84,100
10.	Three outliers of the Great Divide: the Mitumba Plateaux, the Kundelungu Plateau, and the South End of the Urungu (Tanganyika) Plateau	10,000
11.	The Angola Highland	107,000
12.	The Nama-Damara Highland with the outlying great Karass Mountains and the Plateau of the Northern Kaoko Veldt	70,000

Physiographic facts, such as presented to us in South Africa, have a fascinating interest when studied in the light of their geological history. It is certain that our conception of Nature must become more enlarged if we call upon the sister science to help us to a true knowledge of the evolution of the present land-features. From what geologists tell us we have reason to infer that the region of the present Congo-Zambesi Divide consisted in remote geological times of very elevated land, uplifted after the formation of the early palæozoic rocks, and not since submerged. It may perhaps have formed part of the backbone or main watershed of the continental area called Gondwanaland, which then united Africa with India and Australia. This watershed was then, far more than now, the barrier or natural boundary between southern lands and Central Africa, and has greatly aided in determining the topographical features of South Africa. It sent its abundant drainage southward into the shallow inland sea which existed during the Karroo period and northward into the great Congo inland sea which then reached right up to the foot of the Nyasa-Tanganyika plateau. It was, if we accept the theory that the ice-masses which invaded the Karoo basin during the Dwyka period were of Alpine origin and not antarctic icebergs, in the great valleys of this highland region that the glaciers were formed which descended south. It is certain that at this, or at a somewhat later period, the Loangwa Valley already existed, and contained an extensive lacustrine basin. Subsequent to the upheaval of the Karroo area, and the formation of the southern and south-eastern watershed, South Africa assumed the form of a table-land closed in on all sides by a rim of highland and border ridges. The central depression thus formed became the cradle of an enormous lake or series of lakes, which received the drainage from the surrounding border highlands.

Probably the Zambesi constituted the original overflow of this inland lacustrine basin, throwing its waters over the escarpment of the plateau, in the same manner as the Shiré does to-day with the waters of the Nyasa lake. But gradually it carved its way backward upstream through the highland belt, until it drained the lake or lakes. The subsequent degradation of the lower Zambesi valley must then have been comparatively rapid; in its middle track, however, the erosive action of the Zambesi received an early check by encountering the resistance of an enormous band or sheet of basalt, which now forms a natural weir across its course, and produces the grand Victoria Falls. By thus preventing the further recession of the Zambesi rapids, excepting by very slow degrees, the land surface of the Upper Zambesi basin has been saved from anything but very gradual denudation. From evidence furnished by the rivers Zambesi, Limpopo, and Okavango, as well as other minor rivers, the surface level of the great inland sheet of water, of which Lake Ngami represents the shrunken remains, must have stood at not less than 3,200 feet above sea-level. The Loangwa Valley, together with the valley of the middle Zambesi, may have been part of this great lake, or they may have contained a separate lake at a lower level, connected with the upper lake by part of the present Zambesi Valley. The extent of the great south African lacustrine area must have been more than twice the size of the United Kingdom and Ireland. It is of course for geologists to decide whether or no the valley of the Middle Zambesi was at one time part of the Loangwa Lake. The position of the axis of the Loangwa-middle Zambesi valley, and the close proximity to the region of volcanic disturbances which produced the great Rift Valleys, make it appear not unreasonable to conjecture that here we have another of the great subsidences so common on the line of weakness of the Earth's crust, which evidently exists along the eastern side of the African upland.

Generally it may be said that there is a great similarity of geological structure in the highland plateaux which surround the upland plains. With the exception of the south-eastern highland, which owes its rocks to the Karroo age, they are built up chiefly of primary rocks—crystalline schists, clayslate, quartzites and gneiss, broken through often in considerable masses by granite and syenite, which form domes and peaks and even whole mountain systems.

In South Africa, more than in most other countries, the surface agents of denudation have, since early Mesozoic times, had a long period for their work of carving the land into the scenic features as they present themselves to-day. There have, as might be expected, resulted many varieties of land contour characteristic of each region, owing to differences in the nature and strength of the denuding agents, and the lithological and geological structure of the rocks. In so vast a country, situated as South Africa is, there also are naturally great contrasts of climate. There is the contrast between the tropics and the temperate zone, and between the eastern and the western sides of Peninsular Africa. The east coast, situated in the way of the Trade winds, has an abundance of rain, increasing in quantity as we proceed from the south towards the tropics. Generally speaking, the contrast between east and west becomes most accentuated at or about the tropic. In the east, especially in the tropics, we find the denudation of the country has made great strides. The natural drains are here very active, and the rate of erosion in the rainy season is high. The continuity of the eastern rim of the upland plateau once, as we may infer, parallel to the coast, has been terribly eroded and broken down. It is the valleys of the great rivers which most strikingly give evidence as to the extent of the denudation now in progress. The Zambesi, and the Limpopo and Sabi, in the rainy season strengthened by numerous torrential tributaries, have scooped for themselves deep recesses out of the mass of the upland, leaving parts of the plateau and the border range prominently standing out as a huge peninsula (the Rhodesia Plateau). Not allowing for the general recession, caused by denudation, of the border of the upland, as evidenced by such outliers as the Murchison Range and the Sutherland Hills, in the low country of the Transvaal, of the Gorongoza Mountain near the Pungwe, and even of the Mlanje Plateau, all at one time probably part of the original upland *massif*, but drawing a line from the north-east end of the Zoutspansberg to the Gazaland Plateau, and from the Inyanga Plateau to the Zomba Plateau, we find that the superficial extent of land excavated by the Limpopo and Sabi is 64,000 square miles, and that removed by the Zambesi 90,000 square miles. These denudation areas are profoundly carved out —thus the Zambesi, at Zumbo, is only 800 feet above sea-level, and the Limpopo at the junction of the Shashi hardly more. The west, the leeside of the subcontinent, shows quite a different condition of things. Here on both sides of the line of the tropic we have a dreary waste of arid land; denudation and erosion, by water, are replaced by dry weathering, and the accumulation of aeolian deposits along the sea-board. Extensive disintegration of the ground takes place, no doubt, on the arid high plateaux inland, where great extremes of temperature are experienced, and from whence the dust and lighter detritus are carried by frequent and strong winds towards the coast. The amount of land excavated from the upland *massif* by the Cunene and Orange rivers is inconsiderable compared with the work done by the eastern rivers, thus the Orange River a short distance above Pella is still 2,000 feet above sea-level. The superficial extents of the denudation areas of the Cunene and Orange rivers are respectively 21,000 and 35,000 square miles.

The Coast Belt.—Of the belt of lowland which stretches round the subcontinent along the foot of the upland *massif* the south-western portion is by far the most interesting. This region, extending from the Olifants River in the west to the Fish River in the east, the scene of the earliest settlement in South Africa, is unique in its character. Its geology, climate and flora are peculiarly its own. Geologically it is a region where the readjustments of the Earth's crust caused great disturbances in late palæozoic times. Its mountains ranging more or less parallel to the coast round the south-western corner of Africa, over a distance of over 600 miles, are all true mountains, produced by the Earth's crust being thrown into upward folds by thrusts from the south and west, and pressed and dislocated against the solid and immobile mass of the Karoo rocks. These mountains, showing rock-beds of so much variety of structure and degree of decay, situated in a region of abundant rainfall, produce scenery much diversified in character, and often of most striking beauty and grandeur. The principal mountain ranges in the west are the Olifants River Mountains, and east of these the Cedarbergen. Extending from west to east we have the Hex River Mountains, the Langebergen, the Outeniqua and the Long Kloof Mountains. Inland, parallel with these, the Touwsberg, the Zwartebergen and the Kammanassie and Kouga Mountains, with the Zuurbergen stretching still further east. In the south-west, where the trend of the ranges changes from north-south to west-east, the mountain system is more complex, with interlacing ridges and knots, and many prominent peaks. At the junction of the Olifants River Mountains and the Cedarbergen the Great Winterhoek, the highest mountain in western Cape Colony, rises to a height of 7,600 feet; the Du Toit's Kloof Mountain, in the Drakenstein Range, and many other peaks in this part attain a considerable height. The rivers in the south-west region run mostly in longitudinal valleys, between the parallel ridges—the troughs between the uplifted rock-folds—but ultimately force their drainage through the ridges to the sea, by transverse gorges, some of them of great depth and grandeur, such as the Zevenweeks Poort, the Gamka Poort, the Meirings Poort, the Toverwaters Poort, in the Zwartebergen, and the Gouritz River and Keurbooms river gorges in the Langebergen and Long Kloof Mountains. Mr. A. W. Rogers, in his fascinating book on the geology of the Cape Colony, tells us how these gorges were formed, not, as is popularly believed, by violent fissure, but by long continued erosion.

From the Olifants River northward the narrow coast-belt grows more and more barren and uninteresting until, between the Orange River and the Cunene, it becomes a desolate, waterless wilderness of shifting sand-hills, almost devoid of vegetation. North of the Cunene, along the Angola coast, it is less bare of vegetation, but still a poor, sterile, sparsely-watered region, exceedingly unhealthy and uninviting. Northwards along the east coast, from the Fish River to Zululand, the lowland is narrow—in parts, not above fifty miles wide—much broken and diversified, with ridges and spurs, from the upland, extending to the sea-board. Thanks to the plentiful intrusions of dolerite in the Karroo Beds the denudation of the country has, notwithstanding an abundant rainfall and an active drainage-system, been comparatively slow. The country is well-wooded, productive and exceedingly attractive. Further northwards, owing to the recession of the Karroo formations with their igneous intrusions, and the appearance of the older rocks, the coast-belt widens and becomes less broken. From the Limpopo to the Zambesi the coast belt is broad, and consists of uninviting, insect-infested bush-covered plains, unhealthy and unsuitable for European occupation. Beyond the Zambesi the general level of the lowland belt is much higher and is more broken, but is still exceedingly unhealthy.

THE CLIMATE.

Four climatic regions may be distinguished in South Africa, which, however, are not sharply marked off, but gradually merge one into the other :—

(1) *The South-Western Region* coincides almost entirely with the "folded belt." Here we have abundant winter-rains and dry hot summers. This is the country for the cultivation of European cereals, for viticulture and orchard culture. Botanically it also forms a separate region, being the home of the "Cape Flora," abounding in heaths, proteas, pelargoniums and beautiful bulbous plants.

(2) *The Temperate Eastern Region*, with summer rains, often accompanied by thunderstorms, and dry winters. Of this climatic form there are many variations depending upon the relief of the country, the aspect, and the distance from the sea. Here maize and millet are grown in abundance, besides tobacco and fruit-trees. This region supports a large, chiefly native, population. It extends in its higher inland part to the Northern Transvaal, but in the coast-belt does not reach beyond Natal. Inland it gradually merges into the Desert Region.

(3) *The Desert Region*.—This is a large tract of country bounded south-west by the Olifants and Doorn rivers, south by the Touwsberg and Zwartebergen, east broadly by a line from the Zwartebergen, near Willowmore, to the Diamond Fields, and thence to Tati and on to the Zambesi above the Victoria Falls. Thence its northern boundary runs round the southern side of the Ngami system of river-meanders, along the Okavango to its middle course, and thence across to the lower Cunene. From this river the dry belt extends further northwards, along the coast, ranging in width from 50 miles at Mossamedes, 40 miles at Benguela and 150 miles at Loanda. Excepting the Cunene and Orange rivers, which traverse this region on their way from well-watered parts to the sea, no perennial streams are found. In extent this region measures 700,000 square miles. The rainfall varies from practically nothing in the arid, sandy wilderness belt, along the coast between the Orange and the Cunene, and 18 to 20 inches along its southern and eastern fringe. There must also be a not inconsiderable rainfall in the Kalahari south of Lake Ngami, and in its north-western part, as well as in some parts of the Nama-Damara Highland. In the Kalahari, surface water, owing to the great permeability of the soil, is extremely scarce, but there must be abundant supplies of underground water, as witnessed by the vegetation, which consists chiefly of rank grass (Bushman and Twa grass) growing in tufts, and trees of the acacia kind ; these are also characteristic of the western and northern parts of the Desert Region. In the Karoo part, which begins some little distance south of the Orange River, the flora changes. There the country is covered with stunted bushes of greyish-green colour, generally widely spaced, and forming a characteristic feature in the landscape.

(4) *The Tropical Eastern Region*, with summer rains, varying from 25 to 100 inches. Of this form of climate there are also many varieties. Take, for instance, the contrast between the climate of the mangrove swamps of the Zambesi delta and of the bamboo zone of the Livingstone Mountains or of the highland steppe of the Nyika Plateau; again, between that of the Pungwe Valley and of the Inyanga Plateau. The temperate eastern and tropical eastern regions form one botanical region, which on the whole bears the character of the steppe. It is well-watered and well-wooded, but its forests are forests of the steppe—true forests, such as are found in the Equatorial regions of America and Africa, do not exist in South Africa.

We now proceed to a brief outline sketch of the various highland areas of South Africa.

The South-Eastern Highland.—This region, one and a half times the size of the British Islands, owes its origin to the upheaval of the Karroo basin. Its length from the Roggeveldt Mountains (150 miles north-east of Table Bay) to the Zoutpansbergen, in the Northern Transvaal, is 900 miles, and it measures 400 miles in its widest part. It is bounded on the south, along its Karroo part, by the Komsberg, the Nieweveldt escarpment (with the Bulthouders Bank, 6,270 feet above the sea), and the Sneeuwbergen (with the Compassberg, 8,500 feet high); thence by the Tandjesberg, the Great Winterberg (7,600 feet), and the Amatola (with Gaika's Kop, Hogsback, 6,400 feet, and Dohne Peak). On the south-east the Zuurberg escarpment (with the bold Baziya Headland and Mount Grant), extending through the Transkeian territories, marks the edge of the highland. Towards the interior the plateau slopes gradually. The main range of the highland, the Storm-bergen and the Drakensberg or Kahlamba Mountains, is built up of the Stormberg beds, capped with volcanic rocks of great thickness. Extinct volcanic vents still exist along the middle section of the range. For 450 miles the main range extends as an unbroken chain in a north-east direction with a bold, magnificent and much-varied crest line. Numerous peaks and domes, such as the Washbank Peak, Kahlamba Peak, Snow Peak or Ben Lomond, Mount Huxley, Newton Peak, the Three Sisters, rise to a height of from 8,000 to 10,000 feet. At and near the knot of the range, at the sources of the Orange, Tugela and Caledon Rivers, the Drakensberg attains its culminating heights in the Mont aux Sources, Champagne Castle and Giant Castle, which climb above 10,000 feet. For a distance of 250 miles—between Barkly Pass and Van Reenen's Pass—there are no passes for wagon traffic. Branches of the main range on the west side are the northern and the southern Wittebergen (north and south of Basutoland) and the Maluti Mountains, which latter equal the Drakensberg in grandeur and height. Near the sources of the Vaal River the main range becomes much broken, and is called Verzamelbergen, and thence the plateau is bounded on its north-east side by a bold escarpment called the Randbergen. From the Verzamelbergen a hogsback-shaped ridge, 5,000 to 6,500 feet in height, runs westward called the Highveldt and Witwatersrandt. It is on this Highveldt that the Karroo beds terminate and give place to older formations. On its south-east and east side the plateau is much eroded, especially by the Fish, Kei and Tugela Rivers, which break the continuity of the escarpment. Besides being excellent for agricultural and stock farming, the South-eastern Highland is one of the richest mineral districts in the world, containing the Cape and Transvaal diamond fields, the Witwatersrandt goldfields, the Transvaal, Natal and Cape coal mines. The climate is throughout the whole of the Highland thoroughly healthy and invigorating. An idea of the general level may be obtained from the altitudes of some of the towns and villages. Sutherland, 4,776; Fraserburg, 4,200; Victoria West, 4,175; De Aar, 4,180; Richmond, 4,700; Colesberg, 4,407; Steynsburg, 4,750; Cyphergat, 5,450; Aliwal North, 4,350; Herschel, 5,100; Dordrecht, 5,389; Barkly East, 5,831; Kokstad, 4,300; Mooi River (Natal), 4,556; Charlestown, 5,385; Bloemfontein, 4,517; Kimberley, 4,012; Maribogo, 4,320; Mafeking, 4,190; Pitsani, 4,421; Viljoensdrift, 4,760; Harrismith, 5,322; Johannesburg, 5,678; Pretoria, 4,532; Marabastad, 4,100; Pietersburg, 4,000; Smitsdorp, 4,750; Standerton, 5,022; Balmoral, 4,915; Middelburg (Transvaal) 4,971; Belfast, 6,463; Machadodorp, 5,379.

The Rhodesia Plateau.—Situated between parallels 20° 40′ and 17° 50′ S. and meridians 27° and 35° 20′ E. Carved out of the main *massif* of South Africa by the erosive action of the Zambesi, Limpopo and Sabi Rivers, it extends from the confines of the Kalahari Desert, 90 miles west of Bulawayo, in an E.N.E. direction, for 480 miles, with a width not exceeding 90 miles, and a fringe of upland on its northern and southern sides, varying from 30 to 70 miles. At its eastern end the plateau throws off branches to the northward towards the Zambesi, and southward, presenting thus an east front, of 180 miles in length, whence it falls abruptly to the plains of the Pungwe and Buzi, and marked almost throughout the whole of this distance by high ridges and prominent crags and peaks. In the north on the beautiful Inyanga plateau (5,000 feet) the Saunayama Peaks, over 8,000 feet high, are perhaps the highest points of the highland; we then have the Dombo, a granite crag of 6,700 feet on the Manica plateau (6,000 feet,) preceding farther South there are the Inyangami Mountains (6,550 feet), Mount Doe 6,725, the Pungwa Mountain 6,870 feet, the Udza Mountains over 6,000 feet, Chimanimani Mountains 7,450 feet, and finally the Gorima Range 6,250 feet. In the south-west, near Bulawayo, the Matoppo granite hills, showing a steep and deeply eroded escarpment towards the south, form a prominent and remarkable feature in the topography of the plateau. The rock formations are chiefly granite, pre-Cape crystalline limestone, and Table Mountain sandstone, with, in parts volcanic rocks of more recent age. Without doubt the Rhodesia plateau is one of the oldest goldfields in the world. This is testified by the Zimbabwe ruins and other remains of innumerable ancient settlements and workings. As in olden days, the goldmines of to-day are scattered all over the plateau. On the whole the country is well watered, and the climate is temperate and perfectly healthy for Europeans. Before the Matabele war the European settlement on the Mashona plateau led but a precarious existence, its only roads from the south and east being through fever-stricken lowlands. At present the railroad from the Cape runs entirely along healthy upland parts. The following altitudes give some idea of the general level of the plateau :—Bulawayo, 4,469 ; Bembesi, 4,482 Inziza, 4,640 ; Somabula, 4,638 ; Gwelo, 4,650 ; Salisbury, 4,700 ; Marandellas, 5,600 ; Plumtree, 4,561 ; Fort Charter, 4,469.

The Shire Highlands.—These highlands consist of separate small plateaux, standing on an upland base 100 miles in length, which extends from south to north between the middle Shiré and Lake Shirwa. Towards the Shiré and Ruo, west and south, the upland falls steeply, but north and east it gradually slopes towards the great plain of Nyasa and Shirwa. The Northern Highland, the Zomba Plateau, reaches a height of 5,625 feet, and extends in a north-east direction between Shirwa and Nyasa Lakes; Prominent are the Malosa and Chikala Mountains. At its southern extremity is situated the Zomba Settlement and seat of the Administration. On the south-east side of the Shiré upland, the Mlanje Plateau, one of the grandest and most charming mountain areas in Africa, stretches its massive structure, 30 miles long and 18 miles wide from west to east. From its Main Plateau, 6,000 feet high, and measuring 10 by 15 miles, rises a ridge of rocky peaks, 8,000 to 9,680 feet high. The greater portion of Mlanje consists of gneiss ; on the south-west, near the edge of the plateau, there are two extinct craters, showing lava streams and scoriae. Between 4,000 and 5,000 feet there is a belt of forest, and in the higher parts is found the Mlanje Cedar, which attains a height of 160 feet. Between Zomba and Mlanje there is the settlement of Blantyre, and there are other smaller plateaux and mountains such as Solshi Mountain, Chigamula Mountain and the Chola Plateau. The climate on the highlands, especially on Mlanje, is delightful, fresh and bracing.

The Livingstone-Nyasa Highland.—This includes the whole of the mountainous region east of Lake Nyasa, from the volcanic area above the Konde Plain, southward. Granite is everywhere the fundamental rock. In the northern section, north of the Ruhuhu River, there is a zone of gneiss which forms the longitudinal ranges of the Kinga Mountains (8,500 to 9,500 feet). The ridge nearest the lake falls abruptly to the water from a height of 6,000 feet. South of the Ruhuhu the mountains consist of granite and gneiss, and gradually diminish in height, the escarpment on the lake side falling to 4,000 feet. Throughout, the Livingstone Highland has a purely mountainous character. The upper parts contain rich pastures and forests, and the climate is excellent.

The Angoni Plateau.—This highland extends along the west side of the southern half of Nyasa Lake, and further south. With the mountainous extension, south, it measures over 150 miles in length, and in its northern and middle parts 50 to 80 miles in width. Towards the Nyasa Lake the plateau shows a bold escarpment, 4,000 feet high, with granite peaks of 6,000 to 7,000 feet, known as the Mafuta or Kirk range, and further south called the Marurungwi Mountains. On the north and north-west the plateau slopes away to the valley of the Bua River. The higher part, which lies south and south-west, consists of rolling, fertile plains, but is poorly wooded. There are, however, valuable timber forests on the slopes of the Kirk range. It is a beautiful country with a much diversified landscape and a temperate climate—excellent for European settlement. The rock formations are chiefly granite and gneiss; there is gold-bearing quartz in the Lintipi Valley. Iron is abundant, and there is also lead and graphite. Prominent points on the high parts are Mount Deza, 7,000 feet, Mount Chongone, Mount Tambula, Mount Dombwe and the Kongwe Peak.

The Nyika Plateau.—It is bounded north by the Nyasa-Tanganyika Plateau and the Konde basin, east by Lake Nyasa, west by the Loangwa Valley, and south by the Bua Valley, and is 200 miles long and about 80 miles wide. The escarpment fronting Nyasa rises 4,000 to 5,000 feet above sea level. The Grand Plateau of Nyika (beginning about 30 miles south of Karongo) above 8,000 feet high may be called "the roof of South Africa," it measures 30 by 35 miles, with the Nacheri Mountain (8,518 feet) and Mwanemba (8,553 feet) rising above its level. Other high points in the main highland plateau are the Namitawa, 7,285; the Panda Peaks, 6,381; Pirikwamba, over 6,000, and along the eastern escarpment Mount Waller, 4,500; Mount Samara, 7,000; Mount Mayui, 7,500. In the southern part there are Mount Choma, 5,500; Mount Kuningini, 5,000, and Mount Mbabwa. The plateau is traversed diagonally, from south-west to north-east by the South Rukuru (Avenga) Valley. The rocks are chiefly granite. On the peaks of the Grand Plateau the flora resembles that of Mlanje. Everywhere there are streams of beautiful clear water running at all times of the year. The average rainfall is 50 to 70 inches, and in June, July and August there is frost at times. It has the most equable climate in Nyasaland. The soil is good, and in the deeper valleys there is suitable coffee-land, its undulating steppes are excellent for cattle and sheep farming. The Scotch mission stations of Ekendeni (4,346) and Kondowi are situated above the eastern escarpment. The Nyika Plateau—about the size of Switzerland—is an ideal country for European settlement.

The Nyasa-Tanganyika Plateau.—This plateau, situated between the Nyasa and Tanganyika Lakes, forms the waterparting between the Indian and Atlantic Oceans. It rises abruptly from the dead-level flat of the Konde basin, which surrounds the north end of Nyasa. Its general level is from 4,500 to 6,000. The Stevenson Road, which joins Nyasa and Tanganyika, runs a little to the north-east of the main watershed, and maintains for the greater length an altitude of over 5,000 feet, with points reaching

6,000 feet. North-east the plateau extends to the Chigamba escarpment, overlooking Lake Rukwa. The bare rock-peaks Memia, Kusa and Nkukwa rise 1,000 feet above the rugged escarpment. From the main watershed with Mount Sunza (6,889) the plateau slopes gently south-east towards Lake Bangweolo, which is only a few hundred feet below the highland level. Abercorn, near Tanganyika, is situated on the finest part of the plateau. At the south-east end of the plateau, above the Konde basin, there is a volcanic region with crater-lakes, cinder beds and streams of basaltic lava. Here the Rungwe Mountain (10,200), an extinct volcano, stands out boldly from the edge of the plateau. The Nyasa-Tanganyika Plateau consists of grassland interspersed with trees, and is healthy for Europeans.

The Great Divide (*Congo-Zambesi*) *Plateau.*—It was the belief, until a few years ago, that the head waters of the Congo and Zambesi took their rise from extensive marshes which showed no definite water-parting. Recent explorations have by no means confirmed this view; we now know that, excepting in one or two places, the Great Divide—although it is not marked by any mountainous relief—is perfectly definite, and there are no interlacings of the two river systems. Between the Upper Kasai and the Jambeji the Great Divide drops a little below the highland level, and it is here that a division may conveniently be made between the Divide Plateau and the Angola Highland. Measured from here in a straight line to Moir's Lake, and thence to the head of the Loangwa River, the length of the plateau is 950 miles. At Serenjie on the Muchinga it is 100 miles wide, and at the sources of the Kafue 50 miles. However, the plateau throws out broad extensions far to the south; thus the distance across from the Lufira head-waters (near Katanga) to the southern end of the highland between the Kafue and Kabompo Rivers is over 350 miles. The general level of the Divide is from 4,200 to 5,500 feet. Facing the Loangwa Valley, the plateau shows a bold precipitous much broken escarpment, consisting almost entirely of granite. This enormous tract of highland is destined to play in the near future an important part in the development of the interior of South Africa. Undoubtedly it is the natural highway from the west to the east. It is a good farming country, well watered, well wooded, and the climate is healthy.

The Angola Highland.—This magnificent Highland, greater in extent than Italy, is situated about 150 miles from the Atlantic Ocean, and presents a front to the coast of over 450 miles. Its length, measured from the south end of the Cordillera da Chella, opposite Great Fish Bay, to the Upper Kasai is 700 miles. On the coast side it is fringed by a belt of much broken country, 100 miles wide, with foot-hills and spurs, containing a most luxuriant vegetation, forests of lofty timber trees and a plentiful supply of water. The border range of the high plateau is in the south called Cordillera da Chella, with Monte Luciano (5,568), opposite Mossamedes. Serra da Hanha, opposite Benguela, Serra Andrade Corvo, and further north Elongo Mountains (7,329) and Mount Loviti (7,776). The High Plateau is almost treeless, consisting of undulating steppe. The soil is excellent, water is abundant, the climate is healthy and bracing. It is in fact *par excellence*, a white man's country. There is a grand array of important rivers which have their sources on this plateau, viz., north, the Kwanza, Kwango and Kasai; east, the Lumaji, Lungwe Bungu; south, the Kwando, Kwito, Kubango and Kunene; and from its west slopes the coast rivers between Kwanza and Kunene. Some of these rivers attain a fair size before descending from the plateau. The general level of the plateau is 4,000 to 6,000 feet. The rock formations are granite, crystalline schists and red sandstone.

The Nama-Damara Highland.—The central part of this Highland is very mountainous, and is a country of granite and gneiss. About 200 miles east of Walfish Bay the Awas Mountains (6,000 to 7,000 feet) north of which Windhoek is situated, with the great plateau which extends from them north and north-west, form the main water-parting of the highland. Here the Swakop, Kuisib, Nosob and Great Fish—all periodical rivers—take their rise. From the Awas Mountains the Komab Plateau, with many rugged ridges and prominent points rising to over 8,000 feet, extends, between Swakop and Kuisib, towards the coast. From the central mountain region high table lands and table mountains spread north-west, north, east and south; they consist chiefly of sandstone and clay-slate of the Cape Age, and quartzites and crystalline limestone. North-west of the Awas Plateau we have the Ombotoza Mountain, 7,300, further north the Omatako Mountain, 8,800, and north-east of this the Waterberg or Omuveroume Range runs parallel with the Omuramba ua Matake. From the Amas Range the Hakos Mountains extend south-west along the Kuisib Valley, from these again the Hanami Plateau, a high, bare tableland, spreads south with its extension (south-west), the Huib Plateau. East of the Hanami Tableland are the Nunanib and the Urinanib Plateaux. Considerably to the south of these, between the Great Fish and the Nosob, but detached from the main highland, are the rugged Karas Mountains, a complex mass of barren, bare-looking table mountains. North and north-west the highland gradually slopes towards the bush-covered plains, which extend to Ovamboland and the Okavango River; on the east side, towards the Kalahari, it shows a terraced sandstone scarp. Towards the north-west, in the direction of the Kunene the plateau extends as a narrow strip of highveldt which slopes gently to the west, but on the coast side merges into a very broken mountainous zone, consisting of rugged table mountains and outliers of the main tableland, one of these, the Entendeka Mountain, rises to 4,500 feet. This region is called the Kaoko veldt. Here the sand-rivers in the deeply-eroded valleys have an abundant supply of water, and support a considerable vegetation. Copper is found in many parts of the Nama-Damara Highland, notably on the Komab Plateau, and at Otavi in the north. The north-east is by far the best part of the highland, and is considered to be one of the best cattle countries in the world. The south slopes of the Awas Mountains are also excellent for cattle farming. The climate throughout the highland is perfectly healthy, with a uniform daily range of temperature throughout the year.

Hydrography of South Africa.—Having thus given an outline of the relief of the South African subcontinent, there remains for us to give a description of its hydrography. The east and north are, as already mentioned, by far the best watered parts of South Africa; the west is, on the whole, a region of low rainfall and periodical rivers. The following table of drainage areas has been constructed from a physical map of South Africa, specially prepared for this work, of which an enlarged copy will be produced at the British Association meeting.

Principal River Basins :—

	square miles.
Zambesi	538,500
Ngami System	305,800
Sabi	36,400
Limpopo	162,000
Orange River	404,400
Kunene	54,200
Kwanza	62,700

Coast Rivers :—

Between Kwanza and Kunene	60,200
,, Kunene and Orange River	101,100
,, Orange River and Limpopo	192,200
,, Limpopo and Sabi	21,500
,, Sabi and Zambesi	37,400
,, Zambesi and 8° S.L.	218,700

The Zambesi.—The Zambesi, the largest and most important of South African rivers, with a drainage area equal in size to the British Islands, France and Germany combined, rises on the Great Divide Plateau in Lat. 11° 21′ S., Long. 24° 24′ E. The distance from its source to mouth is, in a straight line, 900 miles, measured along its course 1,600 miles, with an average declivity of a little over 3 feet per mile. Its course may be divided into four sections—the *Mountain Track* in a south-west direction for 170 miles, from the source to the Luena Junction, below Kakengi, with a fall of 8 feet per mile; its *Barotse Plain Track*, in a general S.E.S. direction for 510 miles, across the Great Barotse Plain, which measures about 400 miles in width, to the Victoria Falls. Its fall in this section is a little less than 1 foot per mile, and it contains ten rapids within a distance of 75 miles, beginning with the Gonye Falls, 170 miles above the Victoria Falls. In the next section, the *Middle Zambesi Valley Track* from the Victoria Falls, where the river falls 400 feet, to Zumbo, a distance of 400 miles, the river flows in a narrow valley between steep mountains, rising, in parts, over 2,000 feet above the river. In this section are the Devil's Gorge, with the Sichiwana

Cataract, the Molele Rapids, the Lutala Gorge, Kansala Rapids, the Kariba Gorge and the Upper Lupata Gorge. The fall in this section is over 5 feet per mile. In the *Lower Track*, from Zumbo to the sea the Zambesi is seriously obstructed by the Kebrabasa Rapids, 140 miles below Zumbo, which extend over a distance of 40 miles, and are absolutely unnavigable. Thence the river widens, and the mountains recede from its banks. About 50 miles from the sea the river splits up into numerous ramifications, and forms a delta with a width, on the sea-shore, of over 100 miles. The Chinde Channel of the Zambesi is at present most frequently used for navigation. The fall in the *Lower Track* is 1 foot 9 inches per mile.

Tributaries of the Zambesi.—On its right bank the Zambesi receives in its Mountain Track the Luvua, the Kifamaji (which takes the overflow of Lake Dilolo) and the Luena; in its Barotse Valley Track the formidable Lungwe Bungu, which comes from the Angola Highlands, the Luanginga (which enters near Lialui, the Barotse capital), and at Kazungula (45 miles above the Victoria Falls) the Linyante or Kwando, which also rises on the Angola Highlands. One hundred and twenty miles west of Kazungula the Zambesi and Ngami systems are connected by the Magwekwana which, during flood-time, discharges the overflow of the Okavango River into the Kwando. In the Middle Track the Zambesi receives the Guay, the Sengwe, Umay, Sanyati and Jole coming from the Rhodesian Plateau, none of them rivers of great volume; in the Lower Track, also from the Rhodesian Plateau, the Angwa or Hanyani, the Umsengusi and the Mazoe. On the left bank the Zambesi receives in the Mountain Track the Luzabo; in the Barotse Valley Track it is considerably augmented by the Kabompo which is formed by the union of the Lunga and Mumbeshe, both rising on the Great Divide Plateau, and also receives the Luena and the minor rivers Lui, Lumbi, Kwemba, Machili and Umgwezi; in the Middle Track the Zambesi receives the Zongwe from the Matoka Plateau, and, 100 miles above Zumbo, the only tributary of importance in this section, the Kafue River, which comes from the Great Divide Plateau, and is strengthened on its way by the Luanga, Lufupa and Lukanga rivers. At Zumbo the Zambesi is joined by the Loangwa River which rises 500 miles away on the Nyasa-Tanganyika Plateau. Not far above the junction the Loangwa receives the Mulungushe from the Great Divide Plateau. The Zambesi receives, in its Lower Track, the Luivi and the Revubwe Rivers from the Angoni Plateau, and about 80 miles from the sea the important Shiré River, the overflow stream of Lake Nyasa, Ten miles below Nyasa the Shire flows through Lake Pamalombe. which has a length of 15 miles. In its upper and lower reaches, which are separated by the series of rapids and falls called the Murchison Falls, the Shiré is navigable, and forms with the Zambesi the principal highway from the sea to Nyasaland and North-Eastern Rhodesia. The fall of the Shiré between Nyasa and Zambesi is over 6 feet per mile, most of the declivity is, however, confined to a distance of less than 50 miles. Lake Nyasa, the feeder of the Shiré, stretching from south to north, has a length of over 350 miles, attains a width of 50 miles, and a greatest depth (in the northern half) of 386 fathoms. It is hemmed in by high and steep mountains and plateaux, and has but few and unimportant affluents. East of the Shiré Highland, Lake Shirwa, unconnected with any other hydrographical system, but probably formerly part of Lake Nyasa, is now fast disappearing.

The Ngami System.—Livingstone said: "The whole country between this (the Victoria Falls) and the ridge beyond Lebebe westwards—Lake Ngami and Zonga (Botletli) southwards—and eastwards beyond Nchokotsa was one fresh-water lake." No doubt the Ngami system was at no very distant time part of the Zambesi basin, but has since, owing to the deepening of the Zambesi Valley and the general desiccation proceeding in South Africa, become almost separated. Since Livingstone's day, when Lake Ngami presented an open sheet of water, further changes have taken place; Ngami hardly exists, its feeder, the Teoghe, (Taukhe) is blocked by "sudd," and it is now nothing more than a reed-swamp with small patches of open water. The main stream of the Ngami system, the Kubango or Okavango River, rises on the great Burro-Burro Plain of the Angola Highlands in close proximity to the sources of the Kunene and Kwanza; before descending from the highlands, it is already 84 feet wide and 6 feet deep. It first flows S.E.S. for 450 miles through a country densely covered with bush, then eastwards for 160 miles to Lebebe. Twenty-five miles south of Lebebe it spreads and forms the Okavango Swamp, in width from 10 to 50 miles, and extending over 100 miles to southward. The overflow of this extensive reed-swamp discharges north-east into the Zambesi (by the Magwekwana-Kwando), and south into the Tamalakan, which feeds the Botletli River, the former outlet of Lake Ngami; and this river empties itself into the great pans of the Kalahari Desert, of which the Makarikari is the largest. Forty miles above Lebebe the Okavango receives its only but important tributary the Kwito, which also comes from the Angola Highlands. Within 12 miles above Lebebe are the Maturu and Galabe Rapids, at Lebebe the Sekanana (Andara) Rapids, and further down the Dwai and Popa Rapids.

The Sabi River.—The Sabi, which rises on the Manica Plateau (eastern part of the Rhodesia Plateau) has a total length of course of 380 miles, and average fall of 14 feet per mile. For 200 miles it flows south through a very beautiful and mountainous country, with an average fall of 25 feet per mile. In this section it receives the Odzi, which has as tributary the Umtali. After receiving the Lundi from the west, a river half its size, the Sabi turns east and traverses the low country, here densely wooded, to the sea. Its average fall in this section is 3 feet per mile, and its width during the dry season about 250 yards with a depth of 3 feet. At its larger, with a bar half a mile wide, and 5 feet of water at low tide. Both the Lundi and the Sabi, some distance above their junction, have beautiful cataracts. Affluents of the Lundi rising on the mouth it bifurcates, the northern branch, the Makau being the middle Rhodesia Plateau are the Tukwe and Ingwesi.

The Limpopo.—The direct distance from source to mouth of this river is 350 miles, measured along its course 750 miles. Its average fall is 6 feet per mile, but in the last 250 miles of its course, its fall is only about 2 feet per mile. It rises on the Witwatersrand, and after breaking through the Maghaliesberg it descends for 175 miles through a most beautiful country in a N.W.N. direction to a little beyond the junction of the Notuane; thence it flows 210 miles in a north-east direction through bush-covered country to the junction of the Shashi, thence 120 miles east to the junction of the Parfuri or Unvubu, where it has, during the dry season, a width of 200 yards, and from there south-east to the sea. Its tributaries are on the left bank, the Elands and Marico Rivers both from the Witwatersrand, the Notuane, Lotsani, Maclutsie, Shashi with its tributaries Shashani and Tuli from the Matoppo Hills, the Bubye and the Nuanetsi. The latter is, in its lower course, a sand river. On the right bank the affluents are the Zand River, Palala and Nylstroom or Maghalikweni from the Waterberg. The Ingalele and Singwedsi from the Zoutpansberg. Finally the Limpopo is joined by the voluminous Olifants River, which with its tributaries the Elands and Rhenoster Rivers comes from the Highveldt. From the Zoutpansberg the Olifants River receives the Letaba. The country along the middle and lower Limpopo is densely wooded.

The Orange River.—The Orange River is the principal river of temperate South Africa. An idea of the vast extent of the drainage area may be formed, if we consider that the distance between its extreme east and west boundaries—the north end of the Drakensberg, 150 miles from the Indian Ocean, and the Awas Plateau, 200 miles from the Atlantic Ocean—is 900 miles. Of this enormous basin the greater part belongs to the Desert Region, and need not here be further described. The Orange rises in Basutoland near the Mont aux Sources, in the Drakensberg Range. Its upper course is along a grand and wildly romantic valley between the Drakensberg and the Maluti Mountains, which rise to over 10,000 feet. Here it receives the Sengunyana and lower down the Kornet Spruit and Quthing River. At Aliwal North the Orange completes its mountain track at an altitude of 4,300 feet above sea level. Not far below this it receives on the right bank the Caledon River, which drains the more hilly parts of the Orange River Colony and the open and populous parts of Basutoland; its basin is one of the richest grain-producing districts in South Africa. At a distance of 450 miles below its source the Orange is joined by the equally important Vaal River, which rises at the north end of the Drakensberg Range, and has a length of course of 520 miles. It drains the southern slopes of the Witwatersrand and Highveldt and the undulating grassy plains of the south-western Transvaal and the Orange River Colony, a rich agricultural and pastoral area. Tributaries of the Vaal are on the left bank, the Valsch, Sand, Modder and Riet Rivers; on the right bank the Mooi, Makwasi and Harts Rivers. About 700 miles above its source the Orange River enters the Desert Region, and thence receives no more perennial tributaries, excepting the Vaal. Below Upington the Orange widens and forms numerous islands, and below these are the great Aughrabies Falls.

The Kunene River.—The most beautiful river of Angola, has its source on the Great Burro-Burro Plain on the Angola Highlands. It flows in its upper and middle course through a beautiful and most promising country. In its lower course it passes over very broken country, and forms three important cataracts, the upper one 300 feet high. Its total length of course is about 600 miles.

The Kwanza also rises on the Angola Highlands. Its length of course is 520 miles. In its lower course it traverses, for 150 miles, a dreary dry, inhospitable region.

Coast Rivers.—The perennial Coast Rivers begin with the Olifants River, thence round the south and east coasts they get more and more numerous. Their courses are short and precipitous, yet some show a considerable volume of water. The most noteworthy are the Umzimvubu or St. John's, the Tugela, the Pungwe and, north of the Zambesi, the Rovuma.

The Coast.—The coast line partakes of the uniformity which characterises the physical structure of South Africa. It is almost destitute of natural harbours. On the east coast the harbours consist of river estuaries and lagoons mostly obstructed by sand or detritus bars. The only natural harbour is Delagoa Bay. At Durban and East London the harbours have been made safe and serviceable with a large outlay of capital. On the west coast the harbours consist of sand spits, enclosing more or less shallow basins, and formed by the combined action of the south-westerly and easterly winds which make the sand dunes gradually travel towards the north. Harbours formed in this way are Saldanha Bay, Angra Pequena, Sandwich Harbour, Walfish Bay, Tiger Bay and Lobito Bay.

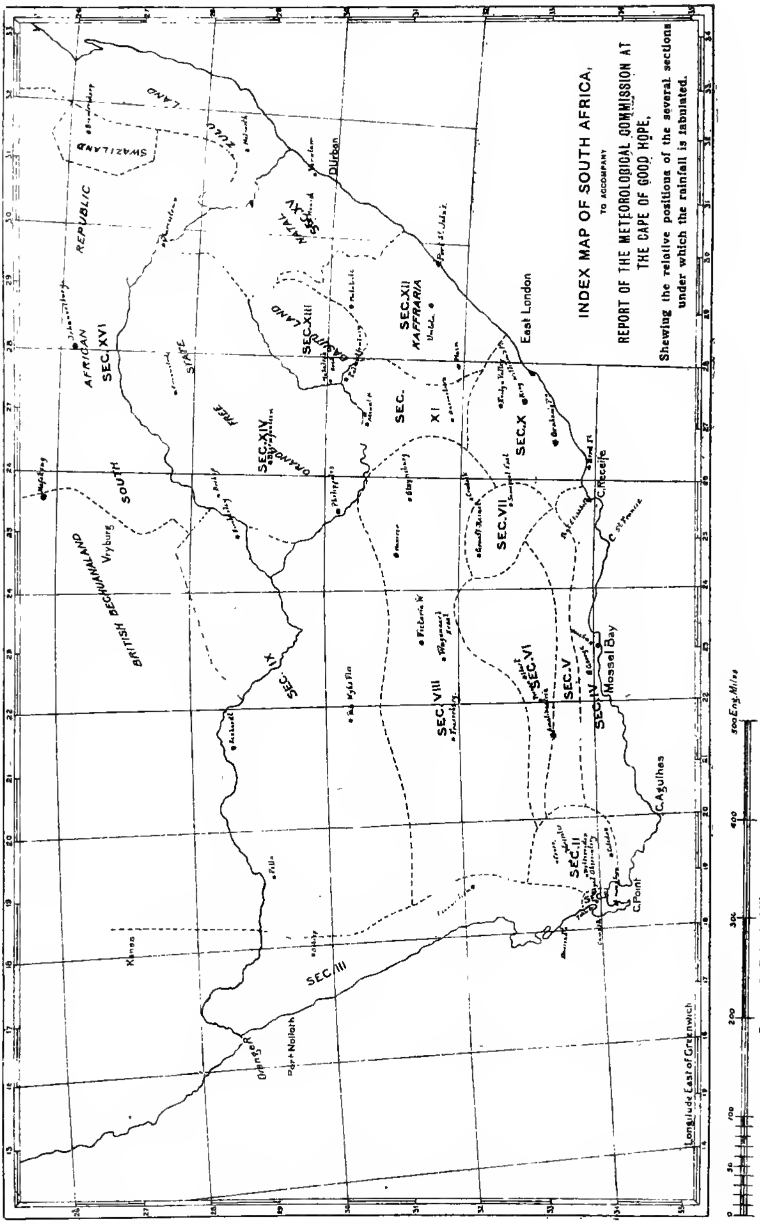
2. THE METEOROLOGY OF SOUTH AFRICA.

By Charles M. Stewart, B.Sc., Secretary, Meteorological Commission, Cape Colony.

The African Continent extends, roughly, from 35° N. to 35° S. Lat., and is the only continent crossed by both the Tropic of Capricorn and the Tropic of Cancer; consequently in traversing the continent from north to south one would pass through a diversity of climates ranging from the hot, moist, equatorial through tropical to the mild, dry sub-tropical. Owing to its peculiar pear shape only about one-third of the total land-surface is situated in the Southern Hemisphere. The object of the following article is to give as accurate an idea as possible of the general principles, so far as they have been investigated, which go to determine the climatic conditions prevailing over that portion of this sub-continent generally known as South Africa. This may be regarded as extending from the valley of the Zambesi in about 15° S. Lat., to Cape L'Agulhas in about 35° S., and as lying between the longitudes of Walfish Bay (14½°) to 33° E., or about 2° further east than Durban. The area indicated includes the Cape Colony, Basutoland, Orange River Colony, Transvaal with Swaziland, Natal with Zululand, Bechuanaland, Rhodesia and German South-West Africa.

The chief materials used in the preparation of the data employed in the discussion of this subject were: The Reports of the Meteorological Commission for the ten years 1891–1900; the Reports of the Government Astronomer, Natal, 1894–1903; and the Appendices ("Meteorology") to the Report on the Administration of Rhodesia, 1900–1903. An abstract of the results is given in tabular form at the end. In the case of those stations whose records are incomplete for this period, an attempt has been made to obtain the averages for a period of consecutive ten years either by falling back on earlier records or by making use of those from 1901 to 1904.

Wherever possible the preference has been given to the period 1891–1900, but in some instances it has been necessary to make use of the observations of earlier or of later years in order to obtain a ten years' average; in several cases it has been necessary to be satisfied with a much shorter period.


INDEX MAP OF SOUTH AFRICA,
TO ACCOMPANY
REPORT OF THE METEOROLOGICAL COMMISSION AT THE CAPE OF GOOD HOPE,
Shewing the relative positions of the several sections under which the rainfall is tabulated.
SWAZILAND
ZULU LAND
REPUBLIC
AFRICAN
SOUTH
SEC. XVI
Durban
NATAL
SEC. XV
SEC. XII
KAFFRARIA
SEC. XIII
East London
FREE
STATE
SEC. XIV
ORANGE
SEC. XI
SEC. X
SEC. VII
C. Receife
C. St Francis
BRITISH BECHUANALAND
Vryburg
SEC. IX
SEC. VIII
SEC. VI
SEC. V
SEC. IV
Mossel Bay
C. Agulhas
SEC. II
SEC. I
C. Point
SEC. III
Port Nolloth
Orange R.
Longitude East of Greenwich
Scale of British Miles

Physical Features.—As the climate of a country as a whole is dependent, to a considerable extent, on its physical configuration, it is advisable to give here a brief description of the *relief* of the land-surface of South Africa.

Taken as a whole, South Africa may be regarded as consisting of a series of four elevated plains or plateaux, separated from each other by steep escarpments which rise to a considerable elevation above the plains themselves, and appear, when viewed from the coast sides, as a series of high mountain ranges running roughly parallel with the coast. This division into plateaux is most distinctly marked on the southern side of the sub-continent, but is not so well defined in the west, where the slopes are more gradual, or in the east where the plateaux partake more of the character of mere terraces; these plateaux have been named as follows:—

1. The Coast Plateau, or Coast Flats, having an average elevation of 500–600 feet, and varying considerably in width, from about thirty miles in German South-West Africa to three or four miles or even less in the south-east of the Cape Colony.
2. The Southern or Little Karoo, a narrow tableland about fifteen miles in width and of an average elevation of 1,500 feet; it is separated from the low coast area of the south by the Langebergen and Outeniqua mountain ranges.
3. The Central or Great Karoo, having an average elevation of between 2,000 and 3,000 feet, bounded on the west by the Cedarberg and Bokkeveld and on the south by the Witteberg, Zwartberg and Zuurberg ranges.
4. The Northern Karoo or High Veld is the innermost plateau, comprising the remainder of the Cape Colony the Orange River Colony and the Transvaal. It is bounded on the south by the Klein Roggeveld, Nieuweveld, Winterberg, Stormberg and Drakensberg ranges. This plain has an average elevation of about 4,000 feet, rising in the eastern portions to 6,000 feet, and forms the main watershed of the country. From the Drakensberg the land slopes northwards and westwards towards the Orange River and the Limpopo, decreasing gradually to an elevation of less than 3,000 feet, but rising again to over 4,000 feet in the Damara-Namaqua Plateau of German South-West Africa and the Mashona-Matabele Plateau of Rhodesia.

It will thus be seen that by far the greater portion of South Africa has an elevation of over 3,000 feet, whilst the area below 1,500 feet forms merely a narrow fringe around the coast.

Divisions.—For the sake of convenience of reference the four plateaux mentioned have been sub-divided into twenty-one sections, according to the plan originally suggested by the late Mr. J. G.

Gamble, Hydraulic Engineer to the Cape Colony. This sub-division is evidently a compromise between the natural physical features and the political divisions obtaining in South Africa, but presents, on the whole, a fairly truthful picture of the various climatic regions of the country. These sections are as follows :—

(1) Cape Peninsula, (2) South-West, (3) West Coast, (4) South Coast, (5) Southern Karoo, (6) West-Central Karoo, (7) East-Central Karoo, (8) Northern Karoo, (9) Northern Border, (10) South-East, (11) North-East, (12) Kaffraria, (13) Basutoland, (14) Orange River Colony, (15) Natal, (16) Transvaal, (17) Bechuanaland, (18) Rhodesia, (19) Damaraland, (20) Swaziland, (21) Zululand. (A key map to these divisions is inserted on page 20.)

Method adopted in Article.—This article may be said to consist of two parts :—

1. The body of the actual text is devoted entirely to a general consideration of the factors which determine the character of the South African climate as a whole.

Although the exigencies of space forbid a detailed description of the climates of the 21 Divisions enumerated above, an attempt has been made in Part II. to extend the scope of the article so as to afford at least some idea of the climatic characteristics of the various parts of South Africa. The method adopted has been to calculate the mean monthly rainfall over each division, mostly for a ten-year period, and to present the results in tabular and diagrammatic form. With regard to temperature, however, it has been considered preferable to select merely one station typical of each area for the purpose of illustration, the mean maximum, minimum and monthly temperature being represented diagrammatically alongside the rainfall of the same district. Some of the data on which these are based are also given in the form of a table.

Part I. Climate—General.

Temperature.—Regarded from the standpoint of temperature alone, one of the most striking features is a remarkable uniformity in the mean annual temperature exhibited by many out of the hundred stations for which the mean monthly temperatures have been calculated. Thus stations as wide apart and occupying such entirely different positions, as regards latitude, as the Royal Observatory (Lat. 33° 56′ S., Long. 18° 29′ E.) in the Cape Peninsula, Cape L'Agulhas (Lat. 34° 50′ S., Long. 20° 1′ E.) on the south coast, Cradock (Lat. 32° 11′ S., Long. 25° 38′ E.) in the Great Karoo, Matatiele (Lat. 30° 15′ S., Long. 28° 46′ E.) in Kaffraria, Bloemfontein (Lat. 29° 7′ S., Long. 26° 13′ E.) in the Orange River Colony, and Johannesburg (Lat. 26° 12 S, Long. 28° 2′ E.) at almost the highest altitude of the High Veld, all possess practically the same mean annual temperature of 62° Fahr. This equality of mean temperature is mainly due to decrease of temperature with increase of elevation above sea-level almost exactly neutralising the increase of temperature which would otherwise occur with the increased intensity of solar radiation due to a nearer approach to the Equator. When, however, we come to examine the mean maximum and minimum temperatures from which the annual mean temperature has been derived we are at once struck by the enormous differences which exist in the mean daily range—at a coast station like Cape L'Agulhas where it amounts to only 10.4°, and at an inland station like Bloemfontein with its 25.7°, or Matatiele with its 33.6°, which is more than treble that at the first-mentioned place. A further perusal of the temperature tables shows that the two coldest stations are the mountain station at Disa Head (Table Mountain) in the Cape Peninsula with a mean annual temperature of 54.7°, at an elevation of 2,500, and Kilrush in Kaffraria with 54.8° at an approximate elevation of 6,850 feet; while the two warmest stations are Tuli in Rhodesia on the Shashi River, a tributary of the Limpopo, with a mean annual temperature of 72.4°, at an elevation of 1,750 feet, and Verulam, in hilly country about nineteen miles north of Durban (Natal), and about seven miles from the coast with a mean of 71.8°. There is therefore a mean difference of 17.7° between the coolest and the warmest stations known in South Africa. Within the Cape Colony itself the warmest station seems to be Port St. John's with a mean annual temperature of 66.9°, Kenhardt coming next with a mean of 66.2°, Clanwilliam being third with 65.4°. Between the first and the last two, however, there is a considerable difference in the range of temperature—the mean maximum at Port St. John's being only 75.7° as against 81.6° at Kenhardt and 80.5° at Clanwilliam, while the mean minima are 58°, 50.5° and 50°, giving mean diurnal ranges of 17.7°, 31.1° and 30.5° respectively. The first occupies a coastal position, the second a continental situation, while the third is situated in a valley about thirty miles from the nearest coast. It will thus be seen that Clanwilliam,which has been termed the "cauldron of the Cape Colony" must give place to Kenhardt in this respect.

Although the examples already given seem to indicate a most irregular distribution of temperature, a more careful examination of the data available shows that there is an increase of temperature from west to east along the parallels of latitude, and that further there is an increase of temperature from north to south along the west coast, from west to east along the south coast, and from south to north along the east coast. Thus, starting from the west coast and crossing the country about the twenty-ninth parallel, we find Port Nolloth with a mean temperature of 57.5°; O'okiep, about 50 miles inland, with 63.0°; Kimberley, about 500 miles in the interior, with 64.8°; and Durban, on the east coast, with a mean of 70.8—an average rate of increase of about one degree (1° F.) for each degree of longitude. Again, Mouillé Point on the south shore of Table Bay, has an annual mean temperature of 62.6°, being 5.1° warmer than Port Nolloth, an increase of a little over 1° F. for each degree of latitude; while Simon's Town, on the shores of False Bay, has a yearly mean temperature of 64.7°, giving an increased rate of rise of temperature southwards of about 1.5° for each degree of latitude. Again, in passing eastwards along the south coast from Cape L'Agulhas (61.5°) to East London (64.8°), the rate of increase of temperature eastwards is reduced to 0.4° per degree of longitude; while between East London and Durban the rate northwards is again increased to about 1.5° per degree of latitude.

Ocean Currents.—As directly opposite conditions obtain along the west and east coasts it is evident that there must be some controlling factor exercising a depressing effect on temperature on one side of the continent, and an elevating tendency on the other. In seeking for at least a partial explanation of these widely divergent results, attention is at once drawn to the fact that a warm ocean current, part of the equatorial surface-drift, washes the shores of Natal and of the south of Cape Colony, at least as far west as Cape L'Agulhas. This current is known as the Mozambique Current in the east, and as the Agulhas Current in the South of the Cape. On the other hand, the western shores of the Cape Colony are subjected to the cooling influence of the cold Benguela Current, usually considered part of the Antarctic Drift but, as pointed out by Hahn, in his book on Climatology, much more likely the effect of the up-welling of the colder and deeper waters under the influence of the prevailing winds.

The mean annual temperature, based on an average of all the stations, is 62.8° F., practically the same as Sydney, New South Wales, and about the same as that of the summer months in London. The mean maximum temperature amounts to 75.0°, and the mean minimum to 50.5°, giving a mean daily range of 24.5°. This last oscillates between the maximum of 26.6° in July, and the minimum of 22.9° in March. When comparing the curves of mean temperatures shown in Fig. I.b, with those for any European or other station in the Northern Hemisphere, it is necessary to bear in mind that the seasons in the Southern Hemisphere are the reverse of those north of the Equator, the three warmest months, December—January, corresponding to the European summer months of June—August; whilst the three months of the latter period are the coldest in the southern Hemisphere. It must further be remembered that during the southern summer, the earth is in its nearest position to the sun (in perihelion); its motion is then more rapid than when it is at its furthest distance from the sun (aphelion), so that the southern summer is shorter than that of the Northern Hemisphere by about eight days. The shorter duration is, however, counterbalanced by the greater intensity of the sun's rays.

On examining the mean monthly temperature curve in Fig. I.b, it will be seen that the warmest month is February, with an average of 71.4°, after which the temperature falls to the minimum of 53.4° in July—most rapidly from April to June; from the minimum it rises much more slowly to the maximum in February. The maximum temperature curve is at its highest (83.6°) in February, and falls to its lowest point (66.3°) in June, to rise again to the maximum in February. The minimum curve is also at its highest (59.1°) in February, but continues to fall till July, when it averages 40.0°, after which it rises to its maximum in February.

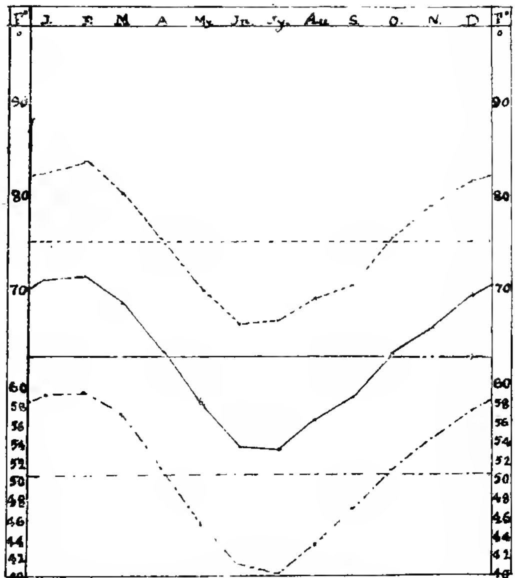


Fig. Ib.—Temperature:—Average Maximum, Minimum and Mean values for S. Africa deduced from 97 Stations. (Max.----- Min.-·-·- Mean———)

This marked divergence of the maximum and minimum curves in July (the day temperatures rising whilst the night temperatures continue to fall) is one of the most interesting points in connection with the meteorology of South Africa, being apparently connected with a peculiar "cold wave" affecting the whole of the country about the middle of the month, and attaining its greatest intensity on the 16th to 17th of the month.* Another striking feature is the peculiar flattening of

* On the relations of Temperature and Pressure in South Africa, *vide* an extremely interesting paper on "Some Temperature and Pressure Results for the Great Plateau of South Africa," by J. R. Sutton, M.A. (*Transactions of the Philosophical Society of South Africa.* Vol. XI., Pt. IV. pp. 243-318.)

the maximum (and consequently of the mean) curve in the month of September, with the subsequent rapid rise in October; this seems to be in part due to, or at least is coincident with a marked increase in the steepness of the cloud curve, which rises from 34 per cent. in August to 38.6 per cent. in September.

The extremes of temperature that have so far been recorded in South Africa appear to be the exceptionally high maximum of 125.0° recorded at Main during the prevalence of a hot wind on January 28th 1903, and the extraordinarily low minimum of 6.0° Fahr. registered at Palmietfontein in June, 1902, after the severe blizzard that occurred over a large part of South Africa from the 9th to the 12th of that month.*

Frost.—Although severe frosts capable of freezing standing water are practically unknown over the coastal districts, the phenomenon of hoar-frost is by no means uncommon, having been occasionally observed during severe winters at the Royal Observatory and Sea Point in the Cape Peninsula. It is, otherwise, however, at those stations inside the coast ranges of mountains where frosts of great severity are of almost daily occurrence during winter. The frozen water is frequently described as "black ice," occurring on pools, etc., exposed to nocturnal radiation, but usually disappears under the heating action of the sun's rays in the course of the day, to be formed again during the night. Statistics bearing on this phenomenon have been investigated for only one station in South Africa, viz., Colonies Plaats in the Division of Graaff-Reinet, in the eastern portion of the Great Karoo, at an elevation of 4,750 feet. An excellent weather diary was kept here from March, 1883, to December, 1902, by the proprietor of the farm, Mr. C. J. Watermeyer. This gentleman, although unprovided with any meteorological instruments except a rain guage, appears to have taken a deep interest in all matters affecting agriculture, and his data may be taken as fairly accurate and representative of a goodly portion of the more elevated parts of the Cape Colony. An examination of his diary shows that during the nineteen years and ten months in which his record was kept, there is no month throughout the year in which frosts are not liable to occur. The actual number of times of their occurrence during this period are given in tabular form below:—

"Total number of frosts observed at Colonies Plaats, Lat. 31° 59′ S., Long. 24° 57′ E.; height, 4,750 feet above sea-level; from March, 1883—December, 1902.

Jan.	Feb.	Mar	Ap.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
5	5	27	91	201	263	341	227	134	66	29	2	1,391

* *Vide* "The Blizzard of June 9th - 12th, 1902." By C. M. Stewart *Report of the S.A. Association for the Advancement of Science for* 1904.

These results agree remarkably well with a temperature curve of any station in the Karoo, the maximum number occurring in July, the coldest month of the year; moreover, their occurrence is in very close agreement with the mean daily barometric pressure curve at the Royal Observatory* for the ten years, 1891–1900, from which it is seen that they are most liable to occur the morning after a crest of high pressure has appeared over the Cape Peninsula. They have been observed during the summer months between the 18th December and the 21st of February, but may reasonably be expected to occur between the 27th of April and the 18th September. The above table yields an average of sixty-seven frosty mornings throughout the year.

Rainfall.—After temperature, the most important factor in determining the climate of a country is the distribution of moisture, more particularly of rainfall, in regard to quantity, time and place. On taking the average of the 278 stations given in Buchan's "Rainfall of South Africa," it appears that the mean annual rainfall for the years 1885–1894 was 23.79 inches, or about the same as Wagga Wagga in New South Wales, and about an inch less than Inverness in the North of Scotland. On inspecting Fig. I., which gives the monthly distribution throughout the year it will be seen that the rainfall curve is at its maximum in March, the beginning of autumn, when 11.3 per cent. (2.69 inches) of the total falls; the monthly quantities then decrease gradually to the minimum of 5.5 per cent. (1.32 inch) in July. From August the curve gradually rises to a secondary maximum of 10.1 per cent. (2.41 inches) in November, to fall again slightly in December, after which it rises to the primary maximum. (The apparent dip in the curve in February is only apparent and not real, being due to the month having only 28 to 29 days as against the 31 in January and March). The greater part of the rainfall occurs during the six warmest months, October to March, when 59 per cent., or about two-thirds of the total falls.

Fig. I.—Rainfall— Average Monthly Distribution over S. Africa.

On calculating the percentage quantity of rainfall during the six warmest months, October to March, and during the six coolest months, April to September, at all stations, Mr. A. Struben found† that South Africa could be conveniently divided into three distinct areas according to the percentage distribution of the rainfall falling during the two above-mentioned periods.

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* Report of the Meteorological Commission for 1903.

† *Vide* "Report of the Meteorological Commission for the year 1897." G.76—98.

He accordingly sub-divided the country into the following three regions. *

(1) *Summer Rainfall Area* having over 50 per cent. of the total rainfall from October to March.

(2) *Winter Rainfall Area* having over 50 per cent. of the total rainfall from April to September.

(3) *Constant Rainfall Area* having the rainfall equally divided between these two periods.

The region of constant rainfall is confined to a comparatively small area on the south coast, extending from a point some distance east of Mossel Bay to Humansdorp, and stretching inland to the neighbourhood of Uniondale.

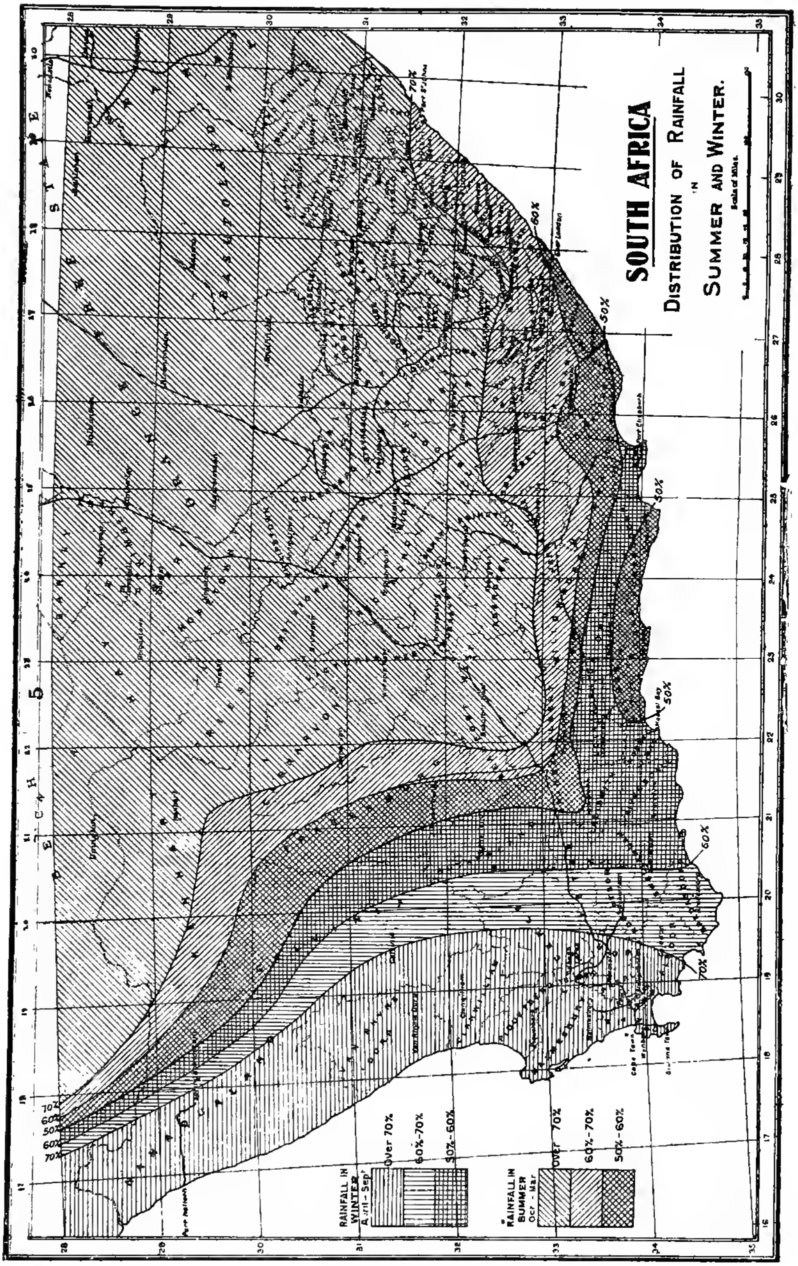
It will be seen from the "Seasonal Rainfall" Map that the dividing line of 50 per cent. separating the summer and winter rainfall areas, starts on the 28th parallel about 17° 40′ E. Longitude, † passes in a sweeping curve (at first convex, then concave, to the west coast), in a general S.S.E. direction to the neighbourhood of Ladismith (Lat. 33° 29′ S., Long. 21° 17′ East), whence it turns in a direction a little south of east to reach the coast about Port Alfred (Lat. 33° 34′ S., Long. 26° 54′ E.). All the land to the north and east of this line belongs to the summer rainfall area, and all to the south and west to the winter rainfall area, with the exception of the area of constant rains already noted.

It must not be forgotten that the above sub-division of the country into three rainfall areas is based upon the relative quantity of precipitation, and has no reference to the absolute quantity which varies considerably over South Africa.

As far as has been ascertained up to the present, the wettest station in South Africa is at Maclear's Beacon (at an elevation of 3,478 feet) about 100 yards down the lee side of the summit of Table Mountain, where the average annual fall of the seven years, 1894–1900, was 86.81 inches, varying between 105.85 inches in 1899 and 69.14 inches in 1900. The driest station seems to be Walfish Bay, where a ten years' average yields the extremely small annual fall of 0.31 inch. As the yearly rainfall of the rest of the country must oscillate between these two extremes, it is obvious that there is considerable room for variation in this important meteorological element which is regarded by some as the chief factor in determining the climates of the different parts of South Africa. The sub-division of the country into the twenty-one areas already mentioned,

* See, however, "An Introduction to the Study of South African Rainfall," by J. R. Sutton, B.A. Trans. S. A. Phil. Soc. Vol. XV., Part I. pp. 1-28.

† If the map were made to include the coast-line of German South West Africa, and the lines extended accordingly, it would be probably found that the 50% line would emerge on the West Coast about the 25th parallel 2° S. of Walfish Bay.


SOUTH AFRICA
Distribution of Rainfall in Summer and Winter.
RAINFALL IN WINTER April-Sept
Over 70%
60%-70%
50%-60%
RAINFALL IN SUMMER Oct-Mar
Over 70%
60%-70%
50%-60%

is based partly on the average rainfall over these districts, which shows considerable variation in quantity. Thus, the wettest districts, so far as the averages calculated enable us to state, are Zululand, with an annual mean rainfall of 39.66 inches, the Cape Peninsula being next with a mean of 38.24 inches for the ten years, 1891–1900. The two driest districts are the West Coast with a mean annual rainfall of 9.91 inches, and the West Central Karoo with 9.96 inches. It is therefore apparent that the driest areas have a rainfall of about only one-quarter that of the wettest areas.

Equally great, if not much greater, contrasts are met with in comparing the rainfall at places within a few miles of each other. Thus the South African College (Cape Town), close in to the south-east side of Signal Hill has an average of 29.77 inches, while Platteklip, about 1½ miles to the south-east, also in the Cape Town valley, on the lower slopes of Table Mountain, has an average yearly total of 42.41 inches, or almost half as much again; while Bishop's Court, also in the Cape Peninsula, about 4 miles from Cape Town has a mean annual fall of 55.22 inches. Again, at George, on the south coast, the average yearly rainfall is 31.04 inches, while Ezeljagt, about 9 miles to the north-east in the Lange Kloof on the north side of the Outeniqua Mountains, receives only an average of 13.30 inches per annum. Again, the village of Balfour, at an elevation of 2,100 feet, has an average of 28.96 inches, while the Plantation on the top of the Katberg (3,380 feet) about 4 miles distant, has an average of 43.27 inches. Evelyn Valley, at an elevation of 4,200 feet, with its average of 58.95 inches, is apparently the wettest station in the eastern half of South Africa, having a rainfall almost treble that at Thomas River Station, with 22.64 inches, situated about 20 miles further North.

Although the rate of fall of the rains is chiefly light to moderate, with occasional heavy falls, some exceptionally heavy rains in a short period have been noted, which were almost tropical in character. Thus, on the 2nd September, 1897, a total of 9.40 inches was recorded at Port Alfred between 8 a.m. and 11.30 p.m. (15½ hours in all), causing considerable damage to the railway line, gardens, etc.; at N'kandhla in Zululand 6.82 inches fell on one day in January, 1898; 4.50 inches at Newlands in May, 1899; 6.29 inches at Grootvader's Bosch, 11th August, 1900, between 9·10 a.m. and 4 p.m.; 4.58 inches at Gwelo (Rhodesia) in December, 1901; 9.25 inches at Flagstaff (Kaffraria) in 22 hours on the 11th and 12th June, 1902; and 8.60 inches at Port St. John's in 23 hours on the same dates; 7.74 inches fell at Van Staaden's River (near Port Elizabeth) between 12th and 13th November, 1903; 6.08 inches were registered on the 26th October, 1904, at Blaauwkrantz in the Knysna Division; while more recently the largest fall was recorded at Vogel Vlei (near Mossel Bay) where the enormous quantity of 10.37 inches was measured off on the 9th April, 1905, having fallen in the 14 hours between 8 a.m. and 10 p.m.

An examination of the maps in Dr. Buchan's "Rainfall of South Africa" shows that the mean annual rainfall decreases in a general way from east to west and from south to north.

The question naturally arises, what are the conditions that bring about such a distribution, and what are the factors that admit of the country being sub-divided into the three areas of Summer, Winter and Constant Rains?

Thunderstorms.—A comparison of the Thunderstorm Frequency Curve shown in Fig. I.A with that of the Average Rainfall Curve (Fig. I.) for South Africa, shows that there is a general similarity in the trend of the curves with, however, some marked differences. Thus, while the rainfall curve is at its principal maximum in March, and falls to the minimum in July to rise to the secondary maximum in November, the Thunderstorm Curve is throughout a month in advance of the former, being at its principal maximum in February, when, speaking generally, the temperature over the land is greatest, and reaches its minimum in June, to rise to a secondary maximum in October. It would, therefore, appear that although a considerable proportion of the summer rains undoubtedly falls in connection with these storms, due in many cases to mere local temperature disturbances, there must be some other cause giving rise to the heavy rainfall of March and November,* or at least reinforcing the precipitation caused by thunderstorms. It may be possible that the increasing dampness of the ground increases the humidity of the atmosphere by its subsequent evaporation, and thus by increasing the conductivity of the atmosphere, enable subsequent storms to part with their moisture without an accompanying disruptive discharge of electricity.

Fig. I.A.— Thunderstorms.— Percentage Frequency (1897-1903)

Rain-bearing Winds.—As all the moisture deposited over a land-surface must be derived originally from the sea, the question naturally arises, What are the principal rain-bearing winds of South Africa? As a considerable amount of controversy† has raged round this point, it seemed desirable to have some reliable data to work on before attempting to pass any opinion. In order to answer, at least partially, this question the records of three anemometers, stationed respectively at the Royal Observatory, Port Elizabeth and East London, were examined for the months of January, June and October of 1904, and the resulting percentage wind-frequencies are given in Table B (see also Plates I., II. and III.).‡

**Vide* "A Discussion of the Rainfall of South Africa during the 10 years, 1885-94. By Alexander Buchan, M.A., LL.D., F.R.S.E." (Cape Town, A. 1-98.)

† *Vide* "Nature" for the early months of 1905.

‡ The deflecting influence of the land is very apparent in these diagrams.

Table B.—Percentage Relative Wind-Frequency.

1904.	January.			June.			October.		
Direction.	Royal Observatory.	Port Elizabeth.	East London.	Royal Observatory.	Port Elizabeth.	East London.	Royal Observatory.	Port Elizabeth.	East London.
	%	%	%	%	%	%	%	%	%
North ...	1·3	0·1	2·6	10·9	7·7	4·7	2·8	1·6	2·3
N.N.E. ...	...	1·1	5·8	1·4	3·4	5·3	...	0·7	8·5
N.E. ...	...	0·8	**14·8**	0·3	2·2	3·6	...	0·9	**18·4**
E.N.E. ...	...	2·8	12·4	0·1	2·6	2·1	...	5·5	5·1
East ...	0·3	12·9	6·0	...	2·3	0·6	0·1	10·5	3·4
E.S.E. ...	1·1	**18·0**	4·2	...	0·3	...	...	7·1	2·6
S.E. ...	0·9	7·4	1·9	1·2	...	...	2·4	1·6	1·5
S.S.E. ...	10·3	4·4	0·9	4·7	...	0·3	12·6	2·4	0·9
South ...	**35·1**	3·6	2·2	10·5	0·5	0·7	**25·4**	2·6	2·7
S.S.W. ...	19·3	5·2	5·8	5·5	1·4	2·8	10·6	8·1	7·4
S.W. ...	2·7	5·1	13·4	1·6	3·9	9·0	0·1	13·7	12·2
W.S.W. ...	0·4	16·5	11·9	1·4	15·0	14·0	0·1	**24·3**	11·7
West ...	1·6	16·1	9·9	4·6	**18·6**	14·2	2·3	8·6	12·9
W.N.W. ...	5·8	3·9	3·9	9·1	13·8	**17·5**	9·0	4·2	6·2
N.W. ...	8·3	...	0·5	12·1	5·6	15·7	13·8	2·0	3·0
N.N.W. ...	4·6	0·1	1·1	**22·4**	7·3	8·6	10·1	1·2	1·2
Calm ...	8·2	1·7	2·7	14·1	15·5	1·0	10·5	5·0	0·1
Average velocity, m. per hour	15·3	17·9	17·4	12·4	12·2	19·5	13·3	17·4	23·2

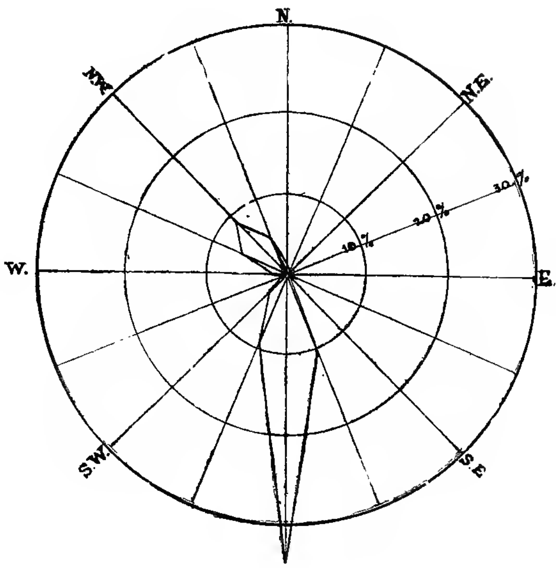
Table C.—Rainfall at Royal Observatory, Port Elizabeth, and East London during 1904.

	Jan.		Feb.		March.		April.		May.		June.	
	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.
Royal Observatory	0·34	4	0·09	2	0·40	7	5·93	16	3·37	14	6·55	17
Port Elizabeth (Lighthouse)	0·22	3	0·95	10	1·45	5	0·22	4	1·40	6	1·69	4
East London (West)	6·28	14	3·19	8	2·14	13	0·20	3	1·39	5	1·89	6

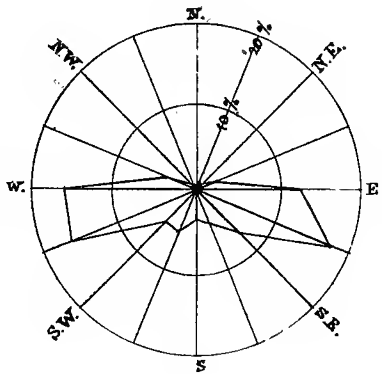
	July.		Aug.		Sept.		Oct.		Nov.		Dec.		Year.	
	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.
Royal Observatory	2·47	9	4·64	11	2·48	11	2·83	10	1·21	6	1·51	5	31·42	112
Port Elizabeth (Lighthouse)	2·41	7	4·51	7	1·69	8	4·78	11	1·37	8	1·26	7	21·95	80
East London (West)	1·17	7	0·78	3	3·16	8	2·04	12	0·49	4	3·57	10	26·30	93

Plate I.

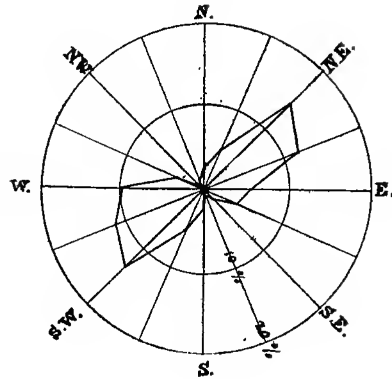
PERCENTAGE RELATIVE WIND-FREQUENCY,
during January, 1904.



Royal Observatory.– January 1904



Port Elizabeth, – January, 1904.

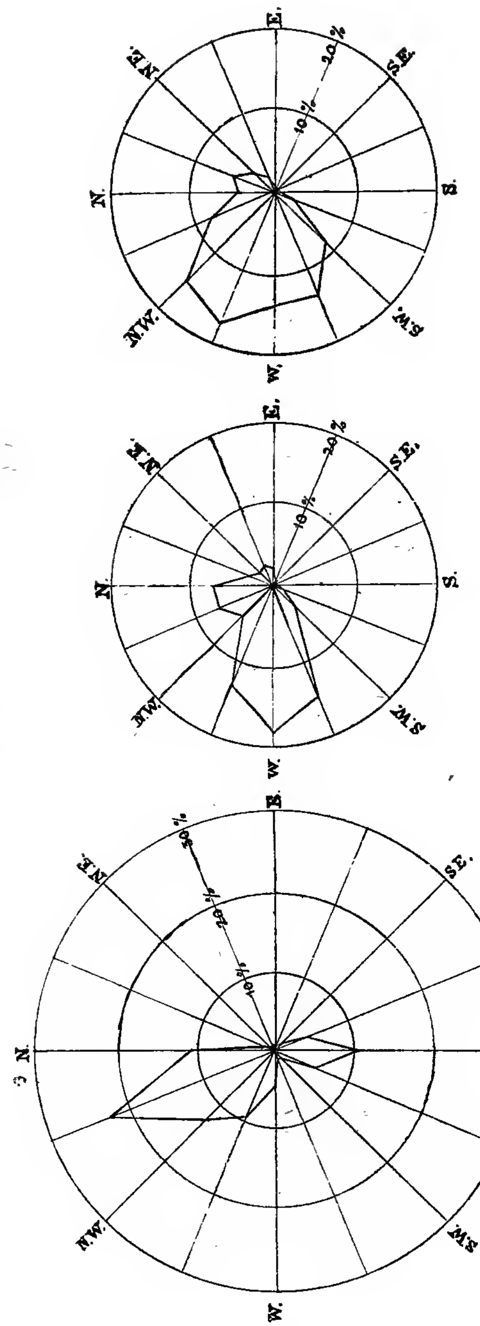


East London,– January, 1904.

Plate II.

PERCENTAGE RELATIVE WIND-FREQUENCY.

during June, 1904.



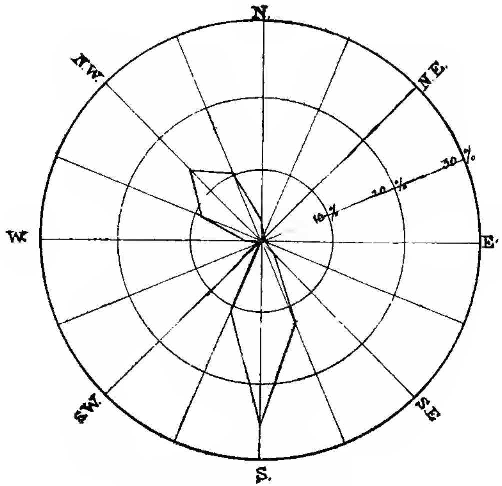
East London, - June, 1904.

Port Elizabeth, - June 1904.

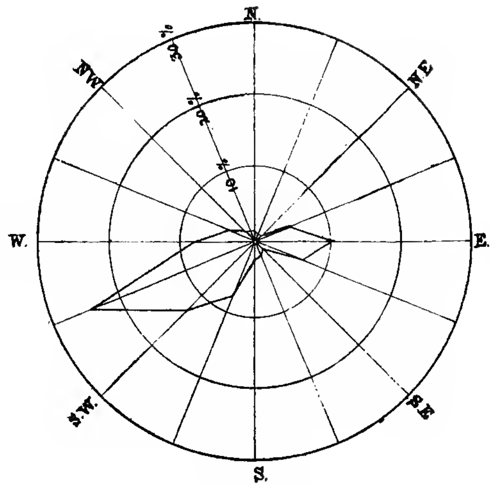
Royal Observatory, - June, 1904.

Plate III.

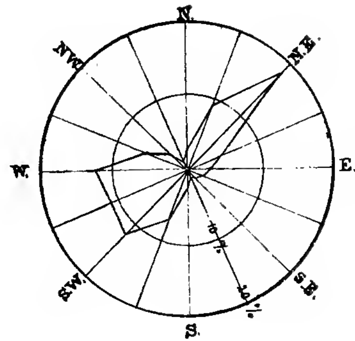
PERCENTAGE RELATIVE WIND-FREQUENCY,
during October, 1904.



Royal Observatory,– October, 1904.



Port Elizabeth – October, 1904.



East London,– October, 1904.

The reason for selecting these three months is that January was the wettest month at East London, June at the Royal Observatory, and October at Port Elizabeth, situated within the areas of summer, winter and constant rainfall respectively. Table C. gives the monthly rainfall, together with the number of days on which rain fell at these three stations during last year.

From Table B it is at once evident that during January the prevailing wind was south at the Royal Observatory, while at Port Elizabeth there was a slight excess of east-south-easterly winds over those from west-south-west and west, and at East London the north-east winds were 1.4 per cent in excess of those from the south-west. On comparing the rainfall of January, 1904, with the average for the same month during the ten years 1891–1900, it is found the Royal Observatory was 45 per cent. below, Port Elizabeth 86 per cent. below and East London 151 per cent. above the normals, and the number of "rain days" one day at Royal Observatory less, two days at Port Elizabeth less and five days at East London more than the average.

During June, however, the prevalent wind-direction was north-north-west at the Royal Observatory, west at Port Elizabeth, and west-north-west at East London. The rainfall during this month was 71 and 63 per cent. above the average at the Royal Observatory and East London respectively, and 16 per cent. below the average at Port Elziabeth. The "rain days" were four and three more than usual at Royal Observatory and East London, and one less at Port Elizabeth. During October the prevailing winds were south at the Royal Observatory, west-south-west at Port Elizabeth, and north-east at East London. The rainfall at these stations was 51 and 157 above the normal at Royal Observatory and Port Elizabeth, and 3 per cent. less at East London, the "rain days" being one, three and four more than the average at the Royal Observatory, Port Elizabeth and East London respectively.

It would, therefore, appear from the preceding that the principal rain-bearing winds are from the north-north-west at the Royal Observatory, from west-south-west at Port Elizabeth and from south-west and north-east at East London.

This conclusion is confirmed by an examination of the wind-directions during the days on which rain fell. Thus during January at East London the wind was north-easterly on five days and south-westerly on seven days, varied from south-west to north-east on one day, and was between south-east and east on one day only out of the fourteen wet days there. At the Royal Observatory the wind-direction was mainly between north-north-west and west on fifteen days and south-westerly on the other two, but veered to the south-west on seven days. At Port Elizabeth the wind was west-south-westerly on nine days, varied between east-north-east and north on one day and from south-south-east to south on one day only. Although this last was the day of the occurrence of the maximum fall for the month any importance which might be attached to this fact is discounted to a great extent owing to its being associated with a local thunderstorm.

These data are utterly at variance with the usually accepted statement that the south-east winds are the main source of precipitation during the summer months at the Cape, so that any theories based on such an assumption must be considerably modified so as to be in accordance with facts.

Again, Mr. Sutton has pointed out* that "a south-west wind brings more rain to Durban than any other direction, the next most important being the south." Again, referring to Kimberley, he states that "heavy thunderclouds mostly advance from the west or north-west. Other rain-clouds and lighter thunderstorms from somewhere between north-east and east." Referring to the rain-bearing winds, he further states that "the resultant direction is appreciably from north by east, practically nothing coming from any point having a south-westerly component."

The first part of this statement is confirmed by enquiries made by the writer during inspection visits along the southern districts of the Cape Colony.

Anemometric data are wanting for Rhodesia, but Mr. E. G. Ravenstein states, apparently on the authority of the observers at Hope Fountain, near Bulawayo, that "The general direction of the wind is south-east changing into south-west before rain."† The observers at Port Nolloth and O'okiep state that the rains come almost wholly from north or north-west.

In all these statements there is little to support the "south east rain" theory, while the anemometer records show that it is only when the winter north-westerly winds over the Cape Peninsula veer to the south-west—indicating the passage of a disturbance to the north-east—that rain may be expected at Port Elizabeth and East London. These facts seem to be capable of explaining the distribution of rainfall over South Africa without calling in the assistance of the idea of a prevalent moist south-east wind, which, as far as the coast stations are concerned at least, seems to have little actual foundation. It ought to be noted that in the only month in which the south-east wind was at all prevalent, viz., January at Port Elizabeth, the rainfall was 86 per cent. below the average at that station.

As the month of maximum rainfall over the various divisions seems to be closely connected with these wind-results, it is interesting to note that January was the wettest month in 1904 over the West Central, East Central and Northern Karoos, the Northern Border, the South-East, the North-East, Basutoland, the Orange River Colony and Rhodesia; February at Durban;

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* "An Introduction to the Study of South African Rainfall." *Trans. S.A. Phil. Soc.* Vol. XV. Part I.

† Climatological Observations at Colonial and Foreign Stations. I. Tropical Africa. By E. G. Ravenstein, F.R.G.S., F.R.Met. Soc. (Met. Office, London.)

March in Bechuanaland; June over the Cape Peninsula and the West Coast; August over the South-West; and October over the South Coast and the Southern Karoo. (This remark refers only to the divisions as a whole, and not to the individual stations in these divisions, among which there is an occasional divergence from this general statement—*e.g.*, at Kimberley, in the Northern Border, the month of maximum precipitation was February and not January.)

Bearing in mind the configuration of the country, the explanation of the distribution of rainfall seems to be that in the region of winter rains the north-westerly winds in passing from warmer to colder latitudes are compelled to part with the greater part of their moisture by the elevated ground forming the western boundary of the interior plateaux, and so pass over the greater part of the country as dry winds. It is important to remember that these north-west winds pass over the coldest part of the South Atlantic, and so, being themselves cooled, are unable to absorb any great quantity of moisture. They are therefore unable to continue as rain-bearing winds for any great distance inland, which helps to explain the comparatively small area affected by the "winter rains."

The region of "constant rains" seems to be watered mainly by the south-westerly winds in the rear of the depressions which pass over or skirt South Africa. These winds appear to form the main source also of the precipitation along the south-east and east coasts.

These south-westerly winds are drained of the greater part of their moisture by the coast ranges, so that they are able to deposit only a comparatively small quantity of their moisture over the Karoos.

Moreover, as they are advancing from higher to lower latitudes they become warmer and hence relatively drier; so that they can only be compelled to part with some of the remainder of their aqueous burden by being considerably cooled. This will take place only when they are subjected to adiabatic cooling by expansion on passing over the higher mountain ranges further inland.

The greater part of the interior of the area of "summer rains" would seem to owe its rainfall principally to the north-easterly winds which, coming from the warm, moist latitudes of the Indian Ocean and passing to higher and colder latitudes, are able to carry their moisture far south and further inland than can the south-westerly winds. The mountain ranges inside the Drakensberg and the other high mountain barriers in the east can have but little effect in causing precipitation from these north-easterly winds as they do not rise to any great elevation above the interior plateaux; moreover, as these winds must be gradually cooled on advancing towards the south they ought to be fairly moist even on reaching the ocean again after crossing the interior. Seeing that they must be adiabatically warmed by compression in descending from the high lands in the interior, it may be necessary for them to be still further cooled by expansion during ascension in such secondary disturbances as give rise to thunderstorms, etc., before they are capable of depositing moisture in the more inland and more southerly parts of Cape Colony. It is not improbable that they themselves thus help to give rise to the conditions necessary for the formation of these storms. This rainfall is, in all probability, further increased by occasional deposits from south-east winds and thunderstorms from the north-west, thus causing the distribution of rainfall shown on the maps in Buchan's "Rainfall of South Africa," already mentioned.

This leaves unexplained the south-west rain-bearing winds in Rhodesia, but as the data available are very incomplete it is inadvisable to attempt any explanation or theory of their action.

Judging from the sudden shifting in the direction of the winds (*e.g.*, from north-east to south-west) so frequently shown on the anemometer records at Port Elizabeth and East London and from other considerations it seems probable that the depressions which visit South Africa are most generally not fully developed cyclones but rather V-shaped depressions and wedges, whilst it is undoubtedly true, as stated by Mr. Howard and Mr. Sutton, that much of our rain falls in connection with "secondary depressions." Very rarely indeed does South Africa seem to lie in the track of the fully-developed cyclones which are supposed to be frequent further south, or of those which affect Mauritius. In fact, our types of barometric depressions appear to approximate more to those of Australia than to those of Europe.

Hail precipitation frequently assumes the form of *hail*, especially during the summer months, and almost invariably occurs in connection with thunderstorms. "True hail" is practically unknown along the coastal districts, but falls commonly in the interior, stripping trees of their leaves, destroying fruit, beating crops down to the ground, piercing sheet-iron roofs and occasionally killing sheep. Some hailstones at Graham's Town on the 27th October, 1903, were reported to weigh $5\frac{1}{2}$ ozs. Again, at Bolotwa, on the 27th December, 1903, a terrific hailstorm passed over the station from the north-north-west. On this occasion the largest stones measured $1\frac{7}{8}$ in. by $1\frac{1}{4}$ in., many being $1\frac{1}{2}$ in. Drift hail lay along the river, 3 feet thick in places, and lasted a week before melting. The paths usually followed by these storms have not been traced out yet.

Snow is of fairly common occurrence at those stations above 3,000 feet, where it may usually be expected three or four times in the course of the year. It is much more frequently seen on the mountains. As in the case of hail, it is a very rare occurrence for snow to fall near the coast, although the summits of the coastal mountain ranges are frequently covered in the course of the winter. Snow may be seen on the mountain tops from about the end of March to the end of September, but has been noticed as late as the 24th December, during a comparatively cold spell which is common about this date and produces the "Christmas rains" over the Cape Peninsula * The area over which snow fell during the blizzard of

* *Vide* "Report of the Meteorological Commission for 1903," Cape Town.

June 1902, extended from Hoachanas in German South-West Africa (Lat. 22° 30′ S., Long. 17° 6′ E.; height 5,315 feet) to the south coast of the Cape Colony.*

Berg Winds.—Another factor which considerably modifies the climates of the coast districts is to be found in the fairly frequent occurrence of hot, dry Föhn-like winds all along the coast from Walfish Bay to Durban. The disturbing effect of these "Berg winds," as they are termed, on the temperature curves is most marked in the winter months of April to September. These winds cause at times a practical inversion of the seasons, the maximum temperatures recorded during the winter months being frequently 30° or more, higher than in summer, while the mean temperature is also considerably raised. They may blow for only a few hours or may continue for two or three days, producing a feeling of great oppression, after which the wind changes its direction, bringing cool, cloudy weather and occasionally rain, greater part of the heat to their being warmed by compression in with a welcome feeling of relief. As these winds owe the passing from the elevated table-land in the interior to the low coast lands the direction from which they blow depends on the direction in which the mountain ranges extend. Thus they are easterly at Walfish Bay,† Port Nolloth, Van Rhyn's Dorp and Clanwilliam, northerly to north-westerly along the south coast (very seldom north-easterly) to Stutterheim,‡ and north-westerly at Durban.§ They mostly occur in narrow strips along the coast, with a high pressure in the interior, and some, at least, are closely associated with the occurrence of "Secondaries."

During the first nine months of the year 1900 there were altogether 41 days on which the hot east winds blew at Port Nolloth, distributed as follows:—April, 1; May, 6; June, 11; July, 12; August, 8; September, 3. These constituted the prevalent wind-direction during June, July and August. The south wind blew with the greatest frequency during the other six months. The effect of these east winds on the barometer, thermometer and wet bulb, together with their mean force and the mean percentage of cloud during their occurrence, as compared with the averages for each of the six months and for the whole period, are given in Table D:—

* "The Blizzard of June 9th-12th, 1902." Report of the *S. A. Assoc.* 1904.

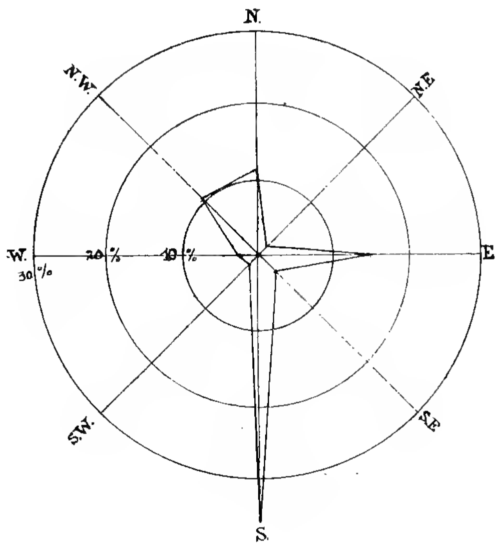
† "The Relation of the Sand-Dune Formation on the South-West Coast of Africa to the Local Wind Currents," by H. Carrington Wilmer (*Trans. of the S. A. Phil. Society*, Vol. V., Pt. II).

‡ "Report of the Meteorological Commission for the year 1901."

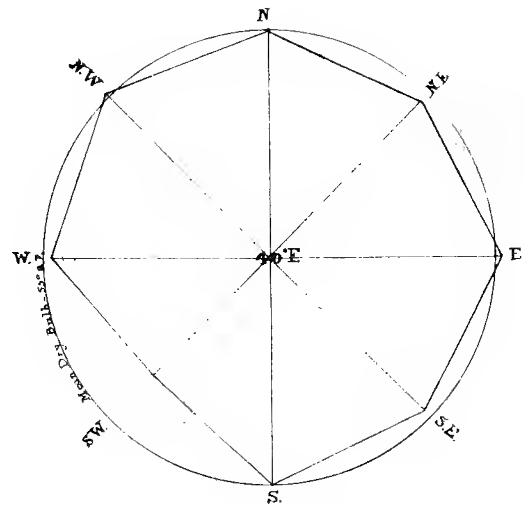
§ "Pressure and Temperature Results for the Great Plateau," by J. R. Sutton, M.A. (*Tans. of the S. A. Phil. Society*, Vol. XI. Pt. II).

Plate IV.

PORT NOLLOTH.— WIND-ROSES. *January – September, 1900.*



Port Nolloth. *Percentage Frequency.*
Jan.– Sept 1900.

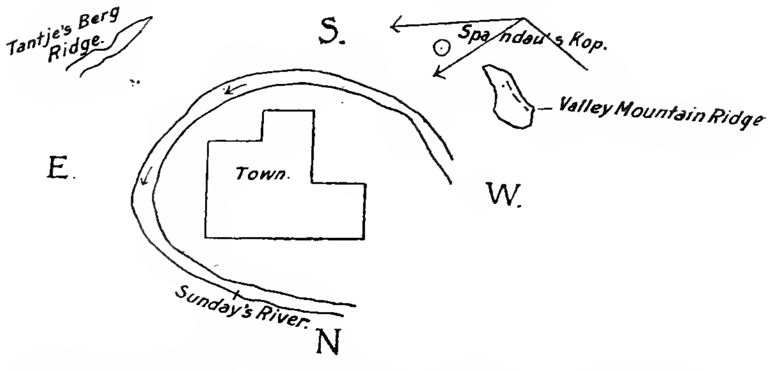


Port Nolloth – *Thermal Wind-Rose Jan.–Sept 1900*
(Note – The radius of the circle corresponds to the Mean Dry Bulb Temperature at 9 a.m. (55°F) for the nine months and is measured from a centre of 40°F.)

Year 1900.	Pressure.	Dry Bulb.	Depression of Wet Bulb.	Wind Force.	Cloud.
	in.		°		%
April	+0·059	+0·7	−0·3	−0·07	−22·0
May	+0·001	+1·4	+2·8	+0·44	−12·8
June	+0·025	+4·1	+3·7	+0·83	−22·8
July	+0·034	−1·5	−0·3	+0·10	−18·2
August	+0·067	+0·1	+0·7	+0·12	−34·3
September	+0·079	+12·8	+4·0	+1·20	−40·3
April–September ...	+0·056	+1·7	+2·1	+0·39	−20·3

From this it will be seen that during the prevalence of "Berg Winds" at Port Nolloth pressure was, on an average, 0·056 in. higher, the air-temperature was 1·7° warmer, the depression of the wet Bulb was 2·1° more, the wind force 0·39 greater and the sky 20·3 per cent. clearer than the corresponding averages for the period in question. (*Vide* Plate IV.)

Duststorms.—Undoubtedly the greatest drawback to the climate of South Africa is to be found in the frequent duststorms which are to be met with all over the country, from Cape Town to Bulawayo and especially in Johannesburg and Kimberley. According



to Sutton these storms herald the approach of the centre of a barometric disturbance, and are closely connected with thunder storms. They are most frequent at the end of Spring, during Summer and at the beginning of Autumn, when the interior of the country is affected by cyclonic disturbances. The fine dust rises as an enormous cloud almost blotting out the landscape, and penetrates everywhere. They seldom last for any length of time, and are usually followed by rain.

The following account of a duststorm at Graaff-Reinet on the 1st March, 1900, kindly furnished by Mr. W. A. Way, shows some peculiar features of considerable interest.

"At about 4·30 p.m. the wind, which had been a gale in the early part of the afternoon, had dropped considerably, but was still blowing from the north. About this time between Spaudau's Kop and the Valley Mountain a belt of low, threatening, blue-black rain-clouds had been gradually gathering.

"In a few minutes this blue-black colour gave place to, or rather was obscured by, a curtain of red dusty mist, of a brown, brick-dust colour. This gradually increased in density and came rolling down on to the town against the wind like a huge wave, in almost solid curves, throwing out huge, rolling feelers of dust before it, down the townside slopes of Spaudau and the Valley Mountain.

"Meanwhile a vast mass had disjointed itself from the main body and swept due west over to the Tantje's Berg range, which it enveloped before the main storm burst on the town.

"The temperature dropped nearly 10 degrees in a few minutes, but, curiously enough, the dust seemed thickest overhead and was not very dense immediately on the surface of the ground. It became very dark and a low rumbling was heard as the storm approached. There was no perceptible earthquake shock, as some people have imagined from this sound. The wind was bitterly cold, and threshed heavily through the trees, stripping off green leaves and blowing them along. The air was impregnated with dust, but the main body of dust rose above. This may have been due to the under-current of north wind meeting the south-west storm. Many of the older inhabitants were greatly alarmed. Dogs and birds were visibly uneasy. The wind, although violent, was not such as to root up trees.

"It had been raining in the town and district for the previous week or so, which made the appearance of the dust all the more remarkable. The storm lasted some half-an-hour to three-quarters of an hour, when thunder was heard and steady rain came on, which did not, however, last more than a few hours.

"The barometer had been falling steadily since the morning, but there was no sudden drop as is usual before the ordinary dust storm. At 8 a.m. the barometer read 27·5 ins.; by 4 p.m. it had fallen ·15 inch."

Cloud.—That there is good reason for the title of "Sunny South Africa" being applied to the sub-continent is shown by the comparatively small percentage of sky obscured throughout the year, the mean annual amount of cloud, based on observations at fifty-seven stations, being only 37·7 per cent. The mean annual amount of cloud varies considerably over the different divisions, oscillating between the maximum of 47·6 per cent. along the south coast, and the minimum of 24·5 per cent. in the northern border. Although at first thought there would seem to be reasonable grounds for supposing that the rainfall curve and the cloud curve ought to be practically identical, this supposition is not borne out by a comparison of their monthly averages. Thus while rainfall is at the maximum in March, the greatest amount of cloud (42·4 per cent.) occurs in October, the month previous to the secondary rainfall maximum in November, March and November being second with 2·2 per cent. less. The cloud curve falls from its primary maximum of 42·4 per cent. in October to a minimum of 39 per cent. in December; it rises to the secondary maximum (40.2 per cent.) in March, to fall to the principal minimum in July. The time of the occurrence of maximum cloudiness, however, varies considerably over the various sections. Thus, the cloudiest and wettest months are the same (viz., January) over the south-east and the north-east. February is the cloudiest month in the Northern Border and Rhodesia, being respectively one month before and one month after the time of maximum rainfalls. March is the month of greatest rainfall and of maximum cloudiness in the West Central Karoo and the Northern Karoo; it is also the cloudiest month in the Orange River Colony, two months later than that of heaviest rainfall. At Amalienstein, in the Southern Karoo, the greatest amount of cloud and of rainfall occur in April. June is the cloudiest month in the Cape Peninsula and over the West Coast, the heaviest rainfall over these divisions occurring in July and May respectively. September is the month of maximum cloud in the South-West, while the maximum amount of rain falls there in June. October is the cloudiest month over the South Coast, where it is one month in advance of, while over the Central Karoo it is two months behind the rainfall maximum. At Durban, October and November are equally cloudy, and the greatest amount of precipitation during the same period fell in the former month. Over Kaffraria the rainfall maximum in January is one month after the crest of the cloud wave. From these considerations it appears that there is little connection between the maximum of cloud and rainfall.

Generally speaking, July is both the clearest and the driest month of the year. The chief exceptions to this broad statement are the occurrence of both minima in January along the west coast, in February over the Cape Peninsula, and June at Durban.

The cloudiest station seems to be Cape L'Agulhas, the meeting point of the cold Antarctic and warm Mozambique currents, where the annual average of cloud is 64.8 per cent., the mountain station of Disa Head coming next with 58.3 per cent., owing to the frequent fogs and mists during both summer and winter. The clearest station is Springbokfontein in Namaqualand, with an av rage of 16.9 per cent., Wagenaar's Kraal being second with 20.1 per cent.

Sunshine.—Although all meteorological changes are primarily due to the heat radiated from the sun, mention of this most important climatic element has been left to the last, purely on account of the scarcity of measurements of its duration in the various parts of South Africa. Records of the duration of sunshine were first started at the Royal Observatory, in the west, in July, 1893, with a Campbell-Stokes instrument; similar records taken with Jordan twin semi-cylinder photographic instrument are available for Kimberley in the centre of the Colony, since January, 1898, and for Stutterheim, in the east, since January, 1900. The average daily duration of bright sunshine at each of these stations is given in Table E., all available data employed in the formation of the Table.

Station.	Years.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
		hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.
Royal Observatory	1893–1902	10·79	10·87	9·28	7·22	6·78	5·34	4·90	5·09	6·76	7·92	9·19	10·14	7·86
Kimberley	1898–1903	10·14	9·36	9·33	8·83	8·84	8·72	8·80	9·34	9·64	10·20	11·21	10·86	7·96
Stutterheim	1900–1903	6·79	6·98	6·56	6·20	6·00	5·52	5·92	7·00	7·48	7·44	6·72	6·71	6·61

As a matter of fact there are very few days indeed in the course of the year on which the sun is obscured all the time it is above the horizon. On the mean of the year the sunniest station is Kimberley, with a daily average of 7·96 hours, or about 80 per cent. of the total possible. The smallest average duration of sunshine is at Stutterheim, where it is only 6·61 hours per day, due partly to the Amatola Mountains cutting short the daily record before the sun has sunk below the horizon, but also largely to the greater percentage of cloud. The sunshine curve is practically the inverse of the cloud curve; thus the maximum percentage of sunshine at the Royal Observatory is 78 in February, with the minimum amount of cloud (26 per cent.); while at Kimberley the greatest proportion of sunshine (84 per cent.) occurs in June, the average amount f cloud at 8 a.m. being 21 per cent. The smallest proportion of sunshine (51 per cent.) at the Royal Observatory occurs in June, with an average cloudiness at 8 a.m. of 56 per cent., while at Kimberley the maximum amount of cloud (38 per cent.), and the minimum proportion of sunshine (71·7 per cent.) occur in February. As Kimberley is typical of a large proportion of the High Veld, these facts have an important bearing on the suitableness of the various stations ever this plateau as health resorts.

In the preceding paragraphs we have dwelt shortly upon all the most important factors which go to determine the climate of South Africa, with the exception of humidity, which has been purposely omitted, owing to the unreliable character of most of the Wet Bulb readings. These are taken only once a day, and so do not give an accurate idea of the average or of the daily variation of this important climatic element.

Part II.

Introduction.—In discussing the variations in mean annual temperature, it was pointed out that the mean coldest station was Disa Head, with an average of 54·7°, and the mean warmest station Fort Tuli, with a mean annual temperature of 72·4°. The former in Lat. 34° S., has an average about the same as Pavia and Boulogne in

45° N. Lat., while the latter (Tuli) in 22° S. Lat. has a mean temperature corresponding to that of Cairo in 30° N. Lat. It is therefore evident, that although South Africa, as a whole, has a much milder climate than stations in the same latitudes in the Northern Hemisphere (due principally to the comparatively small land area being cooled by the various oceans washing its shores), considerable variations in temperature are to be met with, producing a diversity of climates. This is further accentuated by the enormous differences in rainfall, which ranges from that of extremely arid to that of very moist regions.

Some idea of the nature of the variations in the climate over South Africa may be gathered from a perusal of the following Tables, and an inspection of the Diagrams of Divisional Rainfall and of the Temperature curves of the stations which have been chosen as representative of each Division.

TABLE I.—Average Divisional Rainfall.

Division.	Jan.		Feb.		Mar.		April.		May.		June.		July.		Aug.		Sep.		Oct.		Nov.		Dec.		Year.		Seasonal Distribution.	
	Amount.	No. of Rain Days.	Amount.	No. of Rain Days.	Amount.	No. of Rain Days.	Amount.	No. of Rain Days.	Amount.	No. of Rain Days.	Amount.	No. of Rain Days.	Amount.	No. of Rain Days.	Amount.	No. of Rain Days.	Amount.	No. of Rain Days.	Amount.	No. of Rain Days.	Amount.	No. of Rain Days.	Amount.	No. of Rain Days.	Amount.	No. of Rain Days.	Percentage Fall in Summer (Oct.-March).	Percentage Fall in Winter (April-Sept.)
																											%	%
I. Cape Peninsula ...	0·88	4	0·77	3	1·54	4	2·94	7	4·80	9	5·84	13	6·39	12	5·94	12	3·55	10	2·78	8	1·57	6	1·24	4	38·24	92	23	77
II. South-West ...	0·51	2	0·48	2	0·84	3	2·18	5	2·90	7	3·48	8	3·10	7	3·24	8	1·99	6	1·73	6	0·94	4	0·79	3	22·14	60	24	76
III. West Coast ...	0·14	1	0·28	1	0·46	2	1·01	4	1·51	5	1·44	6	1·50	5	1·44	5	0·74	4	0·80	4	0·32	2	0·27	1	9·91	40	23	77
IV. South Coast ...	2·14	7	1·68	6	2·06	7	2·28	6	2·36	6	2·18	6	1·41	5	2·16	6	2·26	7	2·26	8	2·57	7	1·93	7	25·29	78	50	50
V. Southern Karoo ...	0·98	3	0·71	2	1·30	4	1·23	3	0·99	4	0·90	3	0·64	3	0·85	3	0·83	3	0·91	4	1·10	3	0·51	2	10·95	37	52	48
VI West Central Karoo	1·35	3	0·96	3	1·53	4	0·88	3	0·85	3	0·54	2	0·31	2	0·48	2	0·53	2	0·62	2	1·04	2	0·87	3	9·96	31	64	36
VII. East Central Karoo	2·22	6	1·57	5	2·42	7	1·14	4	0·79	3	0·42	2	0·24	2	0·71	2	0·96	2	0·66	3	1·36	3	1·90	5	14·39	44	70	30
VIII. Northern Karoo ...	2·21	6	1·72	4	2·41	6	1·48	4	0·85	3	0·62	2	0·34	2	0·52	2	0·42	2	0·78	2	1·27	3	1·65	4	14·27	40	70	30
IX. Northern Border...	2·62	6	1·83	5	2·85	7	1·60	4	0·62	3	0·42	1	0·17	1	0·25	1	0·15	1	0·62	2	1·22	4	2·04	5	14·39	40	78	22
X. South-East ...	3·91	10	2·80	8	3·61	9	2·37	6	1·35	5	1·03	3	0·62	2	1·39	4	2·14	6	2·45	8	3·25	7	3·48	9	28·40	77	69	31
XI. North-East ...	4·50	10	3·05	7	4·00	10	1·94	6	1·02	4	0·88	3	0·56	2	1·17	3	0·99	3	1·51	4	2·52	6	3·75	8	25·89	66	75	25
XII. Kaffraria	4·56	12	3·52	9	4·02	10	2·08	6	1·10	4	0·79	2	0·52	2	1·22	4	2·05	5	2·64	8	3·31	8	4·36	11	30·17	81	74	26
XIII. Basutoland... ...	6·85	14	3·94	10	4·75	12	2·42	7	1·38	4	0·98	2	0·64	2	1·15	3	1·22	4	2·34	6	3·21	8	5·20	12	34·08	84	77	23
XIV. Orange River Colony	4·91	9	3·02	7	3·50	8	1·95	5	1·04	3	0·70	2	0·48	2	0·69	2	0·73	2	1·42	3	2·23	5	3·16	7	23·83	55	77	23
XV. Natal	5·15	16	4·04	11	4·69	14	2·56	9	1·05	5	0·58	3	0·33	3	1·09	5	2·18	8	3·40	13	3·90	14	5·12	16	34·09	117	77	23
XVI. Transvaal	6·48	15	4·59	10	4·04	6	1·34	7	0·90	3	0·21	1	0·12	1	0·48	2	0·93	3	1·86	8	4·07	11	4·66	13	29·68	80	87	13
XVII. Bechuanaland ...	6·13	10	4·23	8	4·78	9	2·00	6	0·50	1	0·39	1	0·33	1	0·36	2	0·40	1	1·04	4	2·29	6	3·93	8	26·41	56	77	23
XVIII. Rhodesia	8·12	13	7·97	13	3·68	9	1·43	4	0·45	1	0·14	1	0·02	1	0·11	1	0·16	1	0·72	3	3·61	11	5·88	12	32·29	70	93	7
XIX. Damaraland ...	2·53	8	2·14	7	2·38	8	1·88	6	0·24	3	0·03	1	0·11	1	0·03	1	0·03	1	0·18	2	0·45	3	1·45	5	11·45	46	80	20
XX. Swazieland ...	11·22	15	1·64	10	5·27	15	3·39	9	2·08	5	0·02	1	0·09	1	0·25	2	0·99	1	2·84	12	5·14	16	3·29	10	36·22	97	80	20
XXI. Zululand	6·50	15	4·29	13	5·90	14	2·40	9	1·70	6	0·70	4	0·43	4	1·32	6	2·38	10	3·68	15	4·72	14	5·64	14	39·66	124	77	23

TABLE II.—Temperature, &c., at various Places in South Africa.

Place.	Approximate Elevation.	South Latitude.	East Longitude.	Mean Annual Temp.	Mean Warmest Month.	Mean Coldest Month.	Absolute Maximum.	Absolute Minimum.	Average Amount of Cloud.	Average yearly Rainfall.
	ft.	° ′	° ′	°	°	°	°	°	%	ins.
I. CAPE PENINSULA.										
Royal Observatory* ...	40	33 56	18 29	62·0	69·7	54·8	101·3	34·1	46·6	25·64
Simonstown ...	12	34 12	18 26	64·7	72·0	58·4	97·0	47·0	45·9	29·93
Disa Head (Table Mt.)	2,406	33 59	18 24	54·7	61·2	48·8	97·0	30·5	58·3	39·84
II. SOUTH-WEST.										
Worcester* ...	780	33 39	19 26	62·9	73·0	52·5	105·5	29·0	33·7	10·95
Ceres	1,493	33 22	19 20	59·4	70·2	48·0	105·0	24·0	..	41·77
III. WEST COAST.										
Clanwilliam* ...	245	32 10	18 53	65·4	75·8	54·2	112·0	26·0	29·9	8·37
Port Nolloth ...	40	29 16	16 52	57·5	60·1	54·2	104·0	32·0	..	2·11
IV. SOUTH COAST.										
Port Elizabeth* ...	176	33 58	25 37	64·0	69·9	58·8	105·0	39·0	50·4	19·28
Dunbrody	200	33 30	25 28	65·4	74·8	56·3	112·2	24·8	46·2	15·43
V. SOUTHERN KAROO.										
Amalienstein* ...	1,570	33 29	21 29	63·8	75·5	51·2	112·0	18·0	36·0	11·90
VI. WEST CENTRAL KAROO.										
Prince Albert* ...	2,120	33 11	22 2	59·8	69·6	50·1	105·0	28·0	33·6	9·91
VII. EAST CENTRAL KAROO.										
Graaff-Reinet* ...	2,500	32 16	24 32	63·6	74·0	52·4	110·0	20·0	27·8	16·79
Somerset East ...	2,400	32 44	25 35	62·9	71·4	54·0	109·0	26·6	42·1	24·93
VIII. NORTHERN KAROO.										
Hanover*	4,500	31 3	24 26	57·2	69·4	42·9	101·5	10·1	27·4	13·52
Cradock	2,856	32 11	25 38	62·2	72·3	49·9	110·0	19·0	30·4	16·02
Wagenaar's Kraal ...	4,500	31 48	22 48	59·0	70·7	46·2	100·0	18·0	20·1	11·00
IX. NORTHERN BORDER.										
Kimberley*	4,042	28 43	24 46	64·8	75·8	50·2	108·5	20·0	27·2	19·03
Kenhardt	2,700	29 18	21 9	66·2	78·6	51·3	112·0	20·0	22·4	5·41
X. SOUTH-EAST.										
King William's Town*	1,314	32 52	27 23	65·2	73·0	56·6	115·0	26·5	38·3	26·08
East London ...	20	33 2	27 55	64·8	70·0	60·0	101·0	37·0	49·0	23·37
Stutterheim	2,945	32 34	27 27	61·3	68·0	54·4	105·0	27·0	52·0	31·60
Grahamstown ...	1,800	33 18	26 32	62·3	70·8	54·6	100·0	29·0	41·6	26·72

* Temperature Curves shown on Diagrams.

TABLE II. (contd.)—Temperature, &c., at Various Places in South Africa.

PLACE.	Approximate Elevation.	South Latitude.	East Longitude.	Mean Annual Temp.	Mean Warmest Month.	Mean Coldest Month.	Absolute Maximum.	Absolute Minimum.	Average Amount of Cloud.	Average Yearly Rainfall.
XI. NORTH-EAST.										
	ft.	° ′	° ′	°	°		°		%	ins.
Queenstown* ...	3.500	31 54	26 54	61·4	69·9	51·2	104·0	19·0	36·6	26·91
Aliwal North ...	4.330	30 41	26 40	59·3	69·6	46·4	97·0	14·5	33·9	26·34
XII. KAFFRARIA.										
Umtata	2.400	31 35	28 40	63·0	70·6	53·5	110·0	21·0	47·2	26·50
Port St. John's ...	29	31 38	29 35	66·9	72·4	61·5	104·0	40·0	43·6	45·38
Kilrush	6,850	30 23	29 42	54·8	61·4	47·0	88·0	23·0	35·6	31·15
XIII. BASUTOLAND.										
Mohalie's Hoek* ...	..	30 8	27 28	57·8	68·6	43·0	96·0	9·0	..	36·79
Moyeni, Quthing ...	6.000	30 23	27 45	60·2	72·1	46·0	99·0	9·0	..	34·31
XIV. ORANGE R. COLONY.										
Bloemfontein* ...	4.510	29 7	26 13	62·0	72·8	48·0	109·0	16·0	26·6	24·72
Philippolis	4.700	30 13	25 18	59·0	70·2	46·0	99·2	18·2	26·8	20·49
XV. NATAL.										
Durban (Observatory)*	260	29 51	31 0	70·8	76·6	64·6	109·6	42·3	45·6	41·64
Verulam	..	29 39	31 2	71·8	78·8	63·4	110·0	33·0	..	36·20
Howick	3.439	29 29	30 15	63·0	70·5	52·2	102·0	21·0	..	29·45
XVI. TRANSVAAL.										
Johannesburg* ...	5.735	26 12	28 2	61·6	68·5	49·9	96·0	21·0	..	30·64
XVIII. RHODESIA.										
Salisbury*	4,700	17 48	31 5	64·8	70·0	56·0	92·6	32·2	31·7	32·86
Bulawayo	4.600	20 9	28 24	67·6	73·8	57·9	97·0	32·8	..	21·92
Tuli	..	21 52	29 12	72·4	80·3	58·8	106·7	33·0	..	14·48
XX. ZULULAND.										
Melmoth	..	28·35	31 24	68·2	73·8	61·8	109·0	40·0	..	33·03
Qudeni	6,000	..	..	56·9	64·5	48·5	89·0	22·0	..	53·31

* Temperature Curves shown on Diagrams.

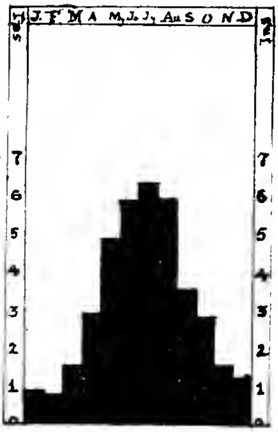


Fig II.— Cape Peninsula. Rainfall.

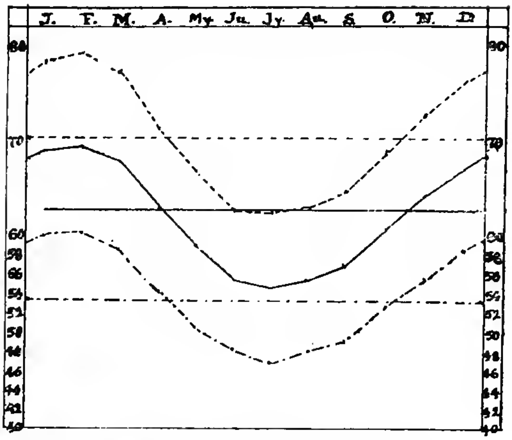


Fig IIa.— Royal Observatory (C.O.G.H.) Temperature Curves.

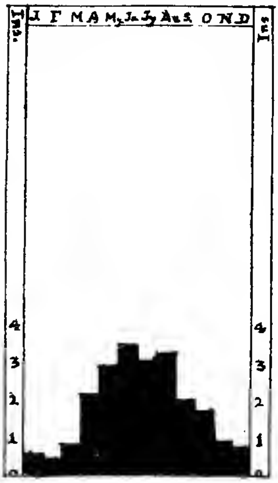


Fig III.— South-West Division,— Rainfall.

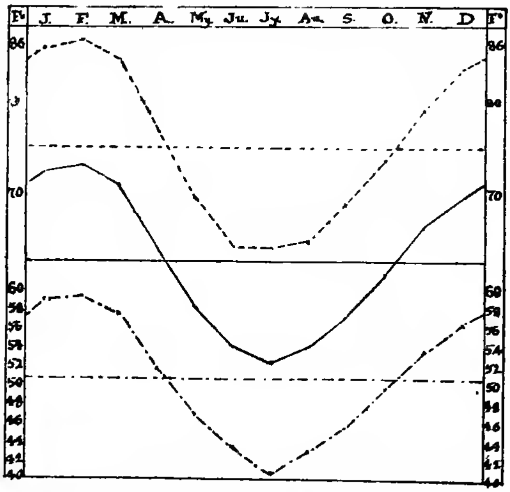


Fig. IIIa.— Worcester-Temperature Curves.

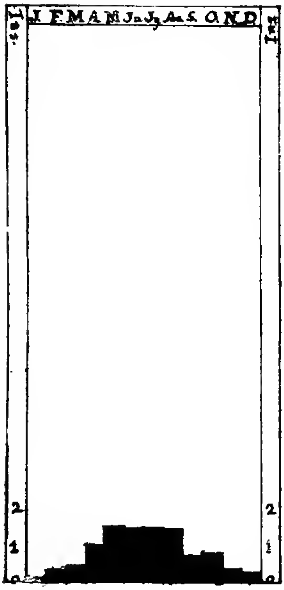


Fig IV. – West Coast – Rainfall.

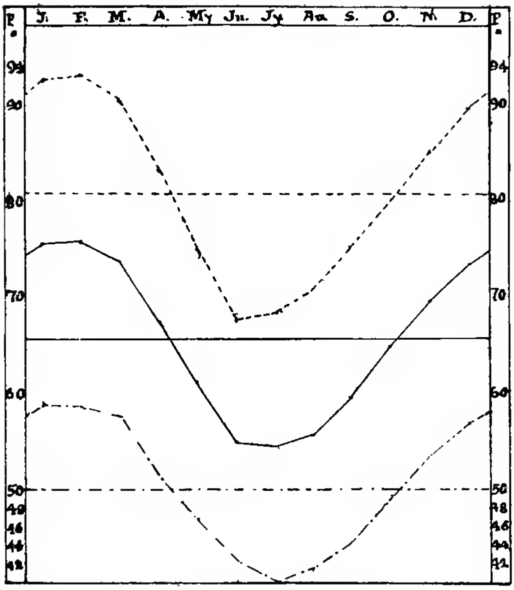


Fig. IVa. – Clanwilliam, – Temperature

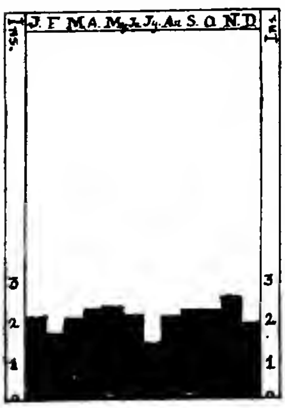


Fig V. – South Coast, – Rainfall.

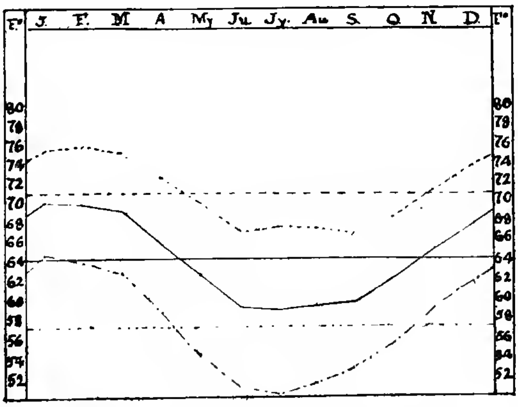


Fig Va. – Port Elizabeth – Temperature.

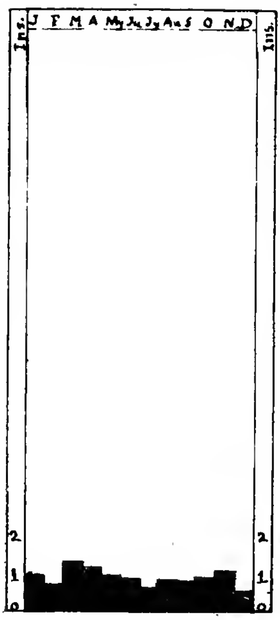


Fig VI.– Southern Karoo Rainfall

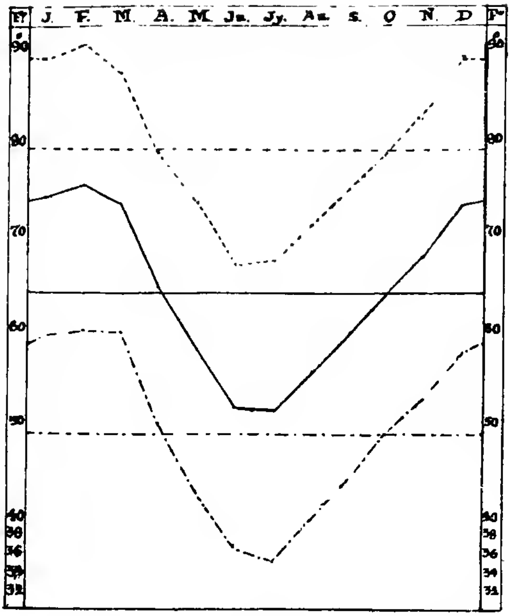


Fig VIa.– Amalienstein – Temperature.

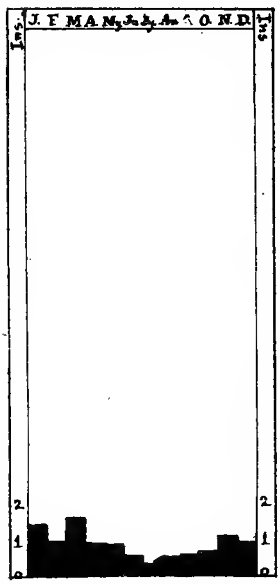


Fig VII.– West Central Karoo.– Rainfall.

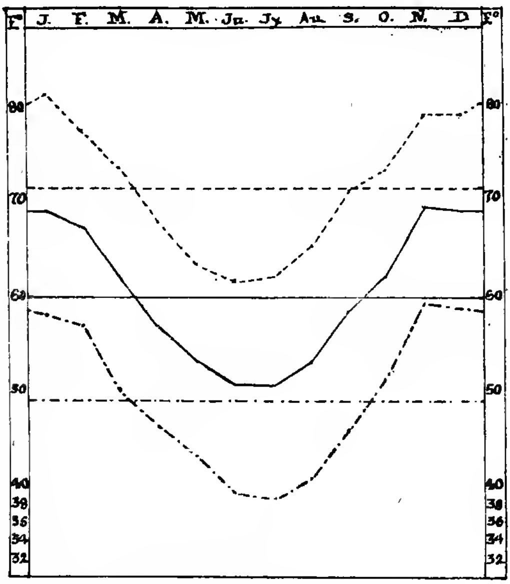


Fig VIIa.– Prince Albert – Temperature.

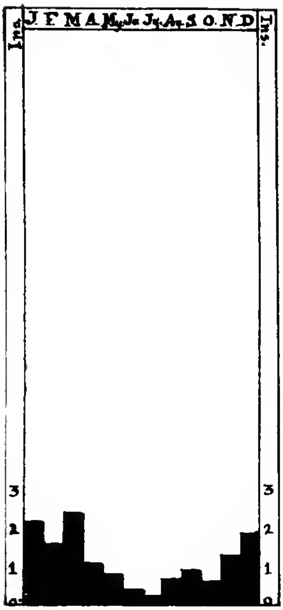


Fig VIII.– East Central Karoo – Rainfall.

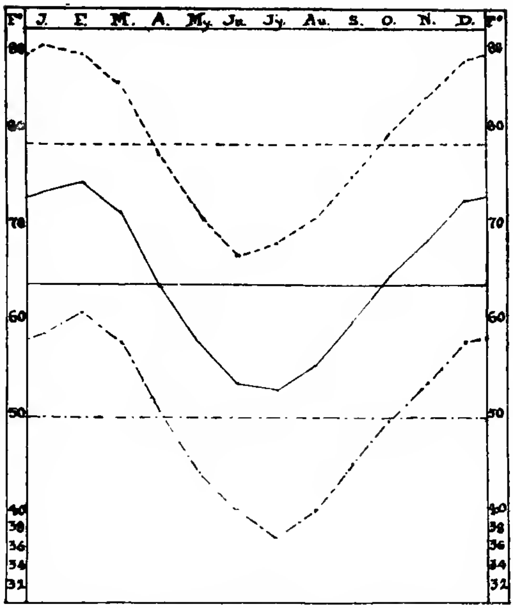


Fig VIII a.– Graaff-Reinet.– Temperature.

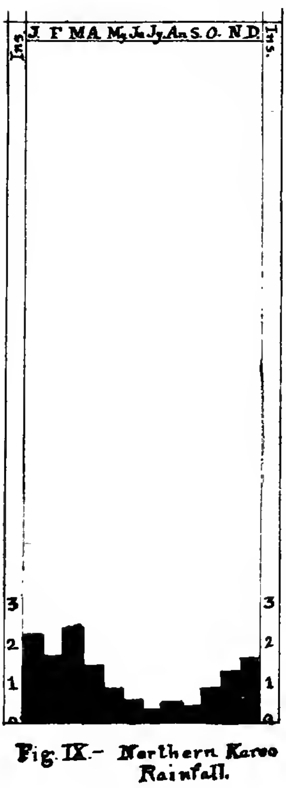


Fig. IX.– Northern Karoo Rainfall.

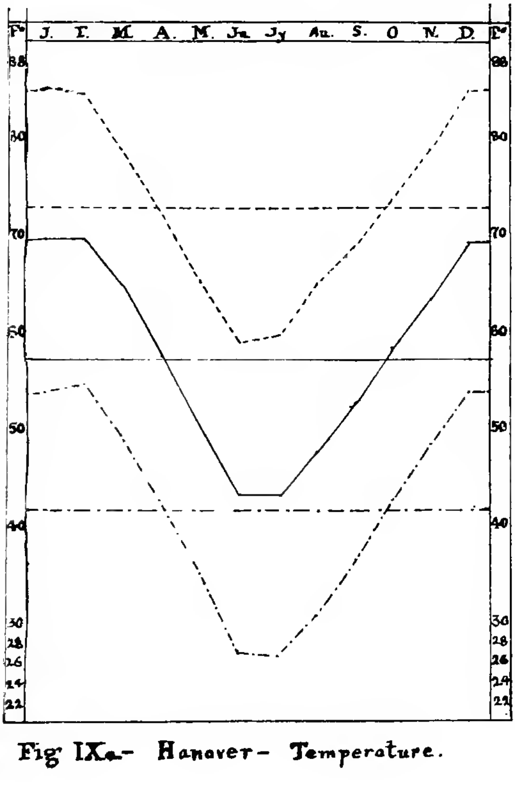


Fig IXa.– Hanover– Temperature.

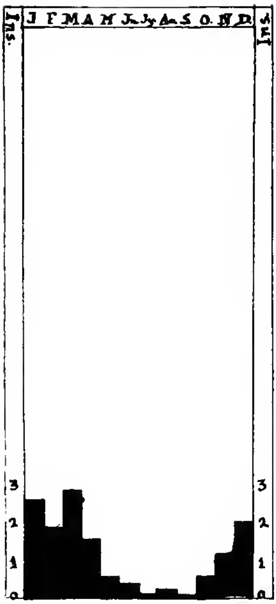


Fig X.- Northern Border- Rainfall.

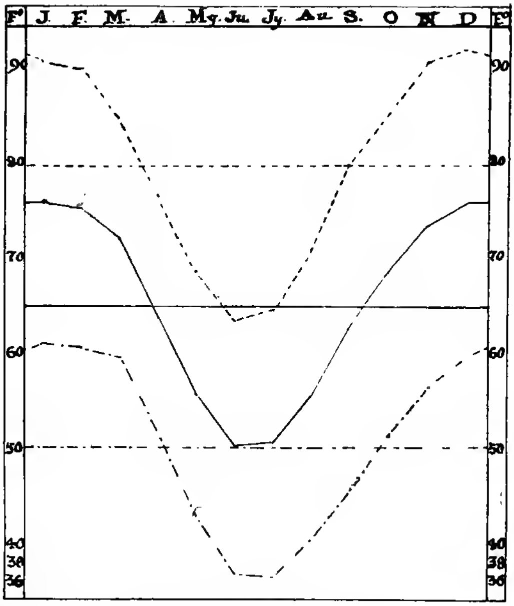


Fig Xa.- Kimberley- Temperature.

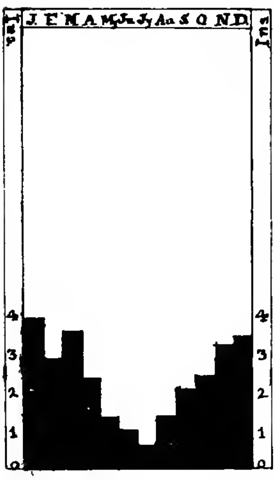


Fig XI.- South-East Division—Rainfall.

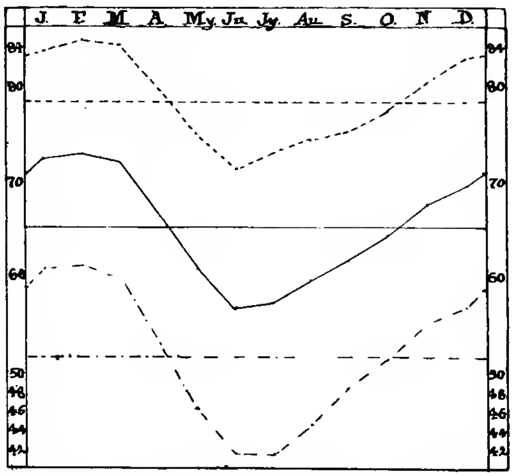


Fig XIa— King William's Town— Temperature

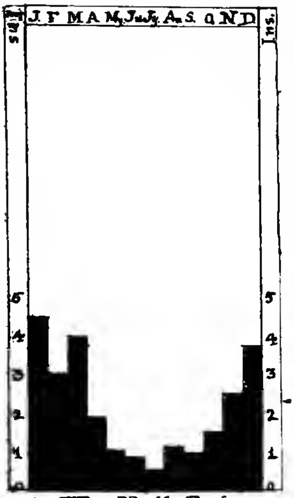


Fig XII.— North-East Division-Rainfall

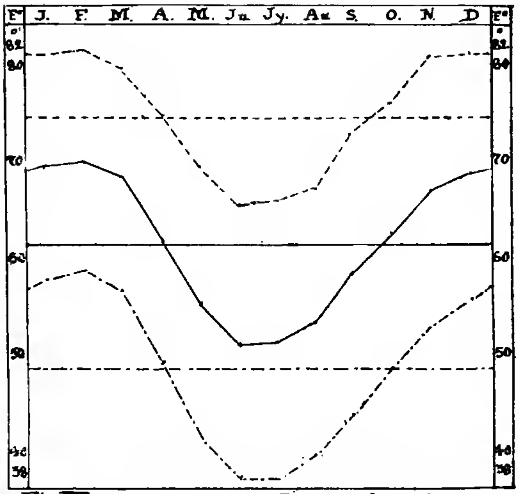


Fig XIIa.— Queenstown — Temperature Curves.

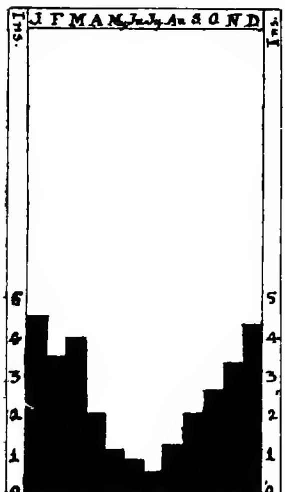


Fig XIII.- Kaffraria - Rain-fall.

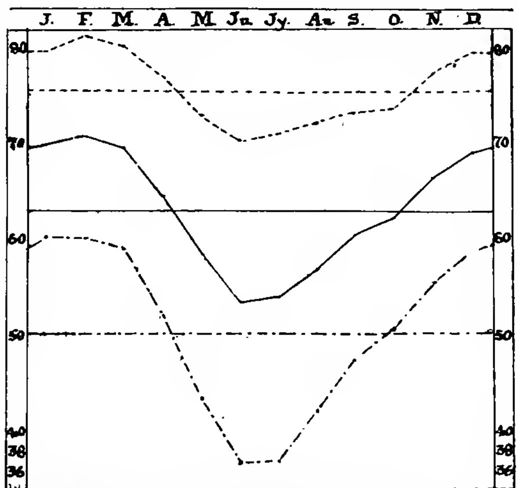


Fig XIIIa.- Umtata.- Temperature Curves.

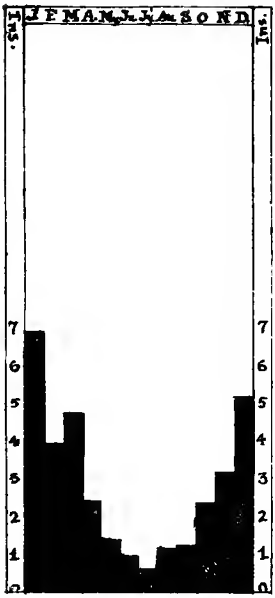


Fig XIV. - Basutoland Rainfall

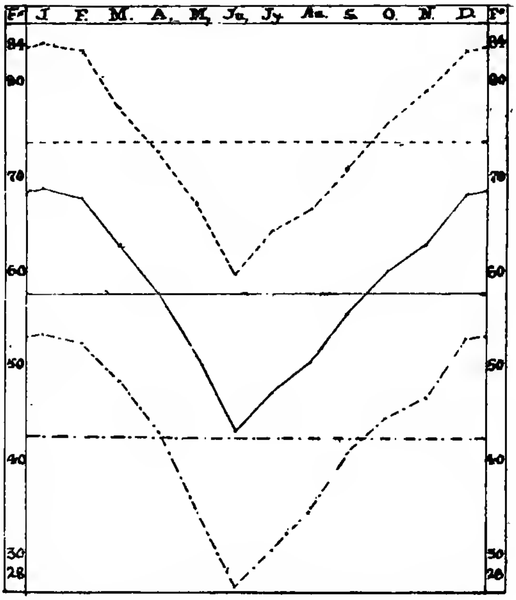


Fig XIVa. - Mohalie's Hoek - Temperature.

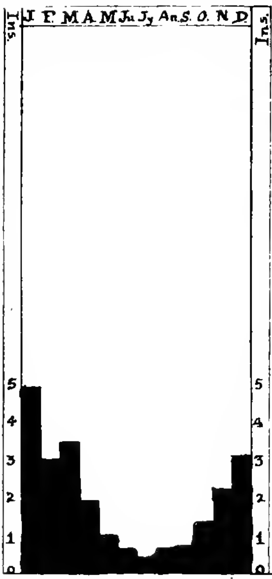


Fig XV - Orange River Colony - Rainfall

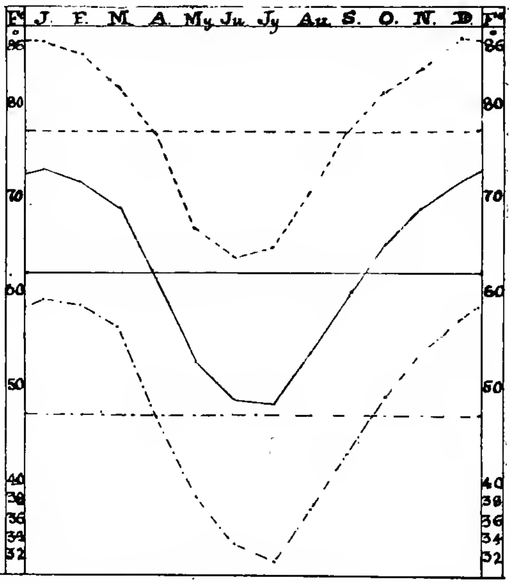


Fig XVa - Bloemfontein - Temperature.

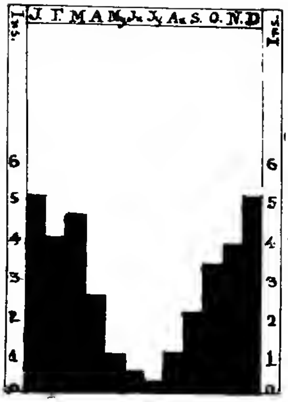


Fig XVI. - Natal - Rainfall.

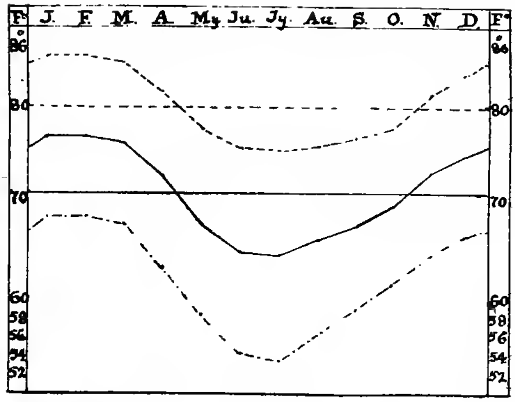


Fig XVI a. - Durban - Temperature.

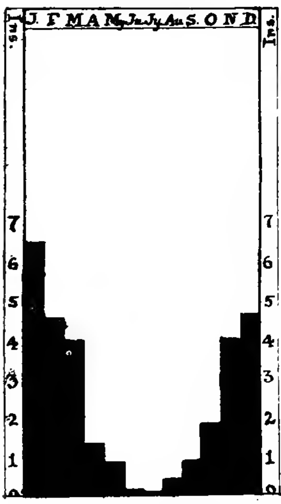


Fig XVII - Transvaal - Rainfall.

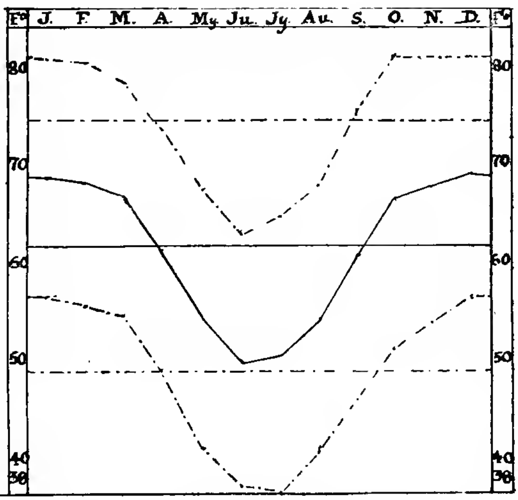


Fig XVII a - Johannesburg - Temperature.

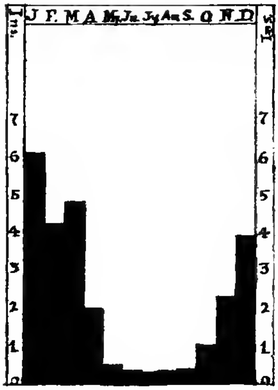


Fig XVIII Bechuanaland Rainfall

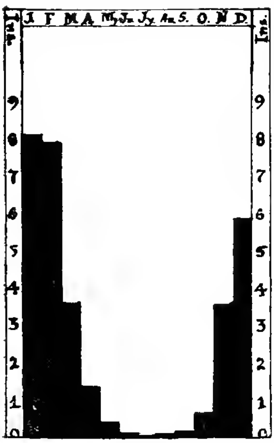


Fig XIX.— Rhodesia-Rainfall.

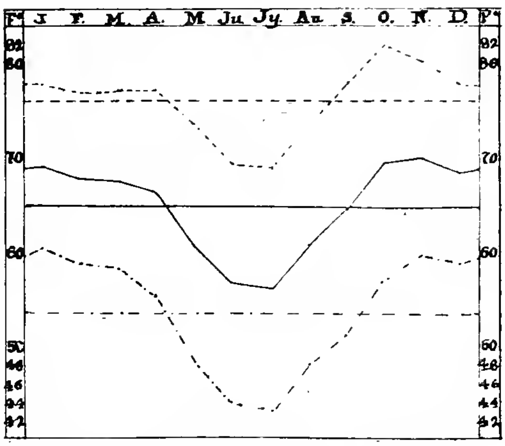


Fig XIX a— Salisbury - Temperature.

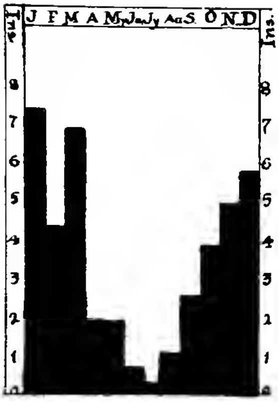


Fig XX. Zululand - Rainfall

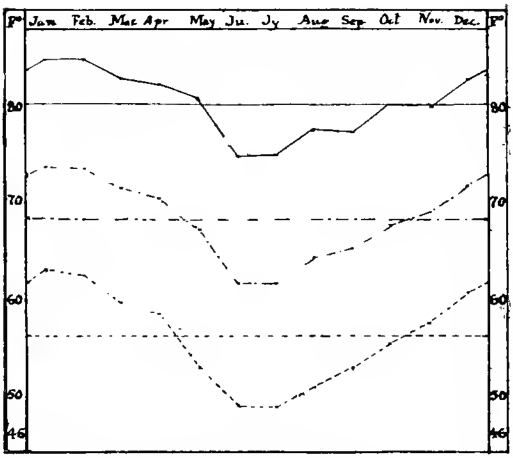


Fig XX a - Melmoth - Temperature.

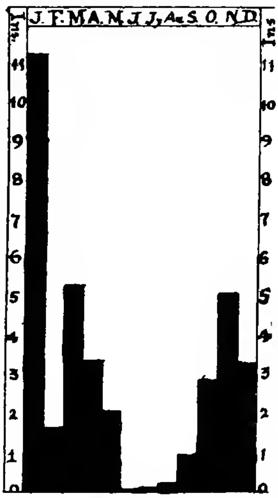


Fig XXI - Swaziland - Rainfall

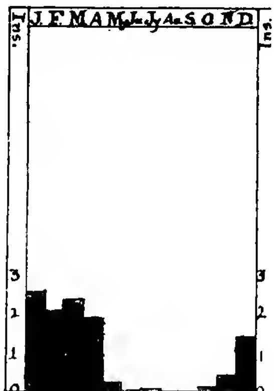


Fig XXII - Damaraland - Rainfall.

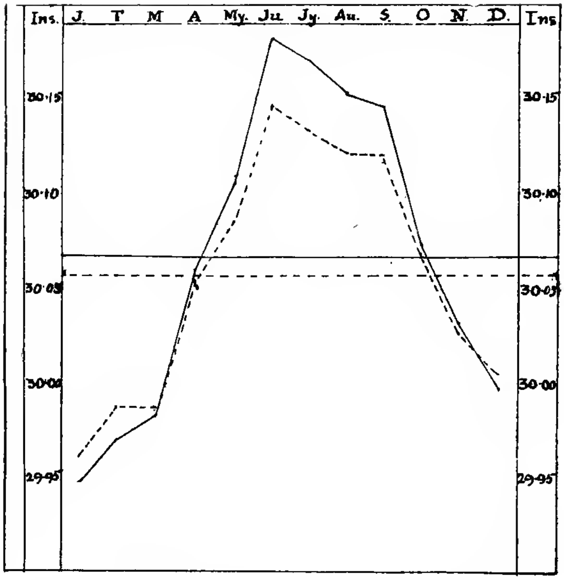


Fig XXIV Mean Monthly Barometric Pressure at Royal Observatory ——— and Cape L'Agulhas ------

3. ASTRONOMY AND GEODESY IN SOUTH AFRICA.*

By Sir David Gill, K.C.B., LL.D., D.Sc., F.R.S.,
H.M. Astronomer, Cape of Good Hope.

The first extensive and accurate catalogue of the stars of the Southern Hemisphere rests on the observations of the Abbe de Lacaille, which were made at the Cape of Good Hope in 1752.

The reasons why Lacaille selected the Cape of Good Hope as the scene of his labours are not far to seek. A glance at the map of the world, and some slight knowledge of the history of civilisation, will show that in 1752 the Cape of Good Hope was perhaps the only spot situated in a considerable southern latitude which an unprotected astronomer could visit in safety, and where the necessary aid of trained artizans to erect his observatory could be obtained. At the Cape these advantages had existed for a century, and besides being the most southerly point conveniently available it is situated nearly in the same meridian as Central Europe, so that almost simultaneous meridian observations of the moon and planets could be made in both hemispheres for the purpose of determining their parallax, or the same phenomena of Jupiter's satellites could be noted in both hemispheres for the purpose of determining the longitude of the Cape.

In these days the longitude of the Cape was very imperfectly known. To secure a fresh and well-determined departure, from a point which would be sighted or touched by most vessels bound to or from the East Indies was a matter of practical importance so well understood that it furnished the most powerful argument for smoothing Lacaille's path, and was accepted by Governor Tulbagh as a sound reason for giving Lacaille a hearty welcome, building an observatory for him, and affording him every aid.

The Cape may thus be regarded as the birthplace of exact astronomy in the Southern Hemisphere.

A bronze tablet has been erected by the South African Philosophical Society on the house now built on the site of Lacaille's Observatory in Cape Town. It bears, as astronomical symbols,

*Abbreviated and revised from a Presidential Address delivered to the South African Philosophical Society, May, 1903 (Transactions of the South African Philosophical Society, Vol. XIV., Part 2).

the stars of the Southern Cross and Lacaille's quadrant; and geometrical figures represent the plan of Lacaille's measurements of an arc at the Cape—another of his labours, to which further reference will presently be made.

The Royal Observatory at the Cape of Good Hope was established by an Order in Council on the 20th of October, 1820, and the cost of its maintenance is borne on the Imperial Navy Estimates. The first holder of the office of His Majesty's Astronomer was the Rev. Fearon Fallows, who arrived at the Cape in May, 1821, and, after some inquiry, selected the site of the present Observatory, and made preliminary observations with portable instruments which he had brought with him for the purpose.

In his days the site was practically a bare rocky hill covered with thistles, infested with snakes (its name was Slang Kop or Snake Hill), the jackals howled dismally around it at night, and a guard of soldiers had to be established to protect the property from theft. To give some idea of the Observatory surroundings, a member of the Maclear family told me that in Fallows's days a hippopotamus found its way from the Berg River into the treacherous marsh which then existed, about half-a-mile from the Observatory, near to the site of the present railway bridge at Maitland. The poor animal sank in the mud so deep as to be unable to get out, and was killed by neighbouring farmers. The story goes that their bullets could not penetrate the animal's hide, so they cut holes in the hide and fired through them.

It was not until December, 1824, that building operations were commenced, nor until the end of 1828 that the instruments were mounted and ready for work.

Meanwhile Fallows, to occupy himself, opened a school and taught the children of neighbouring farmers. His fee was a load of earth for each lesson, and to this we owe nearly the whole of the soil and the amenities of the site.

During 1829 and 1830 observing was prosecuted with vigour. In the latter year Fallows's excellent assistant, Captain Ronald, fell sick, and Fallows was left alone to do what should have been the work of four men—a task in which he was most ably assisted by his wife, whose aptitude and intelligence were such that, with very little instruction, she was soon competent to make observations with the Mural Circle, whilst Fallows himself observed with the transit instrument.

The cares and anxieties which he endured enfeebled his constitution. Fallows had left England full of high aspiration, full of strength and energy, which it was his ambition to devote to the great scientific task before him. The plans for the Observatory, which he had approved before leaving England, were delayed four years before he received them at the Cape. The Whigs, in a fit of economy, suddenly cut £10,000 off the estimates for completing the Observatory, and the building was left without the necessary outhouses and servants' accommodation, without roads or easy means of communication, without sources of food supply—a mere block of masonry on a barren hill. His two original assistants failed him, one suddenly leaving him and the other had to be dismissed for misconduct. By a gross oversight on the part of the maker the great Mural Circle was sent out in an imperfect condition. The worry and perplexity which this caused him by apparently anomalous results (which fortunately affect his observations only in detail but not sensibly in the mean result) are stated on high authority to have been the means of shortening his life.

In the summer of 1830 he experienced a severe attack of scarlet fever, from which his enfeebled constitution never rallied. In March, 1831, he reluctantly went to Simon's Bay for rest, and there died on the 25th of July, 1831, in the forty-third year of his age.

His widow conveyed the manuscripts of his observations to England, and they were finally reduced and published by Sir George Airy. The catalogue contains the right ascensions of 425 stars observed with the transit instrument, but of these the declinations of only 88 were observed with the Mural Circle.

Fallows's successor was Mr. Thomas Henderson, a man who by his inborn genius raised himself by degrees from the position of a lawyer's apprentice in Dundee to that of one of the most accomplished scientific men of his time. He reached the Cape in April, 1832, and, together with his assistant, Lieutenant Meadows, worked unremittingly for thirteen months, and then resigned the post. Henderson was not physically a strong man, and it was impossible for the strongest adequately to fulfil the duties of his office without more assistance; the circumstances pressed too strongly against him, and he was too honourable a man to accept the emoluments of an office without the most punctilious discharge of its duties. In his letter of resignation, addressed to the Secretary of the Admiralty, he mentioned that not only the state of his health rendered him unable much longer to support the requisite exertions, but that the Observatory itself, considered as a place of residence, laboured under so many disadvantages and required a mode of life so different to what he had been accustomed, that he found it impracticable to remain longer.

Henderson was rather the refined observer than the pioneer; he was a man who, granted the means and appliances, knew how to turn them to the best effect and to attain to the highest precision of which his instruments were capable. But he was not the man to fight an uphill battle with neglect at home, and to compel Fate, in the shape of official indifference and incapacity, to do his bidding and raise the status and equipment of the Observatory to the ideal level which he claimed for it. That required a dogged persistence and force of character of another kind.

But Henderson, by his own methods, attained results of high importance in many directions.

His self-sacrifice helped to remove many of the difficulties of his successors, and he overcame the want of official assistance at the Cape by taking the observations to Edinburgh with him and reducing them there. In 1834 he was appointed Astronomer Royal for Scotland, but he continued to devote all the time that could be spared from his other duties to the reduction of his Cape observations. They were all ultimately published, and proved how successfully and faithfully Henderson had worked. He gave to the world a catalogue of the principal southern stars of an equal accuracy with the work of the best Observatories in the Northern Hemisphere, and which will in all time be regarded as the true basis of the most refined Sidereal Astronomy of the Southern Hemiphere. His observations gave by far the most accurate determination of the moon's parallax then available; they determined the longitude of the Cape with a precision which refined modern methods, with the aid of the electric telegraph, have barely changed. Above all, Henderson was the first man to produce reliable evidence of the measurable parallax of any fixed star.

Henderson's successor was Mr. (afterwards Sir) Thomas Maclear. At the time of his appointment to the Cape he was practising his profession of doctor of medicine at Biggleswade, but was well known as one of the most competent and energetic amateur astronomers of his day.

Maclear reached the Cape on January 5th, 1834, and took up his residence at the still desolate-looking Observatory.

Ten days afterwards Sir John Herschel also arrived at the Cape and installed himself, his family and his instruments at Feldhausen, Newlands, within three miles of the Royal Observatory, and the next four years were spent in happy intercourse between the astronomers, each assisting with heart and soul the labours of the other.

Sir John Herschel came to the Cape to catalogue the nebulae of the Southern Hemisphere on the same plan as that on which his father had catalogued the nebulae of the Northern Hemisphere. His expedition was a purely private one, carried out with his own instruments at his own expense, alike an act of devotion to science and a notable tribute to the memory of his father. Sir John Herschel was thus never His Majesty's Astronomer at the Cape, but it was to Maclear and the Royal Observatory that Herschel appealed when he desired the exact determination of the place of a star, and he never appealed in vain.

Herschel worked at Feldhausen from 1834 to 1838, and during these busy years collected a mass of observations which on his return to England he proceeded to reduce; finally, in 1847, he published a splendid volume entitled, "Result of Astronomical Observations made during the years 1834-5-6-7-8 at the Cape of Good Hope, being a completion of a telescopic survey of the whole surface of the visible heavens—commenced in 1825."

During his stay at the Cape, Herschel also, at the request of the Cape Government, devoted much time to the problem of education in the young Colony, and, as the result of his experience, prepared the scheme of education which was adopted and has been followed almost to the present time.

To return to Maclear and his work. Maclear brought to bear upon the difficulties which Fallows and Henderson encountered all the energy and practical talents which distinguished him. By exchange and sale, and purchase of land, the Observatory property was consolidated. By the preparation of well-considered plans, and untiring persistence in urging their execution, he ultimately succeeded in getting suitable outhouses and other pressing works carried out ; better communication with the main road to Cape Town was established, and a windmill was erected for the supply of water from the then unpolluted Liesbeek River, trees were planted, earth was carted, and as time went on the barren hill-sides were covered with verdure ; fruit trees grew in the most favoured spots, and a wide belt of pine and wattle broke the force of the south-easters. Maclear grew each day more and more at heart a Colonist. His bright nature knew no difficulties, no official neglect daunted him, but he returned again and again to press on the execution of any scheme which he deemed essential to the welfare of the Observatory. His frank and cordial manners were peculiarly suited to win him favour wherever he went, and contributed in an extraordinary degree to forward some of his great works.

His administrative duties in no way interfered with the scientific labours of Maclear's office, for to these no man ever gave himself up with more untiring energy. From the date of his arrival the transit instrument and the mural circle were kept in constant use. Under the clear skies of the Cape it was inevitable that, with a man of such a temperament, observations would far exceed the computing powers of a small staff. The personal establishment of the Observatory was much too limited to enable the astronomer to reduce and publish the great mass of observations which he accumulated ; to do this would have required several assistants and an adequate staff of computers, and these Maclear had not. The wonder was not that the observations were not reduced, but that so large a mass of work was actually done. In this respect Maclear was not fairly treated, but he did his best under the circumstances, and no man could do more—few, indeed, would have done as much. He was also carrying out, as the same time, a long series of observations on the bright star Alpha Centauri, to test or confirm Henderson's result for the parallax of that star.

It is an instance of the sanguine and energetic temperament of the man that he could, in addition to these absorbing occupations, turn his attention—not as a separate work, but as a work superadded to the labours of the Observatory—to the measurement of an arc of meridian. In 1838 the first part of this great work, "The Verification of Lacaille's Arc of Meridian," was commenced. The measurement of this arc and its extension was commenced in 1840, and the field work was finished in 1847. It is impossible to convey within the limits of this paper an adequate idea of the indomitable energy and perseverance with which this operation was carried out, of the difficulties surmounted, and of the extent and value of the work accomplished with limited means. That all this was fully recognised at the time is sufficiently testified by the fact that for this work he received the Gold Medal of the Royal Society of London and the Lalande medal of the Institute of France.

In 1847 a 46-inch achromatic telescope by Dolland was mounted equatorially, and in 1849 an equatorial by Merz, of 7 inches aperture and 8½ feet focal length, was added to the instrumental equipment of the Observatory. These instruments were vigorously employed in the observation of double stars, comets, and nebulae, and of occultations of stars by the moon. All comets visible in the Southern Hemisphere were diligently observed by Maclear, and the results of the observations promptly published through the Royal Astronomical Society. Simultaneously with these observations, the meridian instruments were worked with redoubled energy, and during the years 1849-53 the whole of the stars in the British Association Catalogue having south declination were observed generally three times in each co-ordinate. The energy with which this series of observations was carried on is shown by the fact that in 1852 between 9,000 and 10,000 observations of right ascension were made with the transit instrument; on some nights over 100 stars were observed. These observations, in form of the "Cape Catalogue for 1850," have been published by the present astronomer. In 1855 the new transit circle (a facsimile of that at Greenwich) arrived, and was duly mounted with the assistance only of local masons and labourers, and observations were commenced with it at the end of the same year.

After 1860 Maclear's attention was chiefly directed to the reduction of his previous observations. He reduced the valuable series made in 1835-40, which has since been revised and published by his successor, Mr. E. J. Stone, as the "Cape Catalogue for 1840." Sir Thomas also partly reduced the observations made with the new transit circle in the years 1856-60, a work also completed and published by Mr. Stone, under the title, "Cape Catalogue for 1860." In addition to all this, he made a long series of observations of the moon and stars, for the purpose of determining the longitude of the Observatory and the parallax of the moon.

Maclear was the intimate friend of Livingstone. Their acquaintance commenced in 1850, when Livingstone came to him for assistance as to the best means of ascertaining his position when on his travels. Livingstone's quickness and aptitude for the work won Maclear's heart; the men were kindred spirits, and their friendship lasted to the end. The reduction of Livingstone's observations was performed at the Observatory, and formed a serious item in the work undertaken, but the labour was the labour of love.

Sir Thomas Maclear died on July 14th, 1879, and his remains were interred in the Observatory grounds beside those of his wife, not far from the spot where Fallows is buried. The House of Assembly at Cape Town agreed to the following resolution on July 17th, 1879:—"That this House desires to express its deep sense of the signal services rendered by the late Sir Thomas Maclear, Knt., F.R.S., F.R.A.S., to the general cause of astronomical and geographical science while in charge of the Royal Observatory, Cape Town, and also to the material interests of the Colony in the practical application of his researches; and, furthermore, its high appreciation of his devotion for so long a period of years to the cause of South African exploration and civilisation, and that this resolution be recorded in the journals of the House." Never was a like recognition of service better earned. One only regrets that it was not made on his retirement, when it certainly would have been not less grateful to him who had so worthily earned it than it was to his sorrowing family.

Sir T. Maclear's successor, Mr. E. J. Stone, was for many years Chief Assistant at the Royal Observatory, Greenwich, under Sir George Airy. An accomplished mathematician, and well known to astronomers as the author of many admirable and important papers, he was of all English astronomers of his time the man required at the Cape. Apart from the plans which he had formed for his work there, it was known that there existed great stores of observations partially reduced and entirely unpublished which had been accumulated by Maclear, but which were thus unavailable for the purposes of science. There certainly was no man in England so well fitted to complete their reduction and prepare them for press. With a long training in the rigid and methodical methods of Sir George Airy, with great powers of his own in the organisation and superintendence of large masses of computation, with a clearly-defined plan in his mind as to the work he meant to do, and a fixed determination that nothing should interfere to turn him from that purpose, with the entire sympathy and powerful support of his former chief, with official instructions consonant with his own wishes, he applied himself during the whole of his stay at the Cape to two great objects—(1) the preparation of Maclear's meridian observations for press; (2) the re-observation of the stars which had been observed by Lacaille more than a century before, and the formation of a catalogue of southern stars complete to the seventh magnitude.

Unlike Maclear, Stone himself took but little part in observing, but, having strong sympathy at home, he organised an excellent staff and carried out both these great works in a very complete manner. Stone's Catalogue of 10,000 Southern Stars was printed after his return to England, the Cape Catalogues of 1840 and 1860, based on Maclear's observations, having been passed through the press during his stay at the Cape. The whole forms a splendid memorial to Stone's methodical energy, to the high sense of duty which actuated him, a proof of his sound judgment as to the needs of science at the time, and of his concentrated earnestness of purpose in their pursuit.

Stone and his contemporary, Dr. Gould, at Cordoba, in the Argentine Republic, had accomplished great things for the sidereal astronomy of the Southern Hemisphere, and it has been said with truth that for the epoch 1875 from their labours alone we have, on

F 2

the whole, a more satisfactory knowledge of the positions of the stars in the Southern Hemisphere than we have of the same class of stars in the Northern Hemisphere from the combined labours of all the observatories of Europe and America.

In 1879 I had the honour to succeed Mr. Stone as the Astronomer at the Cape.

The limits of space at disposal render it necessary to confine the conclusion of this article to a brief statement of the work undertaken and accomplished at the Observatory since that time.

The traditions of the Observatory and the needs of astronomy demanded a continuance of accurate meridian observations, and we have now published the following accurate Star Catalogues as the result of meridian observations since 1879 :—

The Cape Catalogue of 1,713 stars for the Equinox 1885 from observations 1879 to 1885.

The Cape Catalogue of 3,000 Stars for the Equinox 1890 from observations 1885 to 1895.

The Cape Catalogue of 8,560 Stars for the Equinox 1900 from observations 1896 to 1899.

There is now ready for press another General Catalogue of 4,360 Stars from observations 1900 to 1904.

Besides these the outstanding reductions of Maclear's observations have been reduced and published, viz. :—

The Cape Catalogue of 4,810 Stars for the Equinox 1850 from observations 1849 to 1852 ; and

The Cape Catalogue of 1,905 Stars for the Equinox 1865 from observations 1861 to 1870.

It seemed desirable, however, to widen the field of our work.

Nothing whatever was known about the parallaxes (or distances) of the stars of the Southern Hemisphere, beyond the results of Henderson's and Maclear's determinations of the parallax of α. Centauri. As a first step to such extension I secured, by purchase from Lord Crawford, the Heliometer which he had so kindly lent for my expedition to Ascension in 1877, and, in conjunction with Dr. Elkin, a young American friend who spent two years at the Cape, we determined the parallaxes of nine of the most interesting of the southern stars.

These results justified the Admiralty in granting the present Heliometer, which has been successfully applied in further determinations of stellar parallax and, in conjunction with the Observatories of Yale College (New Haven), Leipzig, Gottingen, Bamberg and Oxford (Radcliffe) in the Northern Hemisphere, has determined from observations of the minor planets Iris (7), Victoria (12) and Sappho (80) the value of the Solar Parallax which has since been adopted for international use. The Heliometer has latterly been employed in refined determinations of the plans of the Major planets near every opposition, and in investigations for determining the mass of Jupiter and the orbits and masses of its satellites.

On the 8th September, 1882, appeared the great Comet of that year. So early as October 4th several photographers in South

Africa had obtained impressions of the Comet with their ordinary apparatus. These photographs had no scientific value as representations of the Comet, since they were taken without means for following the diurnal motion during exposure. At that time the Observatory had no suitable lens nor had we any experience in the development of modern dry plates. Under these circumstances I called in the services of Mr. Allis, a skilled photographer in the neighbouring village of Mowbray. No sooner were the desired objects and conditions explained to him than Mr. Allis volunteered all necessary aid, and entered heart and soul into the work. His camera, with a Ross lens of 2½ inches aperture and 11 inches focal length, was attached to a stout board and clamped to the counterpoise of the axis of the 6-inch equatorial. In this way the optical axis of the lens was rendered parallel to that of the 6-inch telescope, and thus, under the action of clockwork and with the aid of slow motions in R.A. and Declination, it was easy to follow either a star or the nucleus of the Comet during any required length of exposure. Apart from the interest of the photographs thus obtained as representations of the Comet itself, a still wider interest attached to them from the fact that, notwithstanding the small optical power employed, the plates showed so many stars, and these so well defined over so large an area, as to suggest the practicability of employing similar but more powerful means for the construction of star maps, or for cataloguing the stars to any required order of magnitude. The plan was laid before the Academy of Sciences in Paris, and proved one of the means which led in 1887 to the international undertaking of the "Carte du Ciel" now in progress, in which the Cape takes part. Already half of our plates, containing over 400,000 stars, have been measured.

Meanwhile, in 1885, the Cape undertook to make photographic charts, with a Dallmeyer lens of 6 inches aperture, of all stars to 9½ magnitude from 18° South Declination to the South Pole, and in the end of the same year Professor Kapteyn, of Groningen, undertook to measure and catalogue the stars on the plates. Professor Kepteyn devoted twelve of the best years of his life to this work; the results are published in three volumes constituting the Cape Photographic Durchmusterung, issued respectively in 1896, 1898 and 1900, giving the places and magnitudes of 454,875 stars, and thus the Durchmusterung of Argelander and Schonfeld was completed for the whole sky.

Besides these larger astronomical works, the Cape Observatory has determined a telegraphic chain of longitudes from Aden, Mozambique, Zanzibar, Delagoa Bay, Durban and Port Elizabeth, and along the West Coast to Port Nolloth, Mossamedes, Benguela, St. Paul de Loanda, Sao Thome and Bonny, besides many longitude determinations connected with the Geodetic Survey.

All comets and predicted occultations have been regularly observed, and a large number of double and variable stars.

Until the year 1904 there existed neither at the Cape nor in any Observatory in the Southern Hemisphere an adequate equipment for the pursuit of Astrophysics—or the study of "what is a star," as contrasted with the old astronomy which dealt only with the position of Celestial objects in space. For forty years the new astronomy had been vigorously prosecuted in the Northern Hemisphere, the first great harvest of results with moderate means had been reaped, and great establishments were founded for research in the new fields of work. The busy years rolled on, and I had, perforce, almost resigned myself to the idea that, during the period of my directorate at least, the Royal Observatory at the Cape must limit itself to the pursuit of the old astronomy. But one fine morning in 1894 there arrived a letter from Mr. Frank McClean offering to present, for use in the Southern Hemisphere, and preferably to the Cape, a telescope and observatory specially adapted for this work. The Lords Commissioners of the Admiralty accepted with warm appreciation of Mr. McClean's generosity the offer of this splendid instrument, and expressed the view that its possession would greatly increase the utility of the Cape Observatory, and might be expected to result in considerable advancement to science. The instrument was finally erected in 1898.

It is needless here to enter into a description of it and of the work which it has done, because it is to be hoped that all members of the British Association who are sufficiently interested will visit the Observatory and see for themselves.

The large-minded donor of the Victoria Telescope—as he wished it named—is alas! no more; otherwise had he been spared in health and strength there is little doubt that he would have come to South Africa along with the other members of the British Association to see the results of the great pecuniary sacrifices which he made for the work that he loved. It was at the Cape that McClean, with his object glass prism of 12 inches aperture attached to our Astrographic Equatorial, photographed the spectra of the southern stars to the $3\frac{1}{2}$ order of magnitude, and discovered conclusive evidence of oxygen lines in the spectra of some of the Helium Stars. During his stay at the Cape in 1897 he endeared himself to us all; his loss is deplored by every member of the staff as that of a kind and generous friend.

One of the works that appeared to be laid upon His Majesty's Astronomer, although outside his official duties, was that of the Geodetic Survey of the Colony. Lacaille in 1752 had measured a short arc of meridian, and Maclear had remeasured and extended it from Cape Point northwards nearly to the Orange River; but nothing further was done after the year 1848, except a triangulation along the south coast by Captain Bailey executed in 1859-62.

After several unsuccessful efforts to secure the necessary funds to set a Geodetic Survey on foot, an agreement was arranged between the Cape Colony and Natal to carry out the principal triangulation of both Colonies. Between the years 1883 and 1894 the work was completed, under my direction, by Colonel Morris, and I had the satisfaction of finally preparing the results for press; they were printed, and presented to Parliament in 1896. Since then I have superintended the re-reduction of Captain Bailey's Survey to the system of the Geodetic Survey, and have had the satisfaction of issuing it in an accurate and homogeneous form as a second volume of the Geodetic Survey of South Africa.

Having regard to the Geodetic work thus begun in South Africa and looking for opportunities for its extension, it became evident that these opportunities were of the most remarkable and important character. Struve's great Russian Arc of the Meridian extends from the North Cape to the borders of Turkey, and runs nearly along the 30th Meridian. The Natal Arc is also in the 30th Meridian, its extension would run through the Transvaal and Rhodesia to the southern end of Lake Tanganyika, and still further north along the Valley of the Nile. To carry out such an arc and to connect it with Struve's arc round the eastern end of the Mediterranean, would form the longest arc of meridian in the world and the greatest contribution ever made to geodesy. To see this work executed became one of the objects of my life.

In urging the scheme on the late Mr. Cecil Rhodes in 1894, and proposing that the work, so far as it referred to Rhodesia, should be begun at once, Mr. Rhodes at first demurred, but when later (in 1897) Earl Grey in the practical interests of Rhodesia sanctioned its commencement, Mr. Rhodes promised that funds should be provided to carry it to Lake Tanganyika. The chain of triangulation from Bulawayo to Gwelo and thence northwards to the Zambesi is completed, and the work is now being pushed forward under my direction by Dr. Rubin northwards from the Zambesi. Under Colonel Morris the triangles have been measured from the North of Natal as far as Belfast in the Transvaal; the points are selected and beaconed to the Limpopo, and will be measured in the cool season of the present year.

The Berlin Academy of Science is supporting the proposal to obtain the necessary funds for carrying the work through the German Protectorate from the southern end of Lake Tanganyika to the southern border of the British Protectorate in Egypt—and I am given to understand that in course of a year the work will be begun in Egypt proper, so that the possibility of its completion seems daily nearer to realisation.

Visitors to the Observatory—who are interested in such things—may see, besides the Victoria Telescope, the Astrographic Telescope and the Heliometer, the recently-erected Transit Circle with its new contrivances for increased accuracy in fundamental meridian work, and the unique new Sidereal Clock with its many adjuncts for insuring the greatest possible uniformity of rate.

The Staff of the Observatory at present consists of :—

Sir David Gill, His Majesty's Astronomer.
Mr. S. S. Hough, Chief Assistant.
Messrs. J. Lunt, R. T. Pett, W. H. Cox, J. Power, Assistants.
Mr. A. Pilling, Librarian and Accountant.
Mr. R. Woodgate, Established Computer, Higher Grade.

Messrs. J. A. J. Pead, R. W. Cheeseman, A. W. Goatcher, A. J. Wilkin and C. W. Jeffries.

Six Temporary Computers.

Six Ladies employed on the measurement of stellar photographs; and

One Lady Typist.

Any account of the history of astronomy in South Africa would be incomplete without reference to work in the field of Variable Stars. South Africa has been the chief seat of the study of these objects in the Southern Hemisphere, and Dr. Roberts of Lovedale its most accomplished and laborious student. He began observing variable stars in 1891 with no other equipment than an old theodolite and an opera glass. From 1891 to 1894 he made a rough survey of the southern sky south of decl. 30° which resulted in the discovery of twenty variable stars, four of which are of the Algol type. This large increase in the known number of southern variable stars led Roberts to devote himself more and more to the study of the light curves of known variables.

From 1900, with a new equatorial telescope presented to him by Sir John Usher, and specially designed for this class of work, he commenced an elaborate series of observations on what are known as the Algol variables. These constitute a peculiarly interesting class of objects. For many days together the star shines with uniform light, suddenly at a particular moment the light of the star begins to wane, diminishing until a certain minimum is reached and again increasing in brightness till the normal magnitude is restored. These periodic fluctuations recur with great regularity. The obvious conclusion is that two stars revolve about each other nearly in a plane directed towards the sun, and consequently one star in the course of its revolution obliterates the other. When the stars are not in the same line with the sun we see as a single star their combined light, when in a line we see the light of only one *plus* such part of the light of the second as is not obscured by the first. There are thus two kinds of minima, one when star No. 1 is in front of No. 2, and *vice versa.*

From the light curves expressing the amount of light at each instant during the waning and waking of the light Roberts finds it possible to determine the density and figure of the disc of the components, and the elements of the binary system.

Roberts found the accuracy attainable with his new instrument was such as to warrant investigations of this nature, and these led to conclusions bearing directly on the cosmical problem of stellar evolution. He found, for example, that the mean density of eight southern Algol variables is one-ninth that of the sun. Further, in the case of those double stars of which components revolve in contact, he found that the resulting oblateness in the figure of the component stars agrees in a striking manner with that found by George Darwin from purely theoretical considerations.

Besides this he has undertaken an independent determination of the magnitudes of all the stars brighter than 9·2 magnitude which are situated south of declination-30°, and also the regular observation of about 120 variable stars. Roberts has made in all about 250,000 independent estimations of stellar magnitude, and all this as work entirely outside heavy duties in connection with the Lovedale Institute, of which he has, in Dr. Stewart's absence, been the responsible director. I know few instances of more successful devotion of small means and limited opportunity to the attainment of great scientific ends than the work of Dr. Roberts.

In the same field a large amount of work and discovery has been done by Mr. R. T. A. Innes, formerly Secretary at the Royal Observatory. He undertook the revision of the Cape Durchmusterung as a labour of love outside the routine of his office. Kapteyn had naturally found many anomalies between the results of the Cape photographic plates and those of previous Star Catalogues, of which he prepared special lists, containing stars existing in other catalogues not found on the Cape plates.

Every one of these many hundred cases had been examined, and in hardly a single instance has an error been found in the Cape Durchmusterung ; the discrepancies generally arise from misprints or errors of reduction in the other Catalogues, or the stars have proved to be variable or so red as not to be photographically bright enough to produce an impression. A complete account of this revision together with numerous observations of variable stars has now been published.

Mr. Innes, previous to his arrival at the Cape, had devoted himself to this branch of astronomy and, with comparatively feeble means, had discovered about forty previously-unknown double stars and published their estimated distances and position angles. In the course of his revision of the Durchmusterung, and by making use of opportunities of exceptional definition, he has now added about three hundred to the list of known southern double stars, all of a class that would appear single in our photographic plates. He has also applied the 18-inch refractor of the new McClean telescope to that work, and with Mr. Lunt has made many measures of the position angles and distances of southern double stars. In addition to this he has prepared a reference catalogue of southern double stars with a bibliography of the subject, which is published in the Annals of the Cape Observatory, Vol. II., part 2.

Mr. Innes is now Director of the new Observatory at Johannesburg, which will be open for inspection by the Members of the British Association on the occasion of their visit to that city. As yet the Observatory there is equipped only for meteorological work, but it will doubtless ere long be provided with an astronomical outfit to enable its Director to pursue the work for which he has shown such marked capacity, and for which its admirable site and clear sky offer such favourable opportunity.

4. EARTH MAGNETISM IN SOUTH AFRICA.

By J. C. Beattie, D.Sc., F.R.S.E., Professor of Physics, South African College.

I. The Secular Variation of the Different Elements.

The earliest magnetic observations in South Africa date from about 1600. They were made by the navigators of those days, and for a study of the magnetic state of this part of the Continent at that time are unsatisfactory because, firstly, they were made only at places on the coast such as Saldanha Bay, Table Bay, Mossel Bay, Algoa Bay, or at the anchorages in the neighbourhood of these places; secondly, the instruments of observation—the unsatisfactory ships' compasses of that time—give results which are not comparable with one another, and which may be in error because of the imperfections of the compass itself, and the unsatisfactory determinations of the longitude; and thirdly, observations of the declination (variation) only were made.

These earlier observations have been collected, and the best of them published by Sabine and Van Bemmelen. Many of them will be found in a paper published in the Transactions of the South African Philosophical Society, Vol. XIV.

In the same paper will be found the results of later observations of the declination, and of the results obtained for the dip and the horizontal intensity from observations made at Cape Town up to the year 1900.

In addition to the above data, results have been obtained in various parts of South Africa away from the coast. These have been made by surveyors, and the records collected by Mr. Bosman, Geodetic Officer to the Cape Government, by Colonel Jackson, Surveyor-General of the Transvaal, and by Mr. Fourcade. The earliest of these observations is one made at Stellenbosch in 1806. Other early observations are—one at Malmesbury in 1812, several at Grahamstown about 1820, at Simonstown in 1823, at Graaff-Reinet in 1815, at George Town in 1817, Swellendam 1815, Uitenhage 1816, and a few other places about this time. With the help of these and the fuller knowledge we now have it will be possible to draw the isogonic lines for the southern part of Cape Colony for the epoch 1820.

There is also a number of observations of declination made by Messrs. Bosman and Moorrees between 1870 and 1890, chiefly in Bechuanaland.

In recent years the work carried out by the "Challenger," the "Discovery," and the "Gauss" and other surveying ships in the seas around South Africa, will give very valuable information as to the present magnetic state of these seas and of the secular variation of the elements in them.

There is finally the data gathered during the last seven or eight years in connection with the magnetic survey of South Africa. Observations have been made at upwards of 400 places in connection with this survey, the declination, the dip, and the horizontal intensity having been determined at each place. The places are distributed throughout Cape Colony, the Orange River Colony, the Transvaal, Natal, Rhodesia and Portuguese East Africa. The extreme stations are L'Agulhas on the south, the Victoria Falls and Lo Maghonda on the north, Saldanha Bay on the west, Beira and Delagoa Bay on the east. The cost of this survey had been borne by the London Royal Society and by the various South African Governments.

The result of the observations for secular variation of declination shows that about the year 1600 the agonic line passed in a north-west by north direction through Africa. It touched the South African coast at a point a little to the east of L'Agulhas. The following extract from a letter dated 1579—written by the first Englishman known to have reached India by the Cape route, shows very well the state of the knowledge of the variation of the compass at that time. After stating that the variation is just north in the meridian of the Azores, the letter continues: "and thence swerveth towards the east so much betwixt that meridian aforesaid and the point of Africa, it carrieth three or four quarters to thirty-two. And again in the point of Africa a little beyond the point that is called Cape das Agulias it returneth again unto the north and that place passed it swerveth again towards the west."—(Voyages and Travels.)

Since that time till about the year 1870 the agonic line has moved towards the west; at the latter date it had reached its maximum westerly position; at the present day it is moving to the east again with an accelerated motion. The result, so far as Cape Town is concerned, is this: the declination has changed between 1605 and 1870 from 0° to 30° W. of N.; since 1870 the westerly declination has been decreasing and the declination at the present time is about 28° 30′ W. of N.

A rough idea of the secular variation of declination in South Africa for this period may be obtained by imagining a skin fitted on to the surface of the Southern Hemisphere with lines approximately as in diagram Fig. 1.

These lines represent at any epoch the lines of equal declination of a part of the Southern Hemisphere. At the end of the sixteenth and the beginning of the seventeenth century the agonic line—marked 0 in the diagram—had the position stated above. As the years passed by the system of lines moved towards the west till now the thirty line passes near L'Agulhas. The elbow, which at the time of the first observations was in the Indian Ocean passed over South Africa, and is now in the Atlantic Ocean.

The observations of dip show that the S. dip has been increasing from 1750 to the present day with many fluctuations in its rate of increase. It is still increasing, and roughly increases at present in Cape Town about seven minutes per year. Its value in 1750 was 43 °—now it is over 59 °.

The first observations for horizontal intensity were made in 1843. The value at that time was 0.208 c.g.s. units. Its value at the present day is about 0.184 c.g.s. units, and it is decreasing.

The observations for secular variation of dip and of intensity show that the magnetic pole is slowly approaching South Africa.

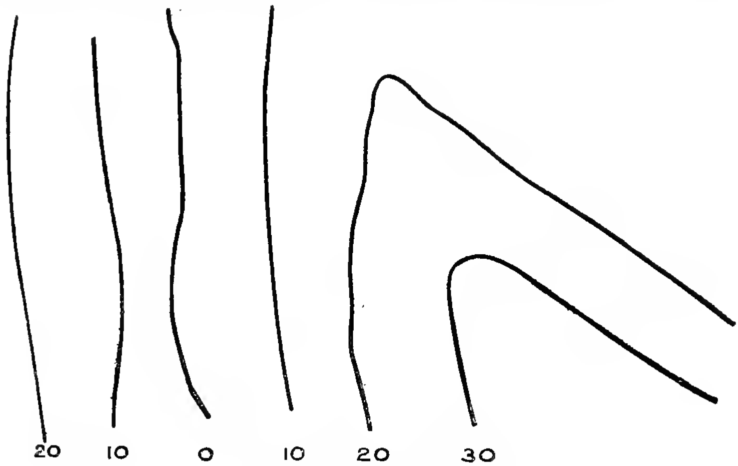


Fig. 1. Secular Variation of Declination in South Africa.

II. Daily Variation.

The data available for the study of the daily variations of the magnetic elements in South Africa are contained in Sabine's reports on the magnetic observations at Cape Town and at St. Helena between 1840–50. Of recent years the only observations bearing on these matters are those made at the Royal Alfred Observatory, in Mauritius, and those by Mr. Nevill at the Observatory, Durban, between 1893 and the present time on the daily variation of the magnetic declination.

At Cape Town the range of daily variation of magnetic declination is about six minutes in the summer months, and about four in winter. The greatest deviation from the mean position is about 9 a.m. Cape Civil time—two hours east of Greenwich—when it is four minutes west of the mean; from that time till about 3 p.m. there is a rapid change, and at the latter hour it attains its most easterly position. It attains the mean position for the day about 4 a.m. In winter the greatest westerly reading of the needle is about 11 a.m. and is then 2 minutes west of the mean position; the greatest easterly position is about 7 a.m., also about two minutes from the mean. About 10 p.m. the needle has its mean position for the day.

The daily variation of the horizontal intensity is about 14 γ in the summer months and 16 γ in the winter months. In summer the horizontal intensity has its greatest value about 8 a.m., when it is 9 γ above the mean. Its smallest value is at 10 p.m., and is then 5 γ below the mean. In the winter months the greatest value is about 10 a.m., and is 10 γ above the mean; the smallest value is between 10 p.m. and 11 p.m., and is 6 γ below the mean.

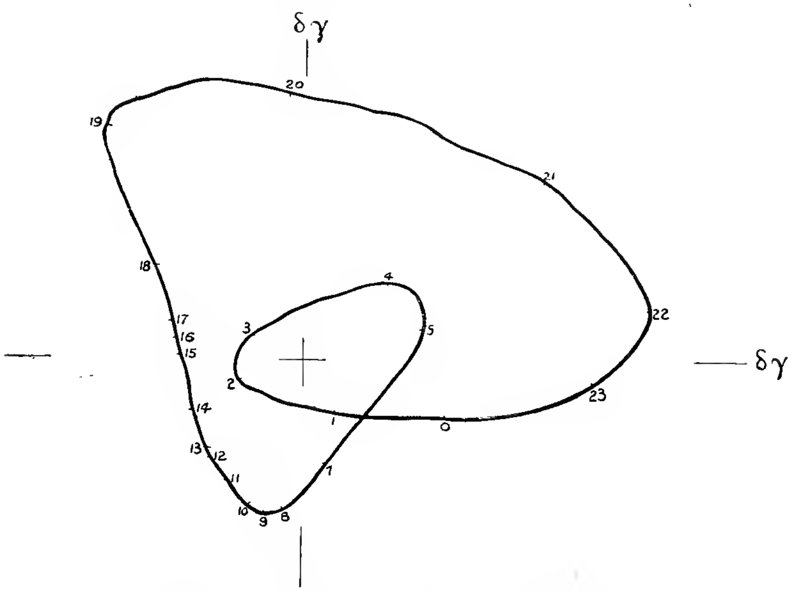


Fig. 2 Vector Diagram for the Cape of Good Hope.—June.

The daily variation of the dip is small, and not accurately known for the Cape.

If the magnetic elements are expressed in terms of the geographical components X, Y, Z, where $X = H \cos D$, $Y = H \sin D$.

H denoting horizontal intensity
D denoting the declination

the daily variation of X and Y may be expressed in the following way:—

$$\delta X = \delta H \cos D - H \,\delta D \sin D$$
$$\delta Y = \delta H \sin H + H \,\delta D \cos D$$

The vector diagrams for the Cape of Good Hope for the months of June and December are given in Figs. 2 and 3 respectively. These diagrams have been drawn from Sabine's data.

The complete figures show that X is most below the mean, X, Y, Z, in the summer months about 11 a.m. Cape civil time, and farthest above the mean about 3 p.m. In the summer it has a maximum value between 8 and 9 a.m., and is 10 γ above the mean; at this season its minimum value is about 6 γ below the mean between 10 and 11 p.m.

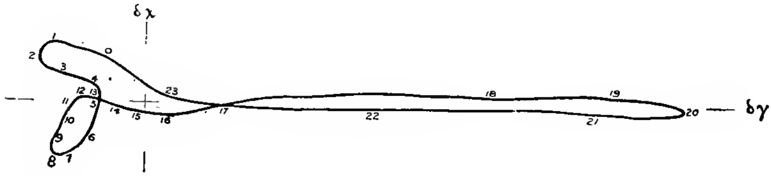


Fig. 3. Vector Diagram for the Cape of Good Hope.—December.

The maximum value of γ in the summer months is about 9 a.m and is 24 γ above the mean; the minimum is about 3 p.m., is 12γ below the mean. In winter the maximum value is about 14γ above the mean between 11 a.m. and 12 noon; the minimum—6γ below the mean—is obtained about 8 a.m.

SECTION II.—ANTHROPOLOGICAL.

1. UNCIVILISED MAN SOUTH OF THE ZAMBESI.

By W. Hammond Tooke, Assistant Under Secretary, Department of Agriculture, Cape Colony.

Ethiopes sao todos, mas parece
Que com gente melhor communicavam.
Camoens *Os Lusiadas*, V., 76.

It is the object in the following pages to describe the Native races situated south of the Zambesi and Cunene rivers as they were before they were influenced in their character and habits by intercourse with the white man. To describe them as they now are—in Reserves, Locations or Compounds—is foreign to the writer's present purpose.

I. BANTU.

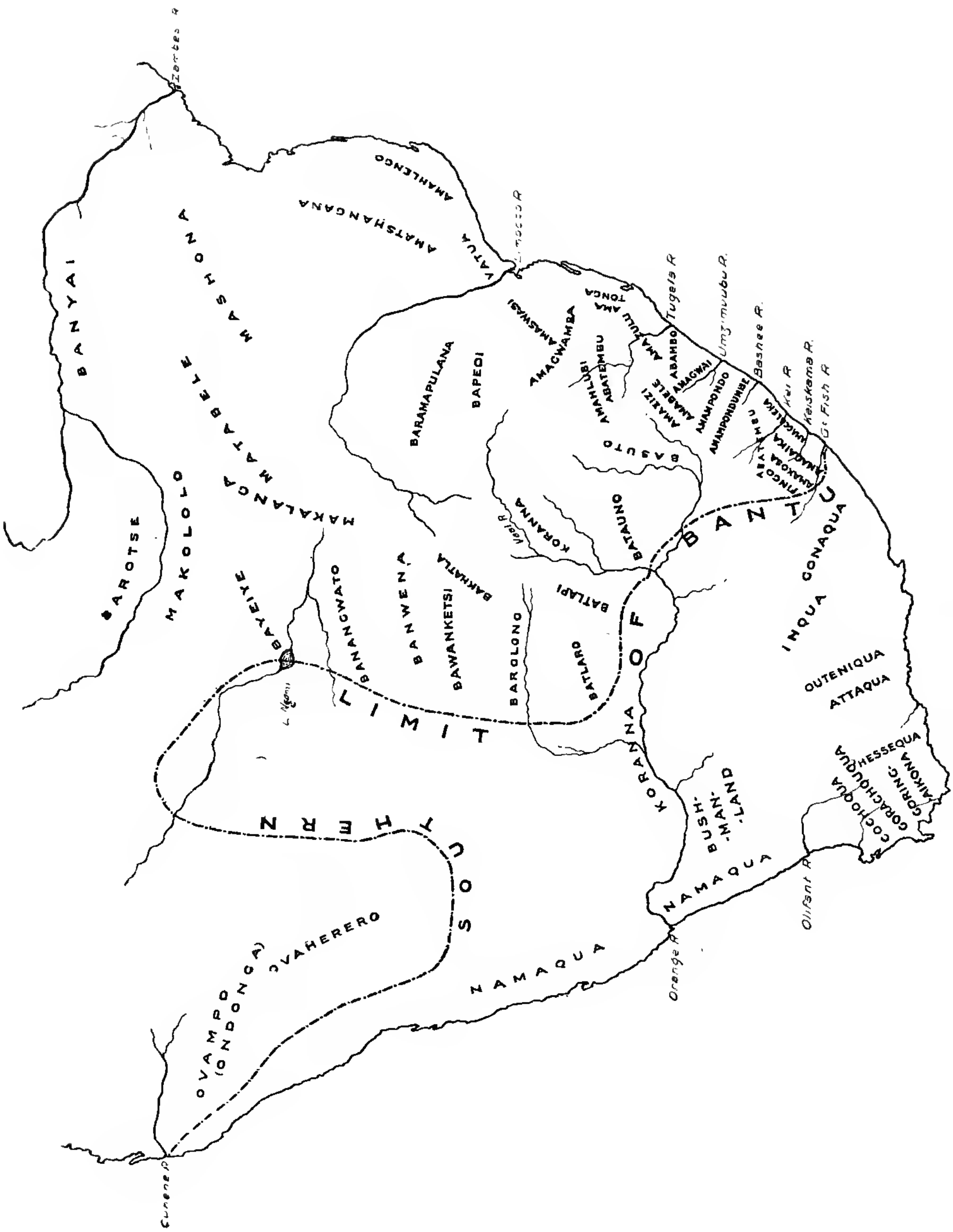
By far the greater number of Native tribes in South Africa belong to the race called Bantu.*

This term is, strictly speaking, applied only linguistically to tribes which show homogeneity of speech; but as they almost universally display a marked similarity physically it can fitly be used to designate one of the great families of mankind.

This statement must, however, be qualified by the remark that the Bantu differ little, bodily, from the adjoining negroid races in the Soudan, whose speech is entirely different; and, further, that the Bantu tribes, who live, or it is supposed once did live, on frontiers contiguous to districts inhabited by Hamitic, Semitic or Negro peoples are evidently of a mixed origin due to the infusion of foreign blood.

Together, therefore, with a general similarity of physical appearance is conjoined considerable variations in detail. In *colour* the Bantu are found of all shades of brown, from the sickly sallow of the Fan or Swaheli to the deep black of the Swasi; but in almost all cases can be detected a reddish ground-tint, leading some ethnologists to consider the original Bantu to have been a red race, which has mingled with the Negro, the Nubian and the Arab.

* "Ba-ntu," "aba-ntu," plural of mu-ntu, man, is a Bantu word meaning "people."


BANYAI
BAROTSE
MAKOLOLO
MATABELE
MASHONA
MAKALANGA
AMAHLENGO
AMATSHANGANA
VATUA
BAYEIYE
BANANGWATO
BANWENA
BAKHATLA
BAWANKETSI
BAROLONG
BATLAPI
BATLARO
BARAMAPULANA
BAPEDI
AMASWASI
AMAGWAMBA
AMA TONGA
AMAHLUBI
ABATEMBU
AMAZULU
ABAMBO
AMAGWAI
AMAZIZI
AMABELE
AMAMPONDO
AMAMPONDUMISE
ABATEMBU
AMAGCALEKA
AMANGQIKA
AMAXOSA
FINGO
BASUTO
KORANNA
BATAUNG
CONAQUA
INQUA
OUTENIQUA
ATTAQUA
HESSEQUA
CORINGHAIKONA
GORACHOUQUA
COCHOQUA
BUSH-MAN-LAND
NAMAQUA
KORANNA
NAMAQUA
OVAHERERO
OVAMPO (ONDONGA)
SOUTHERN LIMIT OF BANTU
Zambesi R
Limpopo R
Tugela R
Umzimvubu R.
Bashee R
Kei R
Keiskama R.
Gt Fish R
Vaal R
L. Ngami
Orange R
Olifant R
Cunene R

Variety of colour is probably much due to geographical position ; as a rule the tribes which inhabit low-lying coasts or humid localities are darker than those on the central plateaux or in arid districts. The *hair* is black, rather short, crisp or frizzly rather than woolly. The *skull* is generally dolichocephalic ; the *jaws* moderately prognathous or even orthognathous ; the *nose* varying from platyrrhine to leptorrhine ; the *eyes* large, black and prominent.

In height the Bantu ranges from 5 feet 8 inches to 6 feet. The bodily proportions are probably determined as much by external environment as by race. Occupation, food supply, climate, account for the difference in physique between the serf of the Kalahari, the trader of the Congo banks, the husbandman of Unyanyembe (the land of hoes), the man-catching Manyuema, the porters of Bihe and Zanzibar, the Herero herdsman, and the warriors of Zimba and Tshaka.

Such is the uniformity of the speech of the various Bantu tribes that it is really but one language of which there are many dialects. The vocabularies of these dialects consist of words practically identical, but subject to general laws of pronunciation, or dialectal transition of consonants. In some cases, beyond mere loan-words, terms have evidently been incorporated from Arabic, Hamitic or Negro sources. Structurally the language is unique, though it is closely united to the Fula languages, and has affinities with Polynesian and even, according to Bleek, with Papuan and Malay. Phonetic decay is more noticeable in some dialects than others, notably the Sechuana and Mpongwe. As to which is the most archaic, the specialist in each dialect is apt to claim the object of his study as the oldest and purest, and accordingly the eshi-Congo, the ci-Tonga, the otyi-Herero and the isi-Zulu and isi-Xosa have each been cited as most nearly approaching the primitive type.

The Bantu tongue is an agglutinative polysyllabic, prefix-pronominal language of which the most salient features are the noun classes and the concord. The nouns are divided into classes or genders which bear no relation to sex, although some of them indicate whether the noun is singular or plural, collective or abstract. This classification is effected by pronominal prefixes which influence the whole sentence in which the governing noun appears, and establishes what is called the alliterative concord.

The geographical area of the Bantu at present extends across the continent of Africa, from the Atlantic to the Indian Ocean. Its northern limit is defined by a sinuous line drawn from the Bight of Biafra to the East coast, a little to the north of the Dana River.

The southern boundary starts from the Cunene Mouth, avoiding the desert sand-belt on the coast ; trends southward until it reaches the latitude of Walwich Bay (long. 16° E.) ; then, in long. 20° E., runs north till it reaches the Botletle at Lake Ngami, when it again turns southwards through the Kalahari till it reaches Kuruman. Then south by east it reaches the Orange near Douglas, which it follows as far as Colesberg. From thence to the coast the boundary has been modified by the European occupation of South Africa ;

but at the time of the Dutch settlement it might be regarded approximately as being continued to the Great Fish River mouth by a line not deviating greatly from the present Midland Railway line.

The territory to the south and west of this boundary, where inhabited at all, was, at that date, peopled by the Hottentot and Bushman races.

The original home of the Bantu was undoubtedly to the north of the present northern limit. Sir H. H. Johnston, than whom no one has a wider knowledge of the subject, after locating it in various places, has finally decided in favour of the Uganda Protectorate.

From this cradle the tribes migrated along two diverging and separate routes: one, the Western, along the great Congo River system to the Gaboon, Angola, Damaraland; the other, the Eastern, past the Equatorial Lakes to the Eastern coast and so south of the Zambesi.

Thus did the "distant Ethiopeans" become—

> "A race divided, whom with sloping rays
> The rising and descending sun surveys";

—a fact apparently not unknown to the author of the Odyssey.

Innumerable must have been the wanderings east and west, north and south, of the tribes which have sprung up and split apart during the subsequent period of two or three thousand years. In historic times we may instance the raids of the Jaga or Mazimba hordes from the realm of Congo to Tette; from Tette to

> "Mombaza and Quiloa and Melind,"

whence the defeated remnants in their flight south scattered terror through Kafirland, whereby Xosa mothers still frighten their children with the man-eating bogey "Zim." A similar dispersion sent Kafir tribes flying before Tshaka as far south as the Kei, drove the Bechuana clans from Lebombo to the Langeberg, and even across the Zambesi; since when Zulu predatory hordes have continued to penetrate north, and still further north, until they reached districts beyond Lake Nyassa and even Lake Tanganyika. Great "Empires" also in the unrecorded past have doubtless risen and fallen, like those of Monomotapa and Uganda, Ulunda and Urua.

In the eighth century A.D. the Arabs and Persians had begun to establish themselves at Kambalu (Pemba) and Magadoxu, and to carry on a thriving trade between these ports and Maskat, Ormuz and Surat. The mariners and traders of Yemen and Oman came into contact with the Bantu tribes who had reached the East coast of Africa from the interior and called them the people of Zeng* from a Persian word meaning "black."

* Cosmas Indicopleustes, A.D. 547, says: "Beyond Barbari there stretches the ocean which has the name Zingion."

To the staid Oriental they had all the lightheartedness we we recognise in the Negro :

> "Splay feet and flat noses are defects indigenous in the Soudan ;
> And joyousness is the privilege of the inhabitants of Zeng."

For that reason probably, among others, they were held in abhorrence ;

> "Search not for thy parentage among the sons of Tagleb ;
> It were better to be kin to the people of Zeng."

El Masudi tells us : "They gave to God the name of Maklandjalo,'* which means the 'Sovereign Master' " ; but as they were not followers of the Prophet they were of course Kafirs—*i.e.*, "infidels" —a term which was adopted by the Portuguese and has clung to them to the present day. There is evidence, therefore, to show that in the tenth century the Bantu clans at Sofala were the ancestors in a direct line of the Zulu Kafirs who then, as now, were in the vanguard of the Bantu march south. Below Sofala the country was still apparently in the occupation of Hottentots (Wakwak).

The Bantu tribes living within Africa south of the Cunene and Zambesi are divided by philologists into five language groups ; these not only are also physically distinct but fall naturally into the existing politico-geographical areas. They are :—

A. The Zulu-Kafir group, dwelling in Cape Colony (Eastern Province), Natal, Matabeleland, Gazaland and Swasiland ;

B. The Gwamba or Tekeza group, dwelling in Portuguese East Africa ;

C. The Makalanga group, dwelling in Rhodesia, East and West ;

D. The Bechuana group, dwelling in Bechuanaland Protectorate, Basutoland, Transvaal and Cape Colony, North of the Orange ;

E. The Herero group, dwelling in German South-West Africa (Damaraland).

A. Zulu-Kafir Group.

As remarked above, the Zulu-Kafir group had in the tenth century A.D. advanced as far south as Sofala. At the beginning of the seventeenth century a mixed race of Hottentot and Kafir (Gonaqua ?) speaking a Bantu tongue were encountered on or near the mouth of the Umtata River by the shipwrecked mariners of the *San Alberto* (1599) and *Nossa Senhora de Belem* (1633).

In 1688 the crew of the *Stavenisse* found north of the Umzimkulu River (near the present Port Shepstone) Kafirs bearing the

*Or Maklangalu. Cf. Zulu Unkulunkulu. For El Masudi's description of the country and people of Zeng see his "Les Prairies d'Or," translated by De Meynard and De Courteille. Paris, 1841. Tomes, I, II.

now familiar names of "Magosse," "Maponte," "Mapontemousse," "Matimbe" "Magossebe" and "Emboa" (or Abambo).*

At the beginning of the nineteenth century, when Tshaka's precursor, Dingiswayo, was studying the British military system at Graaff-Reinet, Ngqika (Gaika) and Ndlambe (Tslambie), the Chiefs of a prominent branch of the Xosa clan, known as the Ama-Rarabe, were struggling for supremacy in the forests and kloofs between the Keiskama and Great Fish rivers.

These tribes are now located in the districts of King William's Town and Stutterheim.

Kawuta, the paramount Xosa Chief whose tribe, the senior Xosa clan, was afterwards under Hintsa and Sarili (Kreli) known as the ama-Gcaleka, built his kraals where the tribe is now located, between the Kei and the Bashu. The aba-Tembu, under Vusani, were situated between the Bashu and Umtata. They subsequently fled before Madikani across the Indwe to the present district of Glen Grey, where some still remain, the others returning to the north of the Kei. Either a branch of this clan or another tribe of the same name resided in Natal on the banks of the Buffalo (near Dundee). The ama-Mpondo under Faku and ama-Mpondumise were situated in what is known now as "Pondoland," but Faku had a territory much smaller than that which he subsequently gained by successful diplomacy after the Zulu invasions.

The chiefs of all these tribes claim a common descent from a reputed ancester, Zwide.

The ama-Baca and ama-Xesibi were living in the Mount Frere and Mount Ayliff districts, and in a portion of Pondoland.

Natal in those days was called Embo, or the home of the great ab-Ambo tribe, which subsequently split up into many large clans, the ama-Hlubi, the senior clan; the ama-Zizi, the ama-Bele, the aba-Sekunene, the ama-Ngwana, the ama-Nxaxina—in all Sir Theophilus Shepstone numbers ninety-four tribes.† All these were either exterminated by Tshaka and his lieutenants, Madikani and Matiwani, or fled under the name of ama-Fetcani (destroyers) or ama-Mfengu (wanderers, Fingoes) into the Colonial boundary within which, in the districts of Victoria East, Peddie and Idutywa, they have, after much tribulation, since resided—at first the allies, subsequently the fellow-subjects of the British. Some of these fugitives straggled through to the West, and were ultimately located at Bloemfontein and Carnarvon.

The ama-Zulu pursued their career of conquest and devastation *eastward* to San Lucia Bay where, under the name of Vatwahs, they were described by Captain W. F. W. Owen, R.N., in 1820; *northwards* as ama-Ntshangana (Shangaans) or aba-Gaza, under the Chiefs Gaza and Umsila, to "Gazaland," where they lived as a

*Ama, and, aba, are prefixes equally denoting the plural of a tribal name, but the prefix ama is generally attached to the names of tribes who have achieved some reputation or notoriety.

† The Lebombo was probably once the country of the Natal tribe, the aba-Bombo. Cf. Lesuto=Basutoland.

semi-independent tribe under Portuguese rule until the deposition of Gungunyama in 1896; *north-westwards* as ama-Ndabili (Matabele) under Umsilikazi (Moselekatje) until they crossed the Limpopo and rendered themselves a dreaded and annual scourge to the Mashona tribes. From thence still further north have predatory bands gone forth known as ama-Tshaka (Landeens), ma-Viti, wa-Viti, wa-Machudi, a-Ngoni, beyond Lake Nyassa and the Rovuma River.

The invincible ama-Swazi, and the people of the fortunate Faku, were the only tribes of the Zulu-Kafir who did not feel the wrath of the great Zulu despots, Tshaka, Dingaan and Cetewayo.

The colour of the Kafir is variable, the Tembu being of a light or clear brown, while the Zulu and Swazi are an intense black. Tembu girls, again, are considered the comeliest, while the Zulu men exhibit the most perfect specimens of manly vigour.

The head is long and high; the features vary between the Negro and the Semitic types.

The height and strength are above the mean Bantu standard.

The muscular strength of the Kafir is, however, not so remarkable as his agility and power of endurance. He is less sensible to pain than civilised man. With women, again, parturition is easy and almost painless; and a Xosa or Tembu mother will give birth while on a journey and walk for miles with her new-born child.

The Kafir is generally credited with marvellous powers of sight and hearing, but he owes his reputation probably not so much to the development of his sensory organs as to the incessant exercise of his perceptive faculties, and to the shrewd inferences he deduces from their use. His voice is powerful, and he can throw the liquid syllables of his language a great distance over the hills and valleys when shouting to his neighbour or uttering his war cry.

He is naturally averse to continuous toil, preferring to bask in the sun with his pipe and blanket while his women hoe the mealie patch or carry water. Nevertheless, with an incentive before him, such as the possession of a gun or a young wife, he will work long and arduously at the docks or in the mines provided he forms one of a gang or party so that the spirit of emulation may lighten his task. He can bear torture with considerable fortitude, but will not submit to it voluntarily to the extent that the Red Indian or Maori does, as a test of manhood, nor is he as susceptible as they are to such epidemics as small pox.

Lighthearted and careless, these people have a keen sense of the ridiculous. By some they are said to be devoid of gratitude, perhaps by those who have given them least opportunity for cultivating that virtue. Thieving is with them a laudable achievement and lying an elegant accomplishment. Notwithstanding, when placed in posts of trust they have proved themselves exceptionally honest and faithful.

Inflamed and enraged by actual conflict, they become cruel, treacherous and bloodthirsty, but this seems to have been less the case before Tshaka commenced his wars of extermination, and awoke and encouraged the ferocity latent in humanity. The old men told Sir Theophilus Shepstone how that in the good old times they did not fight to shed blood, or burn houses, or capture cattle or destroy each other, but to settle a quarrel and see which was the stronger; how that their women looked on while the men fought; that prisoners were taken but not killed, but kept till ransomed; and specially how that many a young warrior when the day's strife was over would hand his shield and assegai to a companion to take home for him that he might accompany his late foes to renew his vows to some daughter of the rival tribe.

Next to the disciplined warrior of the Zulu *impi* and the Swazi, semper invictus, the Gaika bore the highest reputation for warlike prowess; next to him the Gcaleka, the Tembu, and at the bottom of the list the pacific Pondo.

Before the introduction of maize, millet (*Holcus sorghum*) and milk formed the staple food of the Kafirs. "Neque multum pecore, sed maximam partem lacte atque frumento vivunt." The milk is kept in a skin bag or calabash and eaten curdled. The millet is eaten ground and boiled in water Maize was welcomed as a crop less liable to suffer from the attacks of birds, and the use of millet is now restricted to making "beer" (tywala). Meat Kafirs only indulge in on special occasions. Women had to do the hard, continuous work of hoeing the ground, sowing the crops, stamping the grain, but since the introduction of the ox-drawn plough the men now break up the soil. It is their work to milk the cow and attend to the dairywork, the women not being allowed by their presence or contact to pollute the cattle kraals or milk sack.

The Kafirs of Natal cultivated small patches of pumpkin and a sort of sugar cane (*Holcus saccharatum*), and sufficient grain to supply their beer and porridge; but they, and more especially those most to the south, are more of a pastoral than an agricultural people, cattle forming their principal wealth.—eaeque solae et gratissimae opes sunt.* Until they came in contact with Hottentots and Europeans they kept no sheep nor goats.

In his savage state the Kafir wore little except a scanty girdle round the waist, and to keep himself warm a kaross of buckskin or ox hide rendered pliable by his arts. The chiefs wore robes of leopard skins, and the tails of these animals were their insignia of office. No covering was ever worn on the head, but a circular head ring of wax moulded into the hair was the sign of manhood. The face was decorated with white or red clay. The women wore long karosses bound round under the armpits, concealing the breast; in the ample folds of this covering the baby swung from the back.

In times of war the leaders of the tribe wore the plumes of the blue crane (indwe) bound by a fillet round the head, thus adding to their height and menacing appearance. The assegais were formidable weapons with long trenchant double-edged blades made from

* Vide the "Germania" of Tacitus, from which *mutato nomine* a faithful description of the Kaffirs could be extracted.

native iron ore. Their javelins could be thrown by a stalwart Kafir some forty or fifty yards. Tshaka taught his regiments to break off the handle and use the shortened weapons for stabbing at close quarters. They carried large, oval ox-hide shields and knobkerries. Bows and arrows, though used by Bushmen and Hottentots, were never adopted by Kafirs.

Their dwellings were simple bee-hive huts, composed of a wicker frame constructed of young saplings, and thatched with reed, grass or skins. In size they were some twenty feet or so in diameter and seven or eight feet high. They were generally arranged in the form of a ring on the slope of a hill surrounding the cattle kraal, under which was kept the store of last year's grain. The huts of the chiefs or headmen were on the same plan but larger in size.

The scheme of government was simple and patriarchal. The chieftainship was regarded as herditary, descending from one celebrated ancestor, to whom lapse of time had lent divine attributes. A chief so descended is regarded with a reverence that is sacred in its character, notwithstanding that it sometimes yields to the striking personal qualities of a rebel like Rarabe or of a usurper like Ndhlambe. The Fingoes around Alice and Peddie lamented the defeat of Langalibalele, the Chief of the Hlubis and *de jure* paramount Chief of the Abambo tribe, which was scattered to the four winds two generations earlier by the Zulu regiments.

The chief, however, notwithstanding his divine ancestry, did not, as a rule, act despotically. He was surrounded by a council of "indunas," who consulted with him and confirmed all matters which were held to involve the general welfare of the tribe. Absolute authority conflicted in varying degrees, according to the personal influence and character of the chief, with the voice of the people.

All land was considered among the Kafirs in theory as the property of the tribe, for whom the chief merely acted as trustee. He could not alienate without the consent of the council. In practice, however, the custom was more honoured in the breach than in the observance, the chief acting as if the land were his own property. The arable ground he distributed among his followers. This land once allotted was rarely or never alienated, so long as it was cultivated by the occupant. Colunt discreti et diversi, ut fons ut campus ut nemus placuit. Like the ancient Germans, the Kafirs did not congregate in large villages.

The Kafir recognises two classes of offences—those against the chief and those against the individual. The former comprise witchcraft, murder, assault and injury to persons; the latter, rape, adultery, injury to property; the underlying principle seeming to be that the person of the tribesman is the property of the chief. In the first class the fine, if there is one, goes to the chief, in the latter to the injured individual.

The principle of collective responsibility for criminal actions is characteristic of Kafir law. This is especially manifest in the Spoor Law, which is administered on a system closely resembling the Anglo-Saxon system of frank-pledge.

When not vitiated by the behests of ceremonial law the medical practice of the Kafirs is rational, enlightened and scientific. Their surgery is also not unskilful considering their rude appliances. Much of their success is owing to their wide and peculiar knowledge of the medicinal qualities of certain herbs.

The chief ceremonial institution is the initiation of the young into the privileges of the adult. Circumcision, as in nearly all South African Bantu, is practised with elaborate rites. It is called ubukweta, and the corresponding rite among girls intonjane (intombi, a girl). Tshaka abolished circumcision and made his impis armies of celibates.

In Kafir marriage the indispensable custom is the lobola or gift of the bridegroom to the bride's father. This is practically the purchase money (in oxen) for the bride, who is generally disposed of to a wealthy suitor. In adultery the fine goes to the injured husband.

The Kafirs are great believers in fabulous creatures like the mbulu (tailed man), isandula (lightning bird), etc., and in all sorts of sprites and hobgoblins. They believe also in the spirits of the dead (amahlozi, isitongo), in propitiating whom their religion chiefly consists. Their word for God is Unkulunkulu, denoting the first man or progenitor; also Uhlanga and Itongo, the Great Spirit. He is an ancestral deity from whom all men trace their origin. Other terms for God are Tixo and Qamata, the former certainly, the latter probably of Hottentot derivation.

B. Gwamba or Tekeza Group.

The word Tekeza was applied by the Zulu to the language of these people, though it does not differ greatly from their own. Nor are they dissimilar in physique, occupation, ceremonial and religion, and they also practice circumcision. The tribes forming this group comprise the ama-Tonga of San Lucia Bay, the ama-Hlengo around Inhambane, the Natives residing in the province of Lourenco Marques and the ama-Gwamba of the Transvaal. Many of these tribes formerly resided in Natal, and were invaded by the Zulus (Vatwahs) under Tshaka. As fugitives the ama-Gwamba fled over the Lebombo Mountains into the Lydenberg district, where they are known as "Knobnoses," and have played some part in the Native affairs of the Republic.

Many individuals of this group are favourably known as labourers in the Cape Colony, where they are included in the general term "Mozambiques," applied to all Natives of Portuguese East Africa.

C. Makalanga Group.

It is unlikely that when the Sabæans or Minæans or Phœnicians exploited the gold fields lying between the Zambesi and Limpopo rivers the Bantu tribes had yet reached so far southward; and it is supposed that the territory was then occupied by Hottentots and Bushmen.

A considerable interval of time must have elapsed between the final departure of the miners for Arabia (or a more distant country) and the appearance on the coast of their Mahomedan descendants in the eighth century A.D.; and by that time the Bantu had probably arrived at the region now known as Rhodesia. In the sixteenth century when the Portuguese visited the territory they found tribes which, although since then raided by the wa-Zimba, attacked by the Portuguese and invaded and ravaged by the armies of Umsilikazi, have clung to the soil to this day.

These tribes are the ma-Kalanga (ma ka Langa or ma-Vumbe), the ba-Nyai, the ma-Suina (Mashona), located in the west, north and east respectively of Southern Rhodesia, and the ba-Yeiye, near Lake Ngami. They are all closely related, and in colour and physical attributes resemble the Zulu Kafir but are much less robust in form, strength and character. Many of the ba-Nyai are light café au lait, but the Portuguese described the "Mocaranga" as *black* with woolly hair, and as being handsome. Nevertheless they called them a "feeble folk" (gente fraca), the cause or result of their comparatively peaceful avocations; for they preferred agricultural to pastoral pursuits. They reared sheep, however, and a small breed of cattle, and kept swine and poultry.

A sub-tropical climate enabled them to grow orange and lemon trees, vines and fig trees. These they now cease to cultivate, but when visited by Livingstone they still planted sugar-cane, millet, beans, ground nuts, pumpkins, watermelons and cucumbers, and, in addition, the comparatively lately introduced maize. They made butter from a vegetable oil, and, from the millet, bread and the inevitable beer (pombe). Their artificers manufactured ornaments from the gold collected from the rivers and implements of iron, hoes, hatchets, arrow heads, assegais and swords, and wove cotton cloth for the use of their chiefs. Skin robes were worn by the common people.

Their houses resembled those of the other tribes we have mentioned in being round in shape, constructed of wood, but with conical roofs thatched with grass or reed and furnished with mats; and there is no reason to believe that the famous "city" (cidade) of Zimbaohe or Zimbabwe was much, if at all, superior to Ginginghlovu —the "great place" of Tshaka. Yet, if the Portuguese accounts are to be believed, Monomotapa and Kiteve, Sedanda and Tshicanga were very great monarchs who held an elaborate court and dwelt in great magnificence; and it may really have been that intercourse with the Moors and Arabs of the coast allowed of these potentates attaining a degree of civilisation equal to that reached by Mtesa in the palmy days of Uganda, and excelling the "tawdry empires" of Congo in the seventeenth, and of Muata Yamvo and Cazembe in the early days of the last century. The ruins of the ancient temples and forts were perhaps too mysterious and sacred in their character to be utilised for secular purposes and on too great a scale to be imitated. They were the scenes of some of their religious festivals and in some cases the granite blocks have apparently been taken for their cattle kraals.

The exploits of the "Conquistador dos Reynos," Francisco Barreto, and his successors, put an end to this splendour and the civil war between contending chiefs, the slave trade and a gradual disintegration of the tribes supervened; through all which the inoffensive Native continued the cultivation of the kindly fruits of the earth until Umsilikazi and his hordes burst on the scene and converted the country into a desert. The timid tribes were subjugated by the Matabele, and up to the death of Lo Bengula his impis raided periodically the grazing grounds and gardens of the hapless ma-Suina, forcing them to take refuge amid the clefts and crannies of the granite outcrops of Mashonaland. The ba-Yeiye were driven into the waterless plains of the Kalahari. The ma-Kalanga enjoy comparative immunity under the rule of the chiefs of the ba-Mangwato. Among the ba-Nyai the government is a sort of feudal republicanism. The chief is not hereditary but selected from the royal house. The nephew generally is chosen.

The ma-Kalanga (a name supposed to mean "people of the sun—langa") shared the usual Kafir belief in a God, "Molungo," who, as described by Dos Santos, "lived in a heaven of his own." Other authorities, Pory and Gravenbrock say he was called "Mozimo" or "Messimo." The ma-Suina of to-day have sacred "lion" gods or prophets, to each of whom they offer prayer and sacrifice and call "Mlimo" or "Mondoro." These prophets did much in prolonging the Mashona insurrection. Among the ba-Nyai lions were never destroyed, as the people believed that the souls of their chiefs entered them not only after death but during life. This doubtless is the fundamental idea of the Mashona "lion" prophet.

Selous stigmatises the ma-Suina as avaricious, cowardly and callous. Indeed, he says that if an angel were sent among them they would kill him for the sake of his wing feathers if they were of any value. The ma-Kalanga he calls industrious and peaceable.

D. Bechuana Group.

Although it is undoubtedly Bantu in language there exists so great a difference between the group of Bechuana dialects and those of other Bantu tribes, in phonology especially, as to lead some authorities to rank it (with the Makua) as a distinct class of sub-family. There are further differences in temperament, clothing, customs and religion which emphasise this distinctive character of the Bechuana and which lead one to account for their present position in South Africa by a migration from the north or north-east by a middle route much more recent than were the earlier Eastern and Western migrations of the main body.

The various Bechuana tribes seem themselves to have been conscious of this resemblance between each other and their difference from other Bantu, since they give themselves, what is unusual among Bantu, a generic appellation for their group of clans, viz., "Bechuana" (the people who are alike), which is rendered in Herero "Ovatyaona" and "Mationa." The Hottentots and Namaqua called them Birina or Briqua (goat people).

In height the Bechuana are but little if any shorter than the Kafirs or Zulus. Like them also there is considerable variety in tint. Generally they are lighter in colour than the coast tribes, and the sickly sallow of the ma-Kololo is commented on by Livingstone. The Zulus call them Abasunda or Abesuta (whence "Basutu") from a word meaning dun coloured or brown. Invariably the red under tint is perceptible.

To quote Ratzel, "der Betschuana stellt in der ausseren Erscheinung die weichere mildere Ausprägung des Kafferntypus." The body is slenderer than the Kafir's; the aspect softer and gentler, the motions less rough and brusque, the strength not so great. But while the common people are in no way either physically or mentally superior to other Bantu, we frequently find in the ruling caste unusual intellectual power, which leads us to suspect that, as in the case of the Uganda and Unyoro hereditary chiefs we have the descendants of a superior race ruling over one inferior. We may instance the cases of Sebitoane of the ma-Kololo, Sechele of the ba-Kwena, Khama of the ba-Mangwato, and Moshesh of the ba-Suto.

The Western tribes, owing doubtless to remoteness from the coast and its troubled politics, have attained a higher level of civilisation than those in the East. The houses, although circular, are better made, and enclosed with fences to secure privacy. The conical, thatched roof comes down over the walls in eaves, and the whole building is more substantial and commodious. These houses are not clustered in little groups like the kraals of the Kafirs, but form large towns or "stads," with populations extending to ten or twenty thousand inhabitants, such as Kolobeng, Shoshong, Palachwe. Indeed, the mo-Chuana might be said to lead a town life, and prefers to relegate the duties of herding the cattle at his distant posts to serfs or slaves like the ba-Kalahari, or ba-Lala, or ma-Sarwa Bushmen.

Unlike the Kafir, of whom magna est corporis pars aperta, the mo-Chuana wraps himself up in an ample kaross. The women do the same, and besmear their hair with a glistening ointment of fat and mica dust. To the weapons of the Kafir, the mo-Chuana adds the battle axe. The assegai is smaller, as also the shield, which is of a dumb-bell pattern, and not the large long oval of the Zulu.

Like most Bantu the be-Chuana practise circumcision (boguera)* which is performed at the age of puberty. Among some tribes the novitiates are flogged with rods, like the Spartan youths before the image of Artemis, and with the same object—to test their fortitude. The be-Chuana have also a ceremonial initiation of the nubile female into the household and domestic duties of womanhood (boyale), which compares very favourably with the repulsive rites of the Xo a intonjane.

*According to Livingstone boguera is rather a civil than religious rite.

Notwithstanding this agreeable feature we are told that among he Eastern or Mountain be-Chuana sexual immorality is much more rife and unbridled than among the Coast tribes.*

The be-Chuana are, however, remarkable for their honesty, a virtue which has been noticed from Livingstone's time (among the ba-Kwena and ma-Kololo) to the present day among the ba-Tlaro.

They believe in a chief spirit, Morimo, powerful and malicious, but which unlike the Unkulunkulu of the Kafirs seems to bear no ancestral relation to his worshippers. They also, like the Kafirs, believe in the spirits of the dead ba-rimo, with which the priests or senyaka have intercourse. As might be expected in an arid region, where the rivers flow underground, the rain-maker holds a more conspicuous position than the witch-finder. Many tribes bear the names of animals from which they would seem to claim descent, and whom they certainly as their siboko† regard as sacred. Thus the ba-Puti, or " duiker " people, refuse to eat the duiker (cephalophus grimmi), and the ba-Kwena or " crocodile " people hold that saurian in great reverence.

In the main the Bechuana clans maintain the same geographical position as they did when first enumerated by Mr. J. Campbell in 1813.

Of the Western group the ba-Mangwato under Sekhomi and his son Khama; the ba-Kwena, under Setyeli (Sechele, Livingstone's friend); the ba-Wanketsi, known as Gassisive's tribe, now under Bathoen; the ba-Khatla, under Linchwe; the ba-Malete, under Ikaneng, have long dwelt in what is now known as the Bechuanaland Protectorate, the first-named being the most northern, the others in the order named situated more to the south.

The ba-Rolong have their kraals on both banks of the Molopo River. Their situation on the Transvaal boundary involved their Chiefs, Montsiwa and Moshette, in the Boer raids into Stellaland and Goshen. A branch formerly resided in the Orange Free State under Moroko, but was broken up by the burgher government.

The ba-Tlaro, under Toto, lie to the west in the Langeberg (Gordonia). The ba-Tlapi or fish-folk under Mahura, Mankoroane and his son Molala, are now in the Taung Reserve. The ba-Taung or "lion" people, whose chief Molitsane used to be a thorn in the side of Moshesh, are now practically dispersed, a small remnant still remaining in Herschel. In the Transvaal are located the ba-Mapela, ba-Makapan and the ba-Pedi or ba-Peri, well known as Sekukuni's tribe. The followers of Mapoch, Malapoch and Malewa are probably mixed Matabele and Bechuana, as also the scattered fragments of clans scattered by the Zulu and re-united under Ramapulana, a chief of much ability, in the Zoutpansberg district.

The ba-Suto were originally ba-Kwena according to their chief Moshesh, who, like the head of the ba-Ramapulana, collected the waifs and strays of fugitive clans escaping from Tshaka, and by the

*G. Theal. History of the Boers, London, 1887, pp. 15-18.

† Cf. Xosa-Zulu: isibongo, song or title of praise.

force of his rare intellectual qualities welded them into a homogenous nation, formidable once to Boer and British, but now wealthy and prosperous.

Sebitoane, his reputed half-brother, led another horde, the ba-Tlokwa, better known as ma-Kololo, flying from Moselikatze (Umsilikazi) as far as the Zambesi, which he crossed close to the Victoria Falls, and established the Barotse empire, in which most of the ma-Kololo were finally merged—according on one story, by the ba-Rotse (ba-Rozwe), on the death of Sebitoane's son and successor, Sekeletu, from leprosy, rising against their conquerors and killing all the males but sparing the women and girls whom they took into their kraals.

However this may be, the Sekololo language was imposed on the ba-Rotse much more effectually than the Normans' tongue upon the Saxons, and remains the speech of an alien tribe.

Another such horde, the ba-Tlokwa, sometimes confused with the ma-Kololo, whom in fact they preceded (1823) under their chieftainess, Mantitis, swept across the southern portion of the Transvaal in a north-westerly direction until routed by the Griquas near Lithako. This tribe, much reduced in number and power, became ultimately broken into fragments, of which the largest band was finally exterminated by Moshesh, and the chief Sikonyella, the son of Ma-Ntitis, ended his days in obscurity near Herschel.

Individual members of this extinct clan, driven as fugitives hither and thither, are still called by the Boers " Makatees." Hence probably the Kafir word for Bechuana, " amahadi."

E. The Herero Group.

Of this group the ova-Herero or ova-Tyimba and the ovam-Bandieru are the type. These two clans really constitute but one tribe, the Herero. Their speech approaches most nearly what is considered to be the archetype of the Bantu tongue, and seems of all its dialects the least influenced by phonetic decay or change of grammatical structure.

Physically they are one of the finest of the Bantu tribes, having finely-modelled figures indicative of the strength which they are known to possess. Their skin is dark and the features good, but their mental equipment is not of a high order. Indeed, they seem in disposition rather bovine, as befits their bucolic pursuits. Thus, notwithstanding their bodily advantages, they have almost invariably been defeated by the Namaquas, by whom they are called Damap, Damara, or the conquered people. This is accounted for, however, by the superiority given to the Hottentot by the possession of horses and guns. That a warlike spirit, hitherto latent, still exists has been discovered by the German troops, somewhat to their surprise.

Their clothing is scanty, consisting of a few skins, but, unlike the Kafir, they abstain from going entirely nude. Their weapons are a small assegai, light bow and arrow, knobkerrie, and small adze or axe. The women wear an extraordinary head-dress with upright lappets resembling the eagle wings of a Viking's helmet.

The Herero, as explained, are chiefly pastoral, and keep a good breed of cattle. Sheep are held in less esteem, and goats are despised. Their chief food is the ground nut and sour milk.

One striking characteristic of this tribe is that, unlike the Bantu generally, who circumcise at the age of adolescence, they perform this operation on children between the ages of four and seven.

Another singular trait is the sacred fire, omurangere, kept burning at the chief's kraal under the charge of one of his wives (the ondangere). A further peculiarity is the belief that all living things emanated from the sacred tree (omumborombonga). Their God they call Karunga Ondyambi, or "heavenly restorer." He is also called Mukuru, "whose abode is in the north." From the north, they say, they came themselves (notwithstanding the tree legend), and to remind themselves of that fact they, when burying their dead, place the face of the corpse in that direction. According to Andersson they must have come from the east or north-east, and probably arrived at their present habitation not many years ago. The oldest name that they give themselves is ova-Tyimba, and in view of these facts considered with their fine physique and lately exhibited valour, it has occurred to the writer as not unlikely that they are remnants of that terrible tribe the Jaga or ma-Zimba (Makalanga pronunciation)* who, starting from the Congo mouth, twice swept across the continent and disappeared westward about two hundred and fifty years ago. The disorganisation caused by the rout and disintegration of these people would account for the Herero chiefs having little power, and for the tribes being broken up into little bands; and this would also furnish another reason for their ill-success against the Namaqua and Koranna. Kamaherero is the best known of the chiefs, and was generally recognised as paramount during his life time, though in Galton's day there were four or five principal chiefs.

A tribe included in this group as closely akin in speech is the ov-Ampo or ova-Ndonga, who live north of the Herero, extending up to the Cunene River. This is also a finely-made race, but more ill-favoured in feature. Unlike the pastoral Herero, the ov-Ampo are agricultural, and their country, Ondonga, is described as beautiful and park-like, covered in season by golden grain interspersed by fine fruit-bearing trees. They grow two varieties of millet, beans and peas, which they manure from the cattle kraal. In addition to oxen and sheep, they keep goats, dogs and poultry. Every homestead has its milch cows attached, and is supplied with water from wells.

Their word for God is Karunga and Umthithi.

II. THE YELLOW-SKINNED RACES.

The limits of space imposed upon me do not enable me to do more than make a passing reference to the yellow-skinned races

*Herero Ndy=Z of Makalanga and other Bantu tribes. Compare Ndyambi, God, Herero, Zambi.

which have inhabited South Africa. Although the similarity of colour, which varies in both races from pale ivory to cafe au lait, but which is generally a dirty yellow—and its contrast with the dark brown or black of the Bantu leads the cursory observer to regard the Hottentot and Bushman as nearly related, a closer examination of their physical and mental qualities, as also of their customs and life history, reveals the broad gulf that lies between them. This was recognised by the first Dutch settlers who, while calling the Hottentots Strand-loopers or Tobacco thieves, and such like epithets, gave the Bushmen the same names that they had bestowed in Sumatra on the Orang-utan, "Bosmanniken." The Kafirs also appreciated the distinction and while calling the Hottentots as a race Abalawu, designated the Bushmen Abatwa.

The Bechuana called the Bushmen Baroa, the Kora Hottentots (Koranna) Bakhotu; the Herero called the Bushmen Ovatua, the Nama Hottentots (Namaqua) they called Ovaseranda (red men) or Ovakuena, a word adapted from the name the Hottentots gave themselves, Khoi-khoin or men of men. The Hottentot name for the Bushmen was San, Sonqua and Obiqua or robber.

While the Hottentot is of medium stature, averaging 5 feet 5½ inches, slenderly but well proportioned, the Bushman is dwarfed, rarely exceeding 4½ feet and ill proportioned, with large head and pot-belly. In both races there is a tendency to steatopyga, but as that is observable also among Boer women and even the sheep of the country this cannot be considered as a racial distinction, and is probably owing to climate. The woolly hair of the Hottentot is a dense dead black; the peppercorn tufts of the Bushman are a rusty brown. In both races the skull is dolichocephalic, but the Hottentot is more prognathous than the Bushman profile.

The dwellings of the Hottentots are beehive huts ranged in clusters or kraals, like those of the Kafirs, and like theirs also made of wattles covered with skins. The home of the Bushman is the shady cover of a kameeldoorn, a rough "scherm" of branches and skins on the lee side of a clump of bush, or a crevice or cave in the cliffs overlooking a stream. The ordinary clothing of the Hottentots and Bushmen did not differ much except that the skins worn by each were better dressed in the case of the Hottentot. In cold weather, however, the Hottentots wrapped themselves up in karosses described by the Portuguese in the fifteenth century as made "after the manner of French cloaks"; those of the Namaqua were frequently made of leopard or wild cat skin. The women wore ampler covering, and skin caps decorated with beads and shells. The weapons of war of the Hottentots were the assegai, the kiri and the bow and arrow; the Namaqua also used the battle axe. The Bushman was only armed with his tiny bow and poisoned arrow, but having this weapon the "brown serpent of the rocks" was more formidable than either Kafir or Hottentot.

A few arts were practised by the Hottentot. They made a rude clay pottery and carved wooden bowls and pipes, and obtained, by smelting, iron which they beat into spear blades and other articles.

The Namaqua worked up the native copper found in their territory into beads.

The Bushmen had but one art, in which they far excelled other more advanced tribes. Their rude rock paintings displayed not only much artistic skill, but considerable humour.

The Hottentots were a pastoral race, grazing their large, long-horned, slab-sided cattle, and their long-haired, fleshy-tailed sheep over the grass veld and Karroobosch. The Bushman was a hunter only—a hunter of rats and mice and such small deer. "The countless springbok are his flock" when times are prosperous, but in seasons of short fare he contents himself with the lizard and the locust. The social organisation of the Hottentot is tribal, of the Bushman so primitive that it does not even deserve to be called patriarchal, and might be more fitly described as parental. While the Hottentot is polygamous and gregarious, the Bushman is monogamous and unsocial. The position of woman is one of equality in both races, and thus superior to that of the Bantu female.

The language of the Hottentot is agglutinative, sex denoting, pronominal affixing. In its elaborate grammatical structure it may be compared with the Greek or German, but, according to Bleek, its closest affinities are to be found in Northern Africa. Four dialects are known to have existed—I., the Cape dialect, spoken by the Goringaikona, Gorachouqua, Cochoqua, Hessequa and other Western tribes ; II., the Eastern, spoken by the Gonaqua and probably also the Inqua, Attaqua and Outeniqua ; III., the Namaqua, spoken by the tribes north of the lower course of the Orange ; IV., the Koranna, spoken by tribes ranging along the Upper Orange and Lower Vaal rivers. Massouw's tribe near Vryburg and Goliath Ysterbek's band at Bethanie (O.R.C.) seem to have reached the extreme eastern limit.

It is doubtful whether we know the real language of the Bushman. It was probably rich in clicks, some only of which have permeated the Hottentot and Xosa dialects. The language they were known to speak resembles a corrupted *patois* of Hottentot, bearing to it the same relation as Koranna or Griqua Dutch does to the language of Bilderdijk and Beets.

The religion of the Hottentos and Bushmen, like that of the Bantu and Negro on the West Coast, partook more of the character of nature worship, astral and animal, than of ancestor worship. The Hottentots were, as Captain Cowley puts it, "worshippers of Dame Luna," to whom they danced in the long moonlight nights as the coloured people still continue to do. They also paid reverence to a mysterious being called Tsui-goab, or Heitsi-eibib, who wrestled like Jacob with an antagonist, in this case not from the upper world, but from the realms of darkness, who wounded him in the knee. Whether this variant of the Penuel incident may be regarded as another form of the Manichæan principle of the contest between Good and Evil, or, as the school of Max Muller affirm it is, a solar myth representing the struggle of Red Dawn (so Hahn translates Tsuigoab) with "Blackest Midnight," or whether the euhemeristic view be taken, that we have here merely the struggle of some Namaqua hero with a Bantu or Negrito foe I leave to the choice of he reader.

The folk-lore of both races is rich in star-mythology and beast fables. Among the Hottentots "Brer Fox," alias the jackal, plays a leading role, and among the Bushmen the *Mantis religiosa* or "Hottentot God." Each animal in these tales speaks its own *patois*, in which the clicks are an important feature.

The geographical distribution of the Hotten ots when the Dutch a rived did not extend beyond the Orange River basin, but at one time must have reached as far north as Angola, Sofala, and perhaps Kilimanjaro. We have no information as to their original home, although linguistic affinities point to the Western Sudan. If so their retreat has been cut off by later Negro and Bantu migrations from Central or Northern Africa to the West Coast.

I can see nothing to justify the theory held by some ethnologists that the Hottentot are a mixed race derived from a union of Bushmen with Bantu, seeing that the latter at the date the Zimbabwe buildings were erected were not in contact with the races occupying Southern Africa. The Hottentots had probably established themselves then as a distinct race long before the fusion, in the Nile valley or Lake region of Negro and Hamitic or Negro and Semitic into Bantu ever took place. The close conformity to, and persistency of, the type, so different to the variability of the Bantu, is a strong proof of their purity of strain.

Of the cradle of the Bushmen we can say still less than we can of the Hottentot, and the question is further complicated by the sporadic distribution of yellow-skinned dwarf tribes throughout the Continent from Khartoum to Cape Town. Shell mounds at the Buffalo mouth, supposed to be formed by this race, date back to a geologic age coæval with or equivalent to the River Drift of Great Britain. Throughout the country south of the Molopo and Vaal rivers—Stormberg, Stellenbosch, Griqualand West—stone implements of various ages, ranging from the geologic period just mentioned to the time of European occupation, are found mostly of Bushman origin. but the spear heads and pottery found in the sand dunes around Table and Algoa Bays are probably the manufacture of the Hottentot "strandloopers."

The Hottentots were by no means a bloodthirsty or warlike race. Although probably far outnumbering the Bushmen they were no match for these malicious and audacious marauders. Although the advent of the Dutch hastened their disappearance as an independent race yet it seems probable that if no European had landed on South African shores the extermination of the Hottentots would ultimately have been effected by their insidious and diminutive foes. As it was they were preserved from starvation and stealthy massacre by being merged into the other races, white or coloured, of the Cape Colony. The Namaqua and Koranna alone still maintain, if not their purity of blood, their tribal entity. They have retained their language, but lost many of their original customs and beliefs, and have adopted the clothing and other characteristics of the European.

The admixture of white blood, and the use of the horse and musket rendered some of the border clans formidable for mischief, and half-bred bandits like the Bastards and Griquas under Afrikaner, Barends, Waterboer, and Kok displayed at one time much active ferocity. They are now, however, sinking into listless apathy noticeable in the Griquas of Kokstad and Reitfontein, settled by Government in the Transkeian territory.

The extermination of the Bushman was for a long time regarded by the Cape Government as a matter of State policy. Neither peace nor truce was possible with a race so utterly untameable and aggressive, and commando after commando went forth to destroy the savage little robbers who swept off the stock of the Boer, as they had swept off the herds of the Hottentot, and who neither granted nor sought quarter. The few bands, which have not been scattered as herdsmen among the Dutchman's farms, lurk in the sands of Bushmanland and in the crags of the Drakensburg, or are held as serfs by the Bechuana of the Kalahari.

III. BERG DAMARA.

One tribe remains to be noticed, which except for its stunted stature is physically undistinguishable from the Bantu, while mentally it is inferior to the Bushman. I refer to the Ghou Damup or Berg Damara, who live as neighbours to the Herero and Namaqua. Driven to the hills by the Hottentot Kapteyns, they have lost their own speech and speak a Hottentot *patois*. It is a matter of doubt whether they are a degraded off-shoot from the Ovampo or the sole remnant of an earlier Negrito (Negrillo) race, the veritable South African autochthon, the primitive Homo æthiopicus of Keane, whose traces we see in the neolithic and perhaps palæolithic remains of the Transvaal.

APPENDIX I.

Comparative Table of a Few Bantu Words.

English.	*Zulu-Kaffir.*	*Tekeza.*	*Kalanga.*	*Herero.*	*Chuana.*
Man	u-muntu	amuno	munttu	omundu	motho
Goat	im-buzi	em-buti	—	ngombe	pudi
Ox	inkomo	omo, homo	ngombe	ongombe	kgomo
Fowl	inkuku	inko	nko	ondyuhua	kgogo
Snake	inyoka	—	inyoka	onyoka	noga
Tree	umti, umuti	mure	muti	—	—
Rain	imvula	—	ivura	ombura	pula
Water	omanzi	mati	madzi	omevo	metse
Moon	nyanga mweze	muezi	—	—	—
Sun	—	—	—	—	—
God	Unkulunkulu U Tixo, U Qamata	Mulungu	Molungo Reza, Mozimo	Mukuru Ondyambi	Morimo
Three	tatu	raro	tatu	tatu	raro
Great	kulu	—	urwana	kuru	golu
Below	ezantsi	kunsi	kusi	kehi	fa-tla-se
To see	uku-bona	—	u-wona	oku-muna	go-bona
River	umlambo	nambo	—	—	molapo

Number of Pronominal Prefixes in

I.	Zulu Kaffir	14
II.	Tekeza	12
III.	Makalanga	13-15
IV.	Herero	15-18
V.	Sechuana	12-13

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2. THE STONE AGE IN SOUTH AFRICA.

By L. Peringuey, Assistant Director, South African Museum.

General.

In 1866, the late Sir Langham Dale discovered close to his residence on the Cape Flats, near Cape Town, stones showing traces of chipping.

It is worthy of note that some of these implements are the most perfect of their kind found, as yet, in South Africa.

This discovery was followed by others in the Cape Colony, at Kimberley, where they lay imbedded in the claims "intermixed with the precious stones of the diamond diggings," East London, the Orange River Colony, Swaziland, the Transvaal, and Southern Rhodesia. In fact, these implements of primitive civilisation, be they lance or arrow heads, scrapers, hatchets or battle axes, smiting or throwing stones, perforated discs, pounders or mullers, minute or huge, abound all over South Africa from West to East, from North to South, exposed on the surface, or occurring in the "middens" of the sea coast when not ancient, or, when of more remote antiquity, imbedded often very deeply in alluvial deposits or the talus of mountains.

That there are two, if not three types of implements, cannot be doubted.

On the one hand we have some instruments almost puerile in their aspect and often having no particular shape other than a cutting edge, such as we know to have been used only yesterday by the little yellow men of the Khoi Khoin race, or others, better finished, sometimes of a superior workmanship, but never worked on both sides, *i.e., they have always an unchipped face.*

On the other hand, again, we find implements often so large that only a most powerful race could have made use of them, weapons more often of rude workmanship, but occasionally also of a finish that can bear comparison with the best implements of the St. Acheul type, and which in every case are worked on both sides, *i.e.*, have both faces *chipped into facets*. This applies, of course to weapons of offence or defence.

That we have two periods, a palæolithic and a recent one, is indubitable, but there is no evidence as to the time when the former was replaced by the latter, and this point must for long remain conjectural.

Recent discoveries, however, lead me to think that there has been a neolithic period evolved from the palæolithic, although not comparable to the evolution of the palæolithic age into the age of the polished stone, as instanced in Europe and elsewhere. If we assume that the ruder the type the older it is, the better finished weapon of the same type must prove to belong to an exclusively neolithic age. Yet this neolithic age may be replaced by one of a recent period, exhibiting distinct traces of retrogression, and having nothing in common with it, and this is what seems to have taken place in South Africa.

Neither geology nor palæontology have enabled us so far to obtain a clue to the possible age of this quartenary period, in the case of the first, because material of a palæolithic type and of the highest finish, as well as of a ruder kind, have been found together in valleys where no traces of old river terraces could be traced, whereas material of the same type, but perhaps of a less well-finished kind, has been found where such terraces are said to exist; in the case of the second, because no remains of extinct or still living animals have as yet been found in connection with the deposits or "stations" where the implements occur.

Implements of this type, however, have been found made of a surface quartzite which is forming at the present day; these instruments cannot therefore be very ancient, unless indeed they belonged to a period of transition, a presumption for which there is, I think, no foundation.

On the whole, the quartzite implements are wonderfully well preserved, and the edges as sharp as if they had been made quite recently.

I have not as yet met with any evidence that the implements of the palæolithic type were used for barter, I think that such has not been the case, because the best finished ones found in the neighbourhood of Stellenbosch and Paarl differ greatly from the best finished ones found elsewhere.

The banded jasper ones of Griqualand West, which, however, resemble in workmanship, but not in material, the weapons of Vereeniging, occur only in Griqualand West or its neighbourhood.

As for the smaller implements of the recent or, perhaps more rightly called, present age type, the same cannot be said of them, and some have been found where the material of which they are made of is known to be absent. These may have been obtained by barter, but it is more likely that they were carried by owners of a migratory or widely roaming disposition.

For both periods the hardest stone available has been made use of. Thus, for the implements of palæolithic type it is the closely grained Table Mountain sandstone, where that occurs, or other hard quartzite, where it does not, especially in the South-Western part of the Cape Colony; dolerite, shale indurated by dolerite, or quartzite at Vereeniging; jasper in Griqualand West; surface quartzite at Darling and on the confines of Namaqualand; Dwyka chert in the Karroo; for the neolithic implements it is a flint-like chert, sometimes obsidian in Swaziland; the cherty sandstone of the Cape Flats, quartz crystals, agates in the Cape and Orange River Colony, Vereeniging, Johannesburg, etc. All the implements are chipped either on one side or both, but none have yet been found ground or polished by man.

Recent Period.

It is singular that just as the best finished weapons and implements referable to a palæolithic period have been found in the vicinity of Cape Town, a still more restricted locality, the Cape Town Flats, usually called the Cape Flats, have yielded also the finest examples of weapons connected with the recent period. On these Cape Flats are found in addition to, and in conjunction with flakes, knives, scrapers of the usual type obtaining everywhere, and upon which no special care was bestowed, implements, mostly arrow or javelin heads, evincing great care in the making, but chipped on one side only. They are never large, nor have they at the base any notches or tangs that could have been of use for fastening them to a haft, the bulb of concussion is always conspicuously bulging. These are made of a cherty sandstone of extremely close texture, said to be of tertiary age. Implements of this kind have been obtained from middens and other places in the Western Province of the Cape, the Midlands, the Eastern Province, and the Orange River Colony, but the material differs, and the workmanship is usually of a much ruder kind. But whatever the material or the degree of workmanship, these implements do not occur in deposits, nor have they, like those of the palæolithic type, accumulated in the alluvial deposits in the valleys. They are found on the surface, on the edge of the vleis, on the spots where they have been made ready for use; the best finished are found singly, where they have been hurled and lost by the owner, others are found in or near kitchen middens. None, to my knowledge, have been met with imbedded in the laterite or ironstone deposits, and any implement found in this situation may safely be ascribed to the palæolithic age of South Africa. On the whole, however, these arrow or lance heads are of rude workmanship, and the chipping process is of a simple kind; a face struck at one blow for the reverse, a median longitudinal facet and one on each side of it on the obverse, this often suffices for the making of a weapon. But lately, minute implements showing traces of a secondary chipping on the edge have been discovered in the Transvaal.

The chronicles of the early travellers or of the early settlers do not mention, although they speak of the arms worn by the Natives, that their arrows or lances were tipped with stone points, and yet we have proofs that stone implements have been used by some of the present aborigines until barely a century ago. On the Cape

Flats is found a midden, partly buried by the sand dunes, where stone arrow and lance heads, scrapers or knives, are found intermingled with small brass buttons and bowls of old-fashioned Dutch clay pipes evidently obtained from the Dutch settlement. This shows clearly that the use of stone implements was still the custom. There are also found bone awls, pounders, disks made of ostrich shells with a hole punched in the middle, flat stones with a depression in the centre for pounding probably the tough Patella, Haliotis and Limpets used for food. The contents of this midden are similar, except for the presence of objects of European manufacture, to those of similar stations found so numerously along the whole coast, and which contain occasionally cooking pots of remarkable shape. In the Carnarvon District of the Cape Colony there was found lately in a krantz, the lair possibly of some of the last Colonial Bushman, wooden models, a few inches long, of a gun and a spade cut by means of sharply-edged flakes found also *in situ*. In the Museum there is a club heavily knobbed at the tip and made of iron-wood, (*Olea* spec.) which bears unmistakable traces of having been carved into shape by means of a stone knife; the handle of this formidable weapon is much thinned in order to enable the small hand of a Hottentot or Bushman to grasp it firmly. It was found in a cave partly filled with bat-guano in the Montagu District of the Cape Colony. More interesting still, because it shows by what mode of attachment these rude stone implements could be made serviceable, is the discovery on the coast of the George District of Cape Colony, and on the floor of a cave, of the skeleton of an aboriginal, either a Bushman or a Hottentot, wrapped in the remains of a bush-buck skin and a thick layer of seaweed; with it were found three tortoise shells, one immediately beneath the skull, a lumbar vertebra of a large ruminant, and a stone implement embedded into an ovoid mass of gum or resinous matter and having a thin, round, wooden handle imbedded at the other end. The whole implement is 17 cm. long, and the stone part of it of a very rude type. The skeleton is very well preserved, but not so the wooden handle. Yet there is no reason to suppose that the body had been buried very long, although the material which covered the floor of the cave—bats' guano—might have acted as a preservative.

These instances go far to prove that there has been in South Africa a very "Recent Stone-age Period."

THE PALÆOLITHIC PERIOD.

No evidence has as yet been forthcoming that in South Africa the people who manufactured stone implements of the palæolithic type were cave-dwellers. No station or workshop having a claim to be called such beyond doubt has, as yet, been met with. I thought I had found one when, several years ago, I discovered in the cutting through the long sloping talus of the Papagai-berg, at Bosman's Crossing, close to the town of Stellenbosch in the Cape Colony, a thick layer of great length consisting of broken, plainly water-worn Table Mountain Sandstone boulders mixed with large flakes and chips, and of partly-worked or remarkably well-finished stone implements such as axes, sling-stones, etc. This layer rested on the granite. An inspection of the whole Stellenbosch Valley revealed almost everywhere the presence of numerous implements of the same kind and workmanship, even at a very short distance from the foot of the denuded crags of the mountains. I have since traced them to the Paarl, Wellington, Drakenstein, Somerset West, the slopes of Wynberg Hill near Cape Town, and recorded them from the Olifants River Valley, Mossel Bay, Knysna, Port Elizabeth, the Transkei, and other districts.

In the districts of Stellenbosch, Paarl and the Cape, in this Colony, these implements occur especially in conjunction with and often deeply imbedded in deposits of laterite, the "ironstone gravel" used there as road metal.

So numerous are these relics of a primitive civilisation that they can be picked up almost anywhere by the road-side, and a visit to the gravel pits will clearly show whence these implements came. They have been brought down from their once elevated position by denuding agencies. When the side of the mountain is very abrupt they must be looked for in the valley, at the foot of the talus; when it is gently sloping they will be found resting on the slope itself, and were cuttings made, layers of these implements would most likely be found in the valleys, as at Bosman's Crossing.

Deposits of this kind have been found among other places in Griqualand West, when digging wells, and in Griqua Town, on the side of a hill I am told; but all the implements, some of them beautifully worked, are there made of jasper. Lately also, some were met with some thirty miles from Vereeniging, and at Vereeniging itself in the Transvaal. I am indebted to Mr. Ivor Guest for a sketch map of the locality showing the position in which he had found a number of quartzite implements very similar to those discovered at Bosman's Crossing, a locality which he subsequently visited. The situation there is the same it appears as that obtaining in Stellenbosch, Paarl, etc. More recently Mr. T. N. Leslie, who sent me for examination the many types of his extensive collection made at Vereeniging, writes that "there is a talus of 4 or 5 feet in depth and extending some miles along the banks of the Vaal River and about a mile wide; implements both large and small may be found in any part of it."

This accumulation in itself does not necessarily imply a great lapse of time, because of the rate of denudation in a country bare of trees and verdure and where torrential rains prevail. The loosened surface soil is rapidly carried to a lower level, and the stations where these implements were made would thus be rapidly obliterated, not only from post pleistocene times, if they dated so far back (and there is no reason to believe that climatic conditions have much changed since then) but equally so from more modern times.

In Stellenbosch and Paarl there are no traces of an old river terrace; the implements are found imbedded in the rain-wash of weathered granite, in the laterite, or lying on the surface, and no geological evidence as to their great antiquity has as yet been discovered. At Vereeniging, on the other hand, it is claimed that there is an old river-terrace, and that from their position under the alluvium the deposits may prove of great antiquity.

The evidence is thus very conflicting, and, until further discoveries of similar deposits are made, we are not justified on geological grounds in deciding which is the older of the two.

A comparison, however, of the workmanship and also of the material used in both deposits leads me to the belief that at all events some of the Vereeniging implements may prove to belong to a true neolithic period.

The implements (weapons) of the Stellenbosch-Paarl types are often of an elaborate manufacture. They consist of axes or hand-clubs, pick-axes or diggers, adzes or hatchets, sling stones with very sharp edges, round mullers with several polished facets. The flakes, scrapers, etc., are scarce; a few rude sub-orbicular arrow-heads have been met with. The comparative absence of flakes, etc., may be due to their having been carried away before the heavier instruments, owing to their light weight. These implements are *all* fashioned from water-worn boulders of Table Mountain sandstone; the axes or hand-clubs are sometimes tongue-shaped but tapering or even very sharply pointed at one end; the facets are numerous and equally distributed in all on both sides; the edges are sinuously sharp and therefore uneven, pointing out clearly that they could not have been used as cleavers; others as broad at the apex as at the base have a cutting edge, and may be termed axes; another type, which may be called hand-pick, has in many cases retained the rounded part of the water-worn boulder, and the lower part is fashioned into a sharp sometimes polygonal point.

The Vereeniging types on the other hand are formed from two kinds of material, one a hard quartzite, the other dolerite, or shale indurated by the intrusion of dolerite. The quartzite implements cannot compare in workmanship with the Stellenbosch ones; they are more of the cutting axe type, one of the faces having been cleaved at one blow, while the other has often only three broad facets and a few secondary chippings along the edge; these bear a great resemblance to the rude implements of nearly similar texture found at Mossel Bay, Knysna, the Transkei and elsewhere. The workmanship of the dolerite or shale implements greatly resembles that of the Griqualand West jasper ones, although somewhat inferior in finish; some of them have a part of the contour of the original boulder also retained at the top, but the instrument so treated is not a hand pick as in Stellenbosch; the sling stones in both places, made either of dolerite or quartzite, have the same shape; the knives or scrapers of Vereeniging have the edges much rounded, and several of them are partially polished, as if by water, but not so the quartzite implements.

The examination and comparison of these Vereeniging types with those of Stellenbosch would thus go to show that the implements of quartzite, although of a ruder manufacture, have a clearer resemblance generally to those of Stellenbosch, or of the Cape Colony, than have the dolerite ones; the discrepancy in the two types might be explained by the hypothesis that the weapons made of quartzite are of an older type than those made of dolerite or hardened shale, and are probably contemporaneous wi h the Cape Colony ones.

This hypothesis seems to me to be admissible on the following grounds:—Among the Vereeniging dolerite and shale implements I found two arrow or lance heads, having a very distinct peduncle, presumably for hafting; in one the peduncle is one third, on the other half the length of the head; both are made of dolerite, worked on one side only, and are the first implements with a tapering end so far recorded from South Africa. In addition to these there are two weapons of dolerite, 11 cm. and 8½ cm. respectively, of an elongated ovoid form, regularly shaped, equally pointed at both ends and chipped on both sides in the same manner as the lance heads of the Cape Flats, but the Vereeniging implements are too thick in the centre to have been used otherwise than axe heads. These Cape Flats lance heads, made of the same surface sandstone of a tertiary period as the implements of recent date, are so perfect in their workmanship that they can only be compared to the best types of "Laugerie Haute" in the Dordogne, which are figured in *Reliquiæ aquitanicae*, Pl. A. IV., but of course the material differs. They are likewise shaped by repeated chippings into a long, ovate sharply acuminate form. Very scarce indeed are these Cape Flats lance-heads, and their finish made me for a long time somewhat doubtful of their genuineness. But quite lately another one has been found also on the Flats, and, more important still, a perfect example made of the same material has been discovered on the surface in the Drakenstein Valley, at the foot of the talus, where some highly finished implements of the palæolithic type have been also discovered.

Further discoveries may modify the view I now express, but to my mind the evidence of workmanship of the above mentioned Vereeniging implements and of the Cape Flats lance-heads, point strongly towards the existence of a past neolithic period which ended without merging into the polished stone or bronze period, to be replaced by a more barbaric, retrogressive, recent civilisation.

The limit assigned to a paper such as this, in a review of this kind, does not allow of further disquisitions on the so-called and certainly extraordinary "eoliths" of Pretoria, of the partially finished, very much weathered, yet of a superior type sandstone implements of Port Elizabeth, or of the rude cherty banded Dwyka ones of the Cape Karroo which could not have obtained a more water-worn aspect had they been for centuries rolled in the impetuous waters of a spruit, which they probably never have.

We are only on the fringe of a wide field of discovery; a field where very little has been done, and where there remains much to do.

3. RHODESIAN ANTIQUITIES.

By R. N. Hall, F.R.G.S., Co-Author of "The Ancient Ruins of Rhodesia" and Author of "Great Zimbabwe."

Recent Progress in Researches.

Since 1892, when Mr. Theodore Bent published in "The Ruined Cities of Mashonaland" what must be admitted to be a valuable and reliable report on his explorations at Zimbabwe, decided progress has been made both at Zimbabwe and elsewhere in Rhodesia in the investigation of the ancient ruins of the area lying between the Zambesi and Limpopo rivers.

The suggestion that South-East Africa can now be linked up with the ancient history of the Near East is one of more than passing interest. It is one that opens out a vast field for research yet to be investigated by archæologist, antiquarian and ethnologist.

During eight years' examination work of these ruins the writer has always eschewed discussion of the origin of these monuments, or rather the origins of the various and obviously distinct types of ruins so liberally scattered over the area of Southern Rhodesia. In "The Ancient Ruins of Rhodesia" all opinion of any weight from all quarters was impartially noted in encyclopædic form, but without any committal by the authors on any of the points so advanced. This was done in order to rescue from oblivion any fact or argument which might possibly at a later stage be useful in the discussion of the question of origin. In "Great Zimbabwe" the same reserve has been maintained for the reason that the author has aimed at permitting the actual ruins and relics to relate their own story of their forgotten past, unweighted by any considerations of the many traditions, romances and theories which have been woven concerning these monuments. The same policy of reserve as to the most fascinating topic of origins of the oldest type of ruins will be maintained in this article, but as to later ruins there is ample evidence to enable the writer to arrive at some conclusion as to their origin.

The last three years have witnessed the following advance in these researches :—

(1) The re-examination of Great Zimbabwe including the unearthing of floors, passages, drains and walls, with a detailed description of all architectural features, methods of construction and numerous plans and sections, while three hundred photographs of every portion of the ruins of all ages of this

group constitute a permanent record of Zimbabwe, which must prove of incalculable value in any discussion of these ruins.

(2) The re-examination, in the light of discoveries at Zimbabwe, of ruins elsewhere in Rhodesia which had previously been located and described.

(3) The discovery and examination of numerous and altogether fresh ruins of both major and minor importance, the existence of which was unsuspected, including plans, photographs and detailed descriptions.

(4) The recent inspection by the writer of the ruins of the Inyanga area, including (*a*) Hill Terraces, (*b*) Hill Foots, (*c*) Aqueducts, (*d*) so-called "Slave Pits," and securing plans, photographs and reports on explorations and "finds."

(5) The comparisons by means of photographs, plans and written descriptions of the ruins of the Mount Fura district with those at Zimbabwe and elsewhere in Rhodesia.

(6) The plans and descriptions carefully prepared by Mr. Franklin White of certain ruins in Matabeleland, and his recent survey of the Elliptical Temple at Zimbabwe since the exploration.

(7) The inspection by the writer of some scores of stone-built villages and stone rampart forts on hills, of the Makalanga and Barotsie and other tribes in Mashonaland.

(8) The successful tracing of several additional chains of forts in several parts of the country, especially in the Motelekwe and Sabi districts.

(9) The securing of the exact location of some two hundred relics and "finds," with particulars of their associated articles, their locations on certain floors, and the associated features of architecture and construction of the buildings where the relics were found, which buildings represent distinct periods extending from prehistoric times to within, in some instances, but a few score years ago.

(10) The accumulation of a vast fund of opinion of acknowledged expert authorities as to the relative ages and origins of the relics and "finds," and their parallels and identities in other lands.

While all this internal evidence has been obtained from the actual ruins, other researches have, within the last few years, been prosecuted in various quarters from which additional light has been and may yet further be shed on the origin of the Rhodesian Monuments, and, though these are exceedingly important as bearing on this subject, yet beyond the mention of them in this paper they will not be dealt with by the writer. These may briefly be stated as follows :—

(1) Researches in Arabia and the Near East, and further examination of historical records concerning the peoples who are believed to have been responsible for the oldest type of building in Rhodesia, have distinctly advanced within the last few years, and these researches are still in active progress.

(2) The same remarks apply also to researches with regard to the close connections between Arabia and Rhodesia and the

Mozambique coasts existing in mediæval times, and these show that an immense advance has been secured in the knowledge of this subject.

(3) The recent discoveries, by M. Grandidier and other savants, of the traces of the influence of Sabaeans, Phoenicians and Idumean Jews of the Red Sea, on the Mozambique coasts and Madagascar.

(4) Better knowledge of the extent and methods of ancient gold-mining in Rhodesia as apart from gold-mining in these regions by mediæval Arabs and Portuguese, and still later indigenous people, the suggestions made by the late Mr. Telford Edwards, M.E., as to widely-distinct mining operations at different periods and by different peoples being confirmed.

(5) A largely-increased fund of information as to the history of the Makalanga both of Matabeleland and Mashonaland from earliest mediæval times to the present day, and the preparation by Dr. John Helm and Rev. A. A. Louw of the first grammar of the Chicaranga language.

(6) The study now in hand of such of the trees and plants of the ancient mines and ruins area as are not indigenous to South-East Africa.

From these and other external evidences it may naturally be anticipated further information will be forthcoming to aid in a full and conclusive determination of the ruins problem. At present the increased interest of British, French and German savants in Great Zimbabwe and its allied monuments leads one to hope that a satisfactory solution of the enigma may at an early date be secured.

Variety of Ancient Ruins.

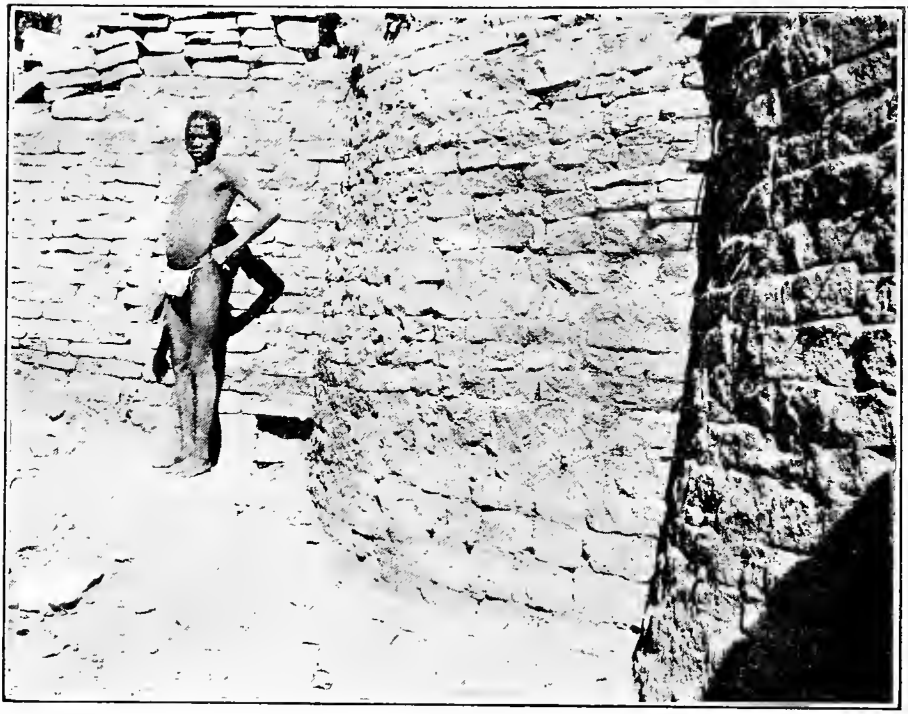
It may be taken as a modest estimate that there have been located in Rhodesia no less than three hundred distinct ruins or groups of ruins, and these, or such of them as were first known, were classed by all writers as "ancient," this term having also been applied to many of such ruins which are mediæval and even of later times.

A. Probably it would be more correct to say that the term "ancient" as relating to the suggested Sabaean occupation of the country can only be applied to a few scores of the Rhodesian monuments, though later investigations may show that certain other ruins are also entitled to rank under the title of "ancient" as so understood. The oldest portions of the Elliptical Temple and of the Acropolis Ruins, and probably some walls in the Valley of Ruins may safely be considered as representing the most ancient form of architecture in Rhodesia.

B. Many ruins showing distinct forms of architecture and hitherto termed "ancient," and once considered to be such can now be shown to be "ancient" in a modified sense only, that is, though they bear evidence of undoubted antiquity the manner of their construction and the nature of the relics yielded on their lowest floors point to a period much later than any Sabaean period.

C. From other ruins of certain well-defined styles of construction it is altogether impossible to obtain any relic which in the opinion of the highest expert authorities can date back later than the 13th, 14th or 15th centuries of this era.

D. Again, ruins exist, also popularly styled ancient, which have clearly been the work of indigenous people, and the construction of which does not in the slightest suggest any controlling influence of a foreign race. and these appear to have been a crude reproduction by natives of somewhat similar but a much superior class of buildings



Elliptical Temple.
View of walls (discovered 1903) which had been buried to the depth of 11 ft.

in the country. In this poorer class of buildings nothing save distinctly native articles are to be found. Some of these structures are doubtless several centuries old, but others are of later date, while some, especially in Mashonaland, are, comparatively speaking, modern.

In "The Ancient Ruins of Rhodesia" the authors defined two principal classes and ages of ruins to be found in Rhodesia, and these were respectively called "First" and "Second Period" buildings. From the descriptions of these distinctive styles of architecture therein set forth, the writer, after three years' additional exploration work in several types of ruins, has nothing, or hardly anything, to withdraw, but on the other hand very much information has been secured to strengthen the argument which can now be carried much further, even beyond the reach of controversy.

It is from the type of First-period ruins alone that authorities advise the writer, that the importation into these regions of the style of building can be demonstrated.

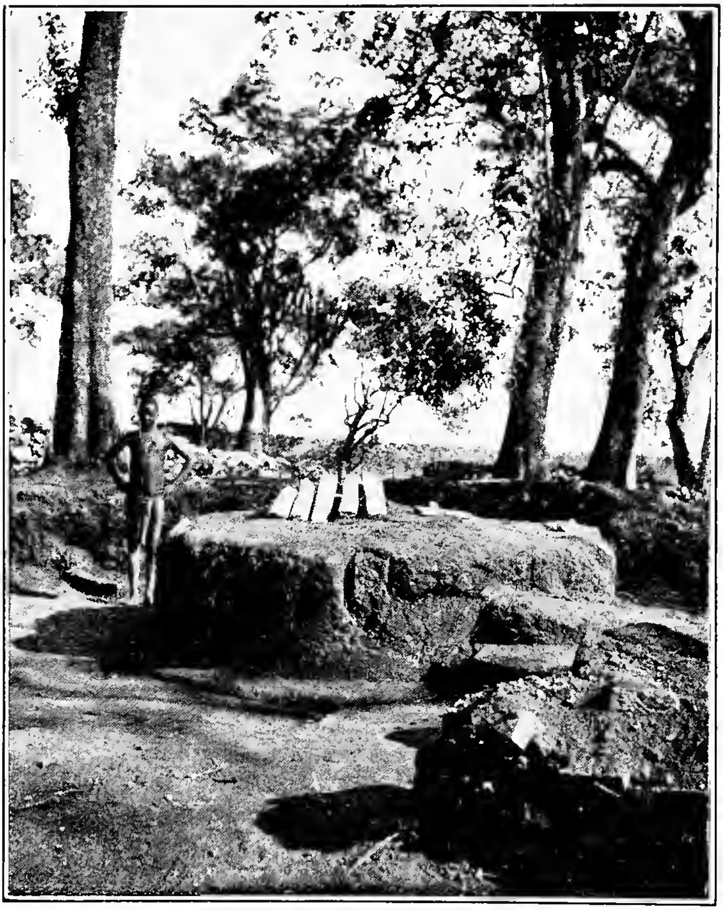
The oldest portions of Zimbabwe and some score, possibly more, of other ruins in the country represent the First-period class of building, while Khami and Dhlo-dhlo and quite a hundred other ruins represent the Second-period class, though both latter ruins named are much obscured by artificial filling-in process, and by obviously native built walls and other structures. What indigenous races both at Khami and Dhlo-dhlo are responsible for the erection of portions of the ruins it would be impossible to say, but there are still later walls at both places for which the Barotsie, from a few centuries ago down to 1836, are manifestly responsible.

Neither Khami nor Dhlo-dhlo nor any of the associated ruins of that type have yielded any of the relics suggestive of the antiquity evidenced by the relics so abundantly discovered at Zimbabwe, nor will the style of architecture and construction at such ruins compare with those of the undoubtedly oldest portions of Zimbabwe. No relic so far discovered at Khami or Dhlo-dhlo takes us back earlier than the 13th or 14th century of this era. On this point the writer possesses satisfactory proofs.

But probably, as Dr. Schlichter remarked concerning Dhlo-dhlo, the ruins as seen to-day at both places mark the former sites of ancient buildings—that is, "ancient" as applied to the older portions of Zimbabwe. Possibly, too, further excavations at both places may yield evidences of a still older occupation than is shown by the walls now standing. There exist in certain portions of Khami some traces of what may be considered as ancient buildings, but these are very few and somewhat uncertain, and several of such spots still remain unexplored.

Dr. Schlichter considered the plan of the building at Dhlo-dhlo to have been ancient, with later structures following generally on the lines of the original plan. Successions of occupiers appear to have utilised the old sites of many ruins in the country. The strategic positions and natural strongholds of many of these ruins might have led later peoples to erect their poorer buildings on such positions, especially as the older ruin, probably too dilapidated for use, would provide building material without the necessity of labour. The filling-in process by past generations of natives is noticeable in almost every ruin in the country, and is an evidence that the ruins of old structures always possessed an attraction for later people.

Regarding Khami, the writer, in view of the visit of the British Association to Bulawayo, would make a further remark. In 1896 it was known to many who took an interest in this group of ruins, and it was frequently affirmed that a tribe of Barotsie had for many generations lived at Khami until the arrival of the Matabele in 1838, when they moved to the Zimbabwe district. The writer in that year was informed that the late Mr. Thomas, a former missionary at Shiloh in the time of Mozilikatzi, was one of the authorities for this statement. But this was also affirmed by other pioneers, and



View of platform and steps recently discovered N.N.W. of conical Tower.

the existence of huge *debris* mounds on the east side of No. 1 ruins at Khami was known to contain sherds of pottery of Barotsie make. This pottery the Makalanga, whose pottery is totally different in make, pattern and ornamentation, were emphatic in disowning. Some of the smaller walls at Khami cross over extensive beds of *debris* containing identical pottery.

But during 1902–4 a series of conferences with Native Commissioners, missionaries, and the older native headmen was held at Zimbabwe in order to obtain information of anthropological interest. At these conferences it was ascertained that Jerri's people, who are Barotsie, migrated from Khami immediately before the Matabele arrived in the present Matabeleland. Jerri's country lies seventy miles south-east of Zimbabwe. Jerri's people never lived at or near Zimbabwe, but the error is pardonable as any district not far from Zimbabwe might in those very early days have been construed as at Zimbabwe. But these authorities were in all other respects perfectly correct.

Jerri's people claim to have left what they called "the great buildings of stones" (Khami) west of where Bulawayo now stands, in 1836–7, and to have removed direct to Jerri Mountains. They state they had left Khami before the Matabele arrived, and they and the older men of the Makalanga and Amangwa of Zimbabwe who well remember the circumstances, state that Jerri's people passed through Zimbabwe on their way to their present country, while the local natives of Zimbabwe, who also know Khami ruins well, further declare that Jerri's people lived at Khami. The older men of Jerri's further state that their people built many walls at Khami. Many other interesting particulars recently obtained regarding Jerri's people and the Khami ruins could be given.

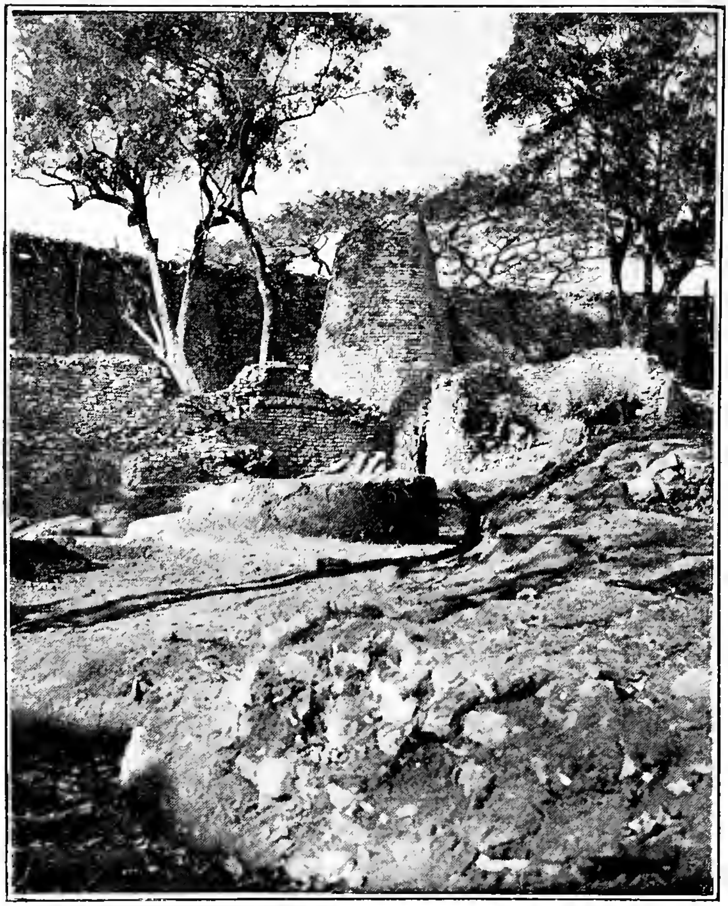
A somewhat similar statement can also now be made with regard to the Barotsie occupation of Thabas Imamba ruins, which place was until about 1838 the chief centre of the Barotsie, who had previously been the over lords of the Makalanga in both Matabeleland and Mashonaland. The dynastic title of the paramount Barotsie chief at Thabas Imamba was Mambo or Mamba, the tribal totem—as distinct from the racial totem, the baboon—being the puff-adder. The Zimbabwe natives state that they and all Makalanga districts paid tribute to the Mamba at Thabas Imamba.

Mural Decoration.

It has always been popularly understood that the mural decoration at the ruins implied some method adopted by the builders for reckoning time. This may be the case, as shown later, with regard to the ruins of First Period, but not at such ruins as are of later date.

Undoubtedly the Chevron and Dentelle are the oldest patterns, that is so far as the Rhodesian monuments are concerned, if we may judge by the very superior class of building in which they are found. The Herring-bone pattern as seen on certain walls also might come under the same category, but this is a matter which is still open to discussion.

Chevron and Dentelle, together with the associated round towers and monoliths, in some instances define an arc wall which extends outwards either to the east or to the west. These are admittedly of splendid workmanship. But there is a Chevron pattern of small design, irregular and of poor construction to be found associated with check pattern and a poorly-executed herring-bone pattern in ill-constructed walls, and directed to any point of the compass and connected with which is no arc wall, monolith or tower, and the construction of the ruins in which such are found is obviously not "ancient" nor do the "finds" in such ruins take us back earlier



View of conical tower since excavations, showing platform covered with soapstone beams recently discovered.

than mediæval times even if so far back as that. These patterns so introduced at haphazard the writer considers to be purely an imitation by natives of the recognised ancient patterns and introduced in the same way as they are employed by natives in their carvings, in the decoration of post and other utensils, and in their beadwork.

The writer has been advised that such most probably is the case. and this coincides with his previously-expressed opinion of such crude decorative work as is to be seen in ruins of poor construction. Check, or draught-board pattern, is not, so far as the writer's experience extends, to be found in any of the oldest type of building. It is altogether absent from Zimbabwe. It makes its first appearance in the second or B class of building; it is continued in the C class of ruins, and practically it is not to be found in the roughly-built ruins of D class where the general absence of courses and the irregular sizes and shapes of the building material employed would cause its introduction to be almost a matter of impossibility. Check is extensively employed in decoration by the Makalanga.

But the well-executed Chevron and Dentelle on the oldest type of ruins is only placed in certain well-defined portions of the walls, and these are associated with monoliths, or round towers or, in two instances, carved birds. In no ruin of this type is the pattern directed either to the north or south, but is always extended either from south-east to north-east or from north-west to south-west.

For instance, at Zimbabwe Chevron pattern of most perfect and delicate construction extends along the outer face of the summit of the main east wall of the Elliptical Temple from north-east to south-east, and this pattern so directed is only just covered by the sun at rising at the summer and winter solstices. Associated with the pattern and only over its length are monoliths and formerly carved soapstone beams, and, it is believed, small round towers similar in size and position to those on the west arc wall of the Western Temple on Zimbabwe Hill.

At the Western Temple is an arc wall, the widest ancient wall in Rhodesia, and on its summits were round towers now shown to have been conical, and monoliths, these extending from south-west to north-west.

The main arc wall of the Eastern Temple bears on the summit of its exterior face a Dentelle pattern, and associated with it were carved soapstone monoliths and carved birds on beams, also slate monoliths. These extended from east-north-east to east-south-east.

At least a score of the ruins of the oldest type can be mentioned as showing similar features. At other ruins of this class the walls are greatly dilapidated and any pattern has disappeared with the walls. It must also be borne in mind that it is only those ruins which possess a decorated arc wall so directed that have yielded the religious emblems of nature worship. Philips' Ruins at Zimbabwe could also be mentioned in this connection, for here the arc wall facing east was once decorated with soapstone beams, some of which were delicately carved, and here was found by the writer the finest bird on beam yet discovered at Zimbabwe, together with numerous religious emblems.

So uniformly is the decoration positioned that, on approaching for the first time a ruin of the oldest type and before seeing the pattern, one is morally certain as to the part of the walls in which it will be found, that is if the walls are not greatly dilapidated. In the same way on approaching a ruin of later type it is known that such patterns so positioned will not be met with.

So distinct are these types of ruins that one is at once aware that in certain ruins nothing suggesting a remote antiquity will be discovered within them. The prospectors for relics engaged by the Ancient Ruins' Coy., Ltd. between 1895–8 met with the same

View of conical Tower before 1903.

experience and found it to be but a loss of both time and money to "work" certain classes of ruins, and so passed such by while paying their whole attention to ruins of the earliest type. This fact is recorded in their official reports. It was an experience they had to purchase, but it is exactly similar to the experience gained by the writer.

That at Zimbabwe and similar ruins elsewhere there existed some means whereby the ancients fixed the seasons and times of the year is now undoubted. This the writer is advised by authorities who have examined the plans, photographs and descriptions, may be taken for granted. This applies only to the oldest type of ruins.

But whether the ancient builders of Zimbabwe and its associated ruins elsewhere carried out to their full extent the principles of geometry and mensuration in their season-reckoning arrangements is a matter which is for the present *sub judice*. At any rate it is obvious that some, at least, of these principles were adopted, but it is impossible to speak dogmatically as to the method of their application. Should it, however, be definitely ascertained beyond all questioning that Zimbabwe, as it is believed, represents the monuments of a colony of the ancient empire of Saba, then it may be taken for granted that such principles were more exactly applied at these ruins.

Inyanga.

Though much information of a general character had previously been secured regarding the ruins area of the Inyanga district, no systematic examination of any of these ruins was made until the writer in 1904, on the instruction of Mr. Rhodes' trustees, undertook such operations.

It must be admitted that the general descriptions given earlier are practically correct, save that each writer started on his descriptions with a manifest bias in his mind that all he saw pertained to the most remote period of antiquity, an antiquity covering the most ancient Zimbabwe period.

In the light of experience gained during eight years' work concerning many classes of ruins throughout the other districts of Southern Rhodesia, the writer, ignoring all such theories as to antiquity, resolved that these marvellous remains of quite a unique character should be permitted to speak for themselves and relate their own story.

The ruins of Inyanga vary very considerably and cannot be described as a whole. These consist of (*a*) Hill Terraces, (*b*) Hill Forts, (*c*) Valley Ruins, (*d*) stone-lined pits and passages, called "slave-pits," (*e*) Aqueducts, (*f*) stone-built native villages and huts, and (*g*) stone-built cattle kraals.

The area covered by these remains covers about sixty miles from north to south and forty or fifty miles from east to west. There is barely an acre of hillside or valley within this area which does not demonstrate the presence in some past times of teeming populations.

The Hill Terraces present an extraordinary sight, these completely covering the faces of many hills from base to summit. They are very roughly built of stones of all sizes and shapes, and doubtless were, as many still are, retaining walls of the soil on the sides of the hills. The positions so terraced face from north-east to north-west, and rarely to the south except where the southern bases of the hills are shielded by other hills. Frequently a species of *Ficus* is found growing in their vicinity. Similar hill terraces, identical in every respect, are found in Arabia, while others have recently been discovered in Swazieland. Cuttings in soil still remaining behind the retaining walls show abundant traces of a former vegetable growth. That the terraces, as in Arabia, were used for horticultural purposes can admit of no doubt, especially in view of their close associations with the aqueducts.

The Hill Forts command strong strategic positions on the summits of the larger hills, and several of these buildings can be seen against the sky-line at the same time in the same line of vision but on different hills. Though of various sizes the description of one is that of all. In every feature they are identical. Four of these forts were surveyed, photographed and explored by the writer. No article suggestive of foreign occupation, or even of any remote age, was discovered, all the "finds" being of exceedingly old native articles. The walls are plumb, the entrances angular; but the walls are built upon a plan of curves.

The interesting and peculiar feature of these ruins, as distinguished from the ordinary features, presented by ruins in Matabeleland and elsewhere in Mashonaland, are—covered entrances, loopholes through main walls, banquette walls on the insides of outer walls, a complete absence of buttresses and of mural decorations, the presence of stone walls of huts similar to those found in villages in Mashonaland, while the walls of the forts are built of irregularly-shaped and sized stones reared up on their ends and sides, that is, with the flat and larger surface outwards, the interior of the walls between the outer and inner faces being filled in with rough stones.

Stone-lined Pits are exceedingly numerous. It is impossible in some places to walk fifty or a hundred yards without coming on one of these pits. They are to be found in blocks of three or four or singly, both in the open and on the gentle slopes of hills, and frequently in lines parallel to the aqueducts. The pits when cleared showed various depths of from nine to twelve feet with diameters of from twenty to thirty feet. Covered passages from twenty-six feet to thirty-six feet in length slope down on to the floor of the pit.

The majority of the pits are either dilapidated or almost completely filled in with silted soil from higher ground. A pit in an almost perfect condition is only met with at rare intervals.

Round each pit is a raised rampart some thirty feet wide, and on this are to be found stone sides of huts and clay granaries.

The floors of pits and passages are paved. Usually a drain through the outer rampart clears the sloping floor of the pit.

The entrances of the passages at their exterior extremity face in the opposite direction to the prevailing winds and rains.

The construction, though substantial, is very rough, the stones being of all sizes and shapes. No article except of obviously native make has been found in any pit so far explored.

The Aqueducts are also a wonderful feature in the Inyanga district. They run from artificial dams in the hills, cross the sides of hills and extend in some instances from hill to hill for a distance of two miles. The writer has examined very many of these aqueducts throughout their whole length. None appear to have been driven through rock, shale being the hardest material cut through. They average two feet in depth and are about two feet wide. All demonstrate a wonderful skill in engineering and irrigation.

Detailed descriptions of the stone-lined pits, with plans, sections and photographs have very recently been supplied by the author to the Anthropological Institute, and also of the Hill Forts, to the Proceedings of the South African Association for the Advancement of Science, while descriptions of these and the other classes of ruins in Inyanga are now in the press and will shortly be published together.

The writer does not consider, for the reasons to be stated later, that the Inyanga ruins are ancient in the fullest sense of the term. Still his opinion is not final. The style of building and the "finds" appear to point to more recent times, possibly to the 11th and 12th centuries of this era, when parts of Rhodesia were occupied by very large numbers of Arabs from Quiloa and other settlements along the east coast. The arrival of these people at that time is a matter of history (see "Great Zimbabwe" introduction by Dr. Keane).

SECTION III.—ZOOLOGICAL.

1. LAND VERTEBRATES OF SOUTH AFRICA.

By W. L. Sclater, M.A., F.Z.S., Director, South African Museum.

In the small space alloted for an account of the vertebrate land fauna of South Africa it is impossible to give any very complete or detailed description of the matter. I have, therefore, thought it best to commence with a short account of the history of South African Zoological discovery and the former distribution of the larger animals; following this is a condensed systematic review of the more noticeable members of the fauna likely to be met with by the traveller; and finally there is a note of the zoogeographical relations of the Cape Fauna. A bibliography of the more important works, useful for reference, is appended.

I. History of Zoological Discovery in South Africa.

Our knowledge of some of the larger and more conspicuous animals of South Africa dates from the founding of the settlement of the Cape of Good Hope in 1652 by van Riebeek; his journal, which has recently been republished in English, contains references to the abundance of the large game and carnivorous animals found close to the "Castle of the Cape of Good Hope." Hippopotami wallowed in the swamp which is now occupied by Church Square in the centre of Cape Town, while about the mountain slopes were large herds of hartebeest, elands and kudus. Rhinoceros were not uncommon, and are frequently mentioned in van Riebeek's diary as inhabiting the slopes of Table Mountain and also the Flats beyond, while later on, in 1685, when the Governor, the elder van der Stel, was proceeding on a journey northwards towards Namaqualand, his coach was upset by a charging rhinoceros, and he himself had a narrow escape.

It was not until the end of the eighteenth century that South Africa was visited by European naturalists purposely in order to collect specimens of the fauna and flora and to make scientific observations. The three names which stand out most pre-eminent among these early travellers are the Swedes, Sparrman and Thunberg, and the Frenchman le Vaillant. Already in their days the larger animals were getting rare near Cape Town, and it was necessary to travel a considerable distance to the eastwards in order to meet with them. The Blaauwbok (*Hippotragus leucophæus*), an antelope resembling the Roan, but somewhat smaller and without the black face markings, was even then on the verge of extinction; the last one of which we have any record having been obtained by Lichtenstein, a German traveller, in 1799. In order to meet with the elephant, rhinoceros, eland and lion a considerable journey to the eastwards had to be made to the valleys of the Sunday and Great Fish Rivers, in what are now the districts of Uitenhage, Somerset and Albany.

With the advent of the English, in 1795, a fresh stimulus was given to exploration, both geographical and zoological, with which the names of Barrow and Burchell must always be associated. The latter landed at Cape Town in 1810 and made a memorable journey into the interior, crossing the Orange River near its junction with the Vaal, and proceeding as far north as Kuruman in Bechuanaland. He brought back to England very extensive collections of mammals, birds, insects and plants, and published his observations, which subsequent research has shown to be extraordinarily exact and methodical, in two quarto volumes issued in 1822–4. Owing to unfortunate differences with the authorities of the British Museum, Burchell never appears to have met with the recognition due to his extraordinary powers as a collector and observer; his collections were dispersed so that no complete account of them has ever been published; but it is understood that Professor Poulton is preparing some account of his life and of his collections of insects, which now form part of the Hope Collection in the Museum at Oxford.

Further knowledge of the fauna of South Africa was gained by the travels and collections of Sir Andrew Smith, who occupied a position in the Army Medical Service, and who during his sojourn in Africa in the second and third decades of the last century made a number of journeys in various parts of the country and acquired extensive collections in all departments of zoology.

His most important expedition was one to the north of the Orange River through Basutoland and the Orange River Colony to Kurrichane, the capital of Moselekatse, the Zulu chieftain, who was then settled in what is now the north-western part of the Transvaal. During this journey a very large number of new species of mammals and birds were first discovered. All Sir Andrew Smith's collections were finally described in four large quarto volumes published in 1849, dealing with mammals, birds, reptiles and fishes, including invertebrates, respectively.

A fresh stimulus was given to the study of South African Zoology by the founding in 1855 of the South African Museum. The first Curator, Mr. E. L. Layard, was indefatigable in his efforts, and quickly amassed large Natural History collections, and by his correspondence and exchanges with museums in England and other parts of the world soon brought his institution into notice among zoologists. He devoted himself chiefly to birds, and in 1867 published the first complete work of South African Ornithology. This, notwithstanding a certain number of errors and omissions due to the inadequacy of his material and reference literature, constitutes the foundation of our present knowledge. He was succeeded in 1872 by Mr. Roland Trimen, who turned his attention to the Lepidoptera. In 1889 he published his well-known Monograph of the South African Butterflies, which remains the standard work on the subject and constitutes a memorial of his exact and careful work.

Among foreigners who have contributed to the knowledge of our fauna the Swedes appear to be most numerous; in addition to Sparrman and Thunberg, who were here in the eighteenth century, Wahlberg and Victorin must be mentioned; the former made very extensive researches in 1838–45 in Natal and inland as far as the headwaters of the Limpopo. After his untimely death, from the charge of an elephant in Damaraland in 1856, his collections were worked up by his countrymen in Sweden, Sundevall, Boheman and Fahraeus. Victorin, who also died young, collected chiefly at Knysna and in the south of the Colony, about the middle of the last century.

Another Swedish naturalist, Mr. C. J. Andersson, first came to South Africa in 1850 as a collector to Mr. Francis Galton; from that date till his death in 1867 he spent almost the whole of his life travelling, exploring and collecting in Damaraland. After his death his notes on the Ornithology of Damaraland were carefully edited for publication by Mr. J. H. Gurney, one of his English correspondents, to whom most of his collections had been sent.

Here we may fitly conclude this brief review of previous workers in the South African Zoological Field. A bibliographical list of the more important works dealing with South African Vertebrate Fauna will be found at the end of this chapter.

II. Review of the Fauna.

(*a*) *Mammalia.*

The group of Monkeys is not very numerously represented in South Africa; this is easily accounted for by the scarcity of forest country. The best known and most widely spread form is undoubtedly the Baboon or Bavian (*Papio porcarius*), often called the Chacma in Europe, a name unknown in South Africa, though said to be derived from its original Hottentot appellation. Baboons are found throughout the greater part of South Africa, especially among the rocky hills, which form so prominent a feature of South African scenery; here they live in troops, issuing forth at earliest dawn to rob the farmer's orchards and gardens, for which they are universally execrated. Baboons still exist in considerable numbers in the Cape Peninsula, on Table Mountain, and along the ridge of rocky hills existing southwards to Cape Point: they can often be seen and heard on the path between Simon's Town and Smits Winkel Bay. The other monkeys in South Africa belong to the genus *Cercopithecus*, and are confined to the more wooded districts of the south and east. The most common (*C. lalandii*) is abundant in Knysna and Pondoland,

and is frequently seen in captivity; it has a black face with a white-frontal band above, and a patch of rufous hair at the ba e of the tail.

The Lemurs, whose headquarters are in Madagascar, are represented by two species of *Galago*, the larger (*G. garnetti*) found in Natal, and the smaller (*G. moholi*) from the more wooded districts of the Western Transvaal, Bechuanaland and Rhodesia. The latter was first met with by Sir A. Smith, in what is now the Rustenburg district of the Transvaal; it is an engaging little creature with large topaz yellow eyes, and a very soft greyish-brown fur, large rather naked ears and a bushy tail. It is nocturnal in habits, sleeping during the day in a nest or on the branch of a tree. In captivity it is very active towards the evening, taking gigantic leaps across a comparatively large cage and landing always at the other side with great sureness of grasp; the Dutch term it the Nacht-apje or Night-ape.

Passing now to the Carnivora, we find South Africa very well provided in this respect. Out of the eleven usually recognised families we have representatives of seven; while the Bears (*Ursidae*), Racoons (*Procyonidae*), Walruses (*Trichechidae*), and true Seals (*Phocidae*) are entirely absent.

The Lion (*Felis leo*) was formerly abundant over the whole of South Africa, and in the early days of the settlement was a constant source of danger and annoyance in the immediate neighbourhood of the Castle at Cape Town. It has gradually retreated before the increasing population and the extermination of large game, and is now quite extinct in Cape Colony south of the Orange River. It is still, however, comparatively plentiful in parts of Rhodesia and the Transvaal, and quite recently, I was informed when at Victoria in Mashonaland, that several donkeys had been carried off by lions close to the celebrated Zimbabwe ruins.

The Leopard (*Felis pardus*) commonly known as the Tiger or Tijger among the Dutch, is a far more plentiful animal, and is found throughout the whole country. Its preservation is probably due to the fact that it inhabits the mountains, and is very difficult to approach and find in its own haunts; while it is only during the night that it leaves its rocky fastnesses. The leopard is still fairly plentiful in the mountains behind Stellenbosch, not thirty miles from Cape Town, and the South African Museum has received several specimens from there during the last year or two.

Black varieties of the Leopard are occasionally met with; these differ from those of Asia, in which the melanism is caused by the darkening of the tawny ground colour, and the black rosettes can still be seen in certain lights; in the South African Black Leopard the melanism is caused by a great increase of the spots, which finally fuse to form a uniform black livery.

Other smaller members of the Cat family are the Serval or Tijger-bosch-kat (*Felis serval*), a dark yellow-spotted form of intermediate size, which is chiefly found in the thick vegetation near streams and lakes. The Blackfooted Wild Cat (*Felis* *nigripes*) is a smaller spotted species, about which little is known, but the skin of which can often be found in the form of karosses. The Caffer Cat (*Felis caffra*), found with slight modifications all over Africa, is probably the ancestor of the ordinary European domestic Cat, which appears to have been derived from Egypt, where these animals were formerly held in great reverence.

The Caracal or Rooikat (*Felis caracal*) found throughout Southern Asia as well as Africa, approaches in some respects the Lynxes of the northern hemisphere as regards its pencilled ears and the absence of the anterior upper premolar, but it has a longer tail and no ruff round its neck, so characteristic a feature of the northern animal.

The creature known as the Hunting Leopard, generally called "Luipard" by the Dutch, (*Cynaelurus jubatus*) of naturalists, is rather rare in South Africa. A curious pale variety with fulvous instead of black spots, was met with some years ago in the neighbourhood of Beaufort West; but though it was given a distinct name it was probably only an example of incomplete albinism.

The second family of the Carnivora is the *Viverridae*, containing the Civets, Genets, Mungooses and Meerkats. It is well represented by eight genera and some twenty species. Most of the members of this family are nocturnal and seldom seen, those which will probably come to the notice of visitors are the two Meerkats (*Suricata tetradactyla* and *Cynictis penicillata*), the latter distinguished by its paler colour and bushy tail, the former by its darker colour, short and slender tail, and by having only four toes to both fore and hind limbs.

Both these little animals live on the open Karoo country in small communities; like the American Prairie Dog they form extensive burrows, at the mouths of which they can often be seen seated even from the passing train, sunning themselves and watching all that is going on. They make very interesting pets, becoming exceedingly tame and friendly, more especially the slender-tailed species. Both the genera *Suricata* and *Cynictis* are confined to South Africa.

One of the most remarkable of the South African Carnivora, whether we consider its structure or its habits, is the Aard Wolf (*Proteles cristatus*); the creature externally resembles a miniature Hyæna, but it has five toes to the fore feet and four to the hind, while contrary to what is the case in the Hyæna, the auditory bulla is divided into two chambers. Perhaps, however, the most remarkable feature of its structure is the degenerate state of the molar teeth, which are reduced to mere formless stumps placed at some distance from one another along its gums. This is doubtless correlated with its diet, which appears to consist entirely of termites and ants. The Aard-Wolf forms a distinct family by itself, and the range of the single species extends from Somaliland to Cape Colony, but does not include the forest region of West Africa or Nyasaland. It is not uncommon throughout South Africa, and occurs in the immediate neighbourhood of Cape Town.

Of Hyænas, which compose the fourth family of Carnivora, South Africa possesses two species, the Brown (*Hyæna brunea*) and the Spotted (*H. crocuta*), the former confined to South Africa, the latter spread over the greater part of the Ethiopian region ; both species have been exterminated by poison and trapping in the more settled districts. The Brown Hyæna is now generally identified with the hyæna whose remains have been found in caves and other comparatively recent deposits in many parts of Europe and Southern Asia.

The cosmopolitan family *Canidae* has five representatives in South Africa. Two of these belong to genera peculiar to the Ethiopian region. One of them, Delalande's Fox (*Otocyon megalotis*), is a gentle and harmless little creature preying chiefly on termites, and distinguished externally by its long pointed ears. Its chief title to fame, however, is the extraordinary number of its teeth, it having from four to six molars in excess of all other members of its family ; indeed, in the total number of its teeth it exceeds all other heterodont mammals.

The Cape Hunting Dog (*Lycaon pictus*), on the other hand, has the same number of teeth as the other members of the family, but has only four toes to both fore and hind limbs ; it is a large wolf-like animal, curiously marked with patches of brown, white and yellow, no two individuals being exactly similar. This species, which is found throughout the greater part of Africa, from Somaliland southwards, hunts its prey in small packs ; they move rapidly about the country and hunt antelopes ; even the larger forms, such as Sable and Wildebeest, do not always escape them. They do much damage to stock and are consequently dreaded by farmers, who destroy them whenever they get the chance.

The last of the families of terrestrial Carnivora, the *Mustelidae*, contains five South African species, distributed in four genera ; two Otters, a larger species, with quite rudimentary claws (*Lutra capensis*), and a smaller and rarer form with well-developed claws (*Lutra maculicollis*) : the Ratel (*Mellivora ratel*), renowned for its love of bees and honey though seldom seen, as it is strictly nocturnal, causes much annoyance to the Colonial apiarist, throwing over the hives and destroying the combs in its efforts to obtain its favourite food. The Striped Muishond (*Zorilla striata*), with its handsome livery of black and white and its skunk-like and fetid odour emitted from the anal glands, and finally the curious little Striped Weasel (*Pœcilogale albinucha*) make up the tale of this family.

The only member of the marine carnivora found about our shores is a Fur Seal (*Arctocephalus pusillus*) belonging to the family of Eared Seals or Sealions (*Otariidae*). This species is quite common along the western coast of the Colony and of German South-West Africa and resorts to the small islands for breeding purposes in November and December. A good number of them are then clubbed for their skins and oil ; the former fetches a good price on the London market, though not so valuable as that of the North Pacific species.

It is among the members of the order Ungulata that the most characteristic of African animals are found; South Africa is exceedingly rich in this group containing as it does representatives of no less than forty-eight species, distributed among six out of the twelve generally recognised recent families; the most important of the absent groups are the Deer (*Cervidae*), spread all over the rest of the world except Australia; while others are the Peccaries, Camels, Chevrotains, Prongbucks and Tapirs.

The African Antelopes now number about 150 species, and of these thirty-three are found in South Africa, an unrivalled assemblage ranging from the lordly Eland to the tiny Bluebuck. The spread of settlement and the increase of population has done its work in sadly reducing the number of these beautiful creatures; but, notwithstanding, only one species has entirely died out; this is the Blaauwbok of Swellendam, which appears to have always had a limited range in the south-west corner of Cape Colony, and which has been extinct since the commencement of the last century. On the other hand several species, notably the Bontebok, have survived through the efforts of individual enthusiasts, to whom all credit is due. For the last fifty years this species has only existed on two farms, the property of Mr. S. D. and Dr. Albertyn respectively, situated near Bredasdorp, in the south-west of Cape Colony.

The following is a complete list of the South African Antelopes :—

BUBALIS CAAMA—Red Hartebeest.

Formerly common south of the Orange River, now confined to the Kalahari and Bechuanaland as a wild animal, but troops are preserved on several farms in Griqualand West, the Orange River Colony and in Natal.

BUBALIS LICHTENSTEINI—Lichtenstein's Hartebeest.

Found only in the eastern portion of Mashonaland, the adjoining Portuguese territory, and along the Zambesi Valley up to Barotseland.

DAMALISCUS PYGARGUS—Bontebok.

As stated above, confined to two farms in the Bredasdorp division of Cape Colony.

DAMALISCUS ALBIFRONS—Blesbok.

Only found on one farm in the Steynburg division of Cape Colony, but preserved in fenced camps in many parts of the Orange River Colony and the Transvaal.

DAMALISCUS LUNATUS—Sasseby.

Southern Rhodesia, extending westwards to Lake Ngami and Ovampoland, eastwards to Portuguese East Africa and the low country of the Transvaal.

CONNOCHAETES GNU—Black Wildebeest.

Never extended north of the Vaal River; now found only on a few farms, where carefully preserved, in the Orange River Colony.

CONNOCHAETES TAURINUS—Blue Wildebeest.

Found in Zululand, the Eastern Transvaal, Rhodesia and Northern Bechuanaland as far as Lake Ngami and German South-West Africa.

CEPHALOPHUS GRIMMI—Duiker.

Universally distributed in suitable localities, and often very common.

CEPHALOPHUS NATALENSIS—Red Duiker.

Natal and Zululand; extending northwards as far as Zanzibar.

CEPHALOPHUS MONTICOLA—Blue Duiker.

Smallest South African Antelope, about the size of a hare; confined to the forest districts along the coast, from Knysna to Mozambique.

OREOTRAGUS SALTATOR—Klipspringer.

Only found at or near the summits of mountains, of extraordinary activity; universally distributed where suitable conditions exist from near Cape Town to the Zambesi.

OUREBIA SCOPARIA—Oribi.

Confined to the eastern portion of the Colony, Natal and Mozambique, and not at all common as a rule.

RAPHICERUS CAMPESTRIS—Steenbok.

The commonest and most widely spread of all South African Antelopes, from Cape Town and Natal to the Zambesi.

RAPHICERUS MELANOTIS—Grysbok.

A common little animal in the neighbourhood of Cape Town, where it is very partial to the young vine shoots. In other parts of South Africa somewhat locally distributed, and unknown in most parts of the Karroo and the high veld of the interior.

NESOTRAGUS LIVINGSTONIANUS—Livingstone's Antelope.

Confined to Zululand and the low country northwards to the Zambesi.

MADOQUA DAMARENSIS—Damaraland Dik-dik.

Only known from the rocky hills of Damaraland, from Walvisch Bay northwards.

COBUS ELLIPSIPRYMNUS—Waterbuck.

Never found south of the Vaal River, but from the Limpopo northwards fairly common; the female of this and the other members of the genus is hornless.

COBUS LECHE—Lechwe.

First discovered by Oswell and Livingstone on the banks of the Botletli River, which flows out of Lake Ngami; it is also to be met with on the upper waters of the Zambesi.

COBUS VARDONI—Puku.

A smaller species than the Lechwe, also first discovered by Livingstone on the upper Zambesi, above the Victoria Falls.

CERVICAPRA ARUNDINUM—Reedbuck.

Found in the low country and along the river valleys of the eastern coast from Komgha in the Colony, through Natal and Zululand to the Zambesi.

CERVICAPRA FULVORUFULA—Rooi Rhebok.

A mountain form found in the eastern half of Cape Colony, and extending northwards as far as the Limpopo River.

PELEA CAPREOLA—Vaal Rhebok.

Another mountain Antelope spread all over the Colony, Orange River Colony and Transvaal. The genus, of which this is the only species, is confined to South Africa.

AEPYCEROS MELAMPUS—Pallah.

This species is not met with till the Limpopo Valley is reached, north of which it is fairly common as far as the Zambesi.

AEPYCEROS PETERSI—Angolan Pallah.

This species replaces the ordinary Pallah in Ovampoland and Angola.

ANTIDORCAS EUCHORE—Springbok.

This is perhaps the most characteristic of South African Antelopes, and is still exceedingly abundant in some districts. The genus, which contains only the single species, is confined to South Africa. It is distinguished by the curious erectile white fan of long hairs along the middle of the back, and by the absence of the anterior premolar teeth in the jaw.

HIPPOTRAGUS LEUCOPHAEUS—Blaauwbok.

A small form somewhat resembling the Roan, found formerly in the south-western districts of the Colony, and exterminated at the commencement of the last century.

HIPPOTRAGUS EQUINUS—Roan.

Never found south of the Orange River; still fairly abundant in Rhodesia and the Eastern Transvaal.

HIPPOTRAGUS NIGER—Sable.

First obtained by Cornwallis Harris in the Magaliesberg, near Pretoria; still fairly numerous in Eastern Rhodesia, Mozambique and the North-Eastern Transvaal. On the whole the handsomest of all South African Antelopes.

ORYX GAZELLA—Gemsbok.

A desert-loving form, formerly widespread over the central plains of the Colony, now confined to Bushmanland, south of the Orange River, and the Kalahari and German South-West Africa, north of that river.

TRAGELAPHUS SYLVATICUS—Bushbuck.

Confined to the wooded districts of the south and east from Knysna to the Limpopo. This form is only a geographical sub-species of the widely spread *Tregelaphus scriptus*, found throughout the greater part of Africa.

TRAGELAPHUS ANGASI—Inyala.

A rare and handsome species confined to the swampy forest districts of Zululand and Southern Mozambique.

TRAGELAPHUS SELOUSI—Sitatunga.

The most aquatic of Antelopes found only in the swamps of Lake Ngami and the Chobe River.

STREPSICEROS CAPENSIS—Kudu.

A forest-haunting species found in a good many districts of Cape Colony, and perhaps the most widely spread of all the larger Antelopes. Its range extends northwards to Somaliland.

TAUROTRAGUS ORYX—Eland.

The largest of the African Antelopes, formerly abundant all over South Africa, now found only in the Kalahari and perhaps along the Drakensberg in Natal. Elands from the Zambesi Valley and Mozambique are distinguished by having white transverse markings, and may be considered as a sub-species (*T. oryx livingstonii*) of the typical form.

The only other representative of the *Bovidae* to which the Antelopes belong is the Cape Buffalo (*Bos caffer*). At the present time a small number of these animals are still to be found within the limits of the Colony in the Addo Bush, near Port Elizabeth; elsewhere they are now becoming very scarce, chiefly owing to the ravages of rinderpest which swept through Africa from north to south some years ago, destroying not only the domestic cattle, but many of the wild bovine animals as well.

Here may be mentioned one of the very few hitherto described fossil Mammals of South Africa, this is the long-horned *Bubalus baini* of Seeley. The original specimen was found on the banks of the Modder River in the Orange River Colony, by Mr. A. G. Bain, and is preserved in the South African Museum. Its most noticeable characteristic is the great length of the horn cores, each of which measures 5 feet 2 inches. The species is supposed to be closely allied to *Bos antiquus* Duvernoy, from the Pleistocene beds of Algeria.

The second family of the Ungulata contains only the Giraffes, and perhaps the recently discovered Okapi. The Giraffe of South Africa (*Giraffa capensis*) is distinguished from the northern species by its spotted legs and blotchy body markings; it appears never to have been found to the south of the Orange, but was abundant to the north as far as the Zambesi, and is still to be met with in the Northern Kalahari, and perhaps in Zululand and along the Sabi River in the Eastern Transvaal.

The Hippopotamus or Zeekoe, as it is invariably termed by the Dutch, is still to be found on some of the more unfrequented and remote rivers of Zululand and Portuguese East Africa; while it is comparatively common on the Zambesi near the Victoria Falls, and has there been the cause of a good many accidents to canoes and boats on the river. The last survivor of those which formerly inhabited the Colony is said to have mysteriously disappeared about the year 1874 from the Berg River, about seventy miles north of Cape Town, while the skull of one killed on the same river in 1856 is still preserved in the South African Museum.

No wild pigs of the genus *Sus* exist in the Ethiopian region. Two other genera of the same family take their place; of each of these South Africa possesses one representative, the Bosch vark (*Potamochoerus choeropotamus*), a nocturnal, forest-haunting creature, not uncommon in the wooded districts along the south-west coast of the Colony and in Natal; and the Wart Hog (*Phacochoerus aethiopicus*), distinguished by the possession of fleshy warts on its face and by its long lower canines, which often protrude ten or twelve inches beyond the long sockets. It does not now occur south of the Vaal River.

One of the most characteristic of South African animals is the Zebra, the several species of which form a distinct section of the *Equidae.* Three species are South African, one of which is now extinct—the Quagga (*Equus quagga*); this animal was formerly very abundant all over the Karoo plains of the interior of Cape Colony and the Orange River Colony, where it consorted with Black Wildebeeste and Ostrich in considerable herds. What evidence there is, seems to point to the fact that it became extinct in Cape Colony about 1860, and in the Orange Free State in about 1878.

There are a few mounted specimens existing in the English and Continental museums, while in its old home there is only one survivor, a foal, preserved in the South African Museum at Cape Town.

The Mountain Zebra (*Equus zebra*), no doubt owing to its attachment to inaccessible mountain ranges, still survives in fair numbers in Cape Colony. The latest returns of the Agricultural Department state that there are about 340 individuals found in the divisions of Cradock, George, Oudtshoorn, Uniondale and Ladismith; while in Kaokoland in the north of German South-West Africa there exists a Zebra recently described by Herr Matchie, of the Berlin Museum, as distinct (*Equus hartmannae*) which very closely resembles the Cape Colony Mountain Zebra.

The third South African species is Burchell's Zebra, a widely spread form, ranging from the Orange River Colony northwards to Masailand in East Africa; this species shows a series of progressive modifications throughout its range, chiefly in the matter of the amount of the striping on the legs, and the presence or absence of faint stripes, called shadow stripes, between the primary ones on the body. In consequence of this a very large number of sub-species or geographical races have been described of late years by

Matchie and Pocock, and there are now recognised by these authors no less than seven sub-species from north of the Zambesi alone. That there is a certain amount of progressive variation from south to north is certainly the case ; but there is also without any doubt a certain amount of individual variation in animals found in the same herd, as well as variation due to age and season, and I cannot help thinking that a good many of the seven sub-species above mentioned will be found to have no true geographical significance, the only justification for their existence.

Both the species of Rhinoceros found in Africa belong to the Atelodine group of the genus, distinguished by their single horns, comparatively smooth skins, their thick rounded and truncated nasal bones, and by the absence of incisor and canine teeth in the adults. The larger species (*R. simus*) generally called the White, but better termed the Square-lipped Rhinoceros is, after the Elephant, the bulkiest of land animals now existing. It was formerly found in large numbers all over the grass country north of the Orange River; now it is on the verge of extinction, only a few examples being still to be met with in Zululand,where, however, it is to be hoped that they may slowly increase under the strict laws and fostering care of the Administration. A very fine male, shot in Mashonaland in 1895 and presented to the South African Museum by Mr. Cecil Rhodes, is exhibited in the galleries of that institution ; while another shot by Mr. C. R. Varndell in Zululand in 1894, was presented to the Transvaal Museum at Pretoria by Mr. Carl Jeppe. The White Rhinoceros was, up till recently, supposed to be confined to the country south of the Zambesi, but recently the skull and horns of an undoubted specimen shot by Major Gibbons on the Upper Nile, near Lado, were exhibited at a meeting of the Zoological Society of London.

The Common or Black Rhinoceros is a smaller species, and can at once be distinguished by its prehensile upper lip, which has a sort of medial prolongation resembling a small proboscis. It is a browser and not a grass-eater like the other species. The Black Rhinoceros has a much more extended range than the White, being found from the Upper Nile Valley and Somaliland southwards. It is now only met with in a few out of the way parts of South Africa, such as Lydenburg in the Transvaal, Zululand, and perhaps parts of Rhodesia.

The Dassies (*Hyracoidea*), of which some twenty species are known, form a family confined to Africa and Arabia. They have no near affinities to any particular group, nor has palæontology thrown much light on their origin up to now.

South Africa possesses representatives of three species, the best known of which (*Procavia capensis*) is very common throughout the greater part of the country wherever there are rocky cliffs or stony hills. The Dassie externally resembles a large guinea pig ; it lives in small family parties in the crannies and cracks in the rocks, and can often be seen sunning itself there in the middle of the day.

The last family of the Ungulata contains the Indian and African Elephants, the latter of which was formerly widely spread all over South Africa from the immediate neighbourhood of Cape Town northwards. Within the boundaries of Cape Colony there are still two wild herds, one said to number about forty individuals, in the Knysna forest, and the other, about 350 in number, in the Addo bush, near Port Elizabeth. The skeleton of a male and the mounted skin of a female, both from Addo, are exhibited in the South African Museum.

Eight families of the Rodents are represented in our fauna, but the number of species, about seventy, is not very numerous, and does not form so preponderating a proportion of the fauna as in most other parts of the world. Two of the families are confined to the Ethiopian region—*Bathyergidae* and *Pedetidae*.

The best known of the representatives of the Squirrel family is the Ground Squirrel (*Xerus capensis*), distinguished by its rudimentary external ears and its coarse, harsh fur; it lives in burrows in the open country and feeds on bulbous roots; it is frequently confused by the colonists with the Meerkats, in whose company it is often found, and to whom it has a slight superficial resemblance. Two or three other species of arboreal squirrels inhabit the more wooded districts. The Dormice (*Gliridae*) and the true mice (*Muridae*) are fairly abundant but are little known, and probably a good many forms still remain to be discovered.

To the family *Bathyergidae* belong the Rodent-Moles; there are seven or eight species described, the best known being the large Sand Mole (*Bathyergus maritimus*), which forms long burrows all over the sand-hills in the neighbourhood of Cape Town; so completely is the ground riddled in some places that riding becomes positively dangerous. The eyes are very small and rudimentary and the ear conch is absent, while the limbs are short and powerful and armed with long, strong claws for burrowing. A somewhat smaller species (*B. janetta*) has recently been described from Namaqualand by Mr. Thomas. The Blesmol (*Georychus capensis*) still smaller, is common in gardens where it ravages bulbs and potato tubers; it is so called from the "bles" or white spot on the top of its head.

Another curious and rather anomalous rodent, for which a special family has been created, is the Spring-haas (*Pedetes caffer*), a fair-sized animal, about as large as a rabbit, with short fore and long hind limbs, on which it rests in kangaroo fashion; when pressed it progresses by a series of great bounds; it is nocturnal in habits, spending the day in deep and complex burrows, in which several families live together. The Porcupines have a single representative (*Hystrix africae-australis*), not very different from that of Europe; and the Hares, known as the Vlackte haas (*Lepus capensis*), Rhebok haas (*L. saxatilis*) and Roode haas (*L. crassicandatus*), together with several other species recently discriminated by Mr. Thomas are spread all over the country.

As is the case in other parts of the world, but little attention has been paid to the Bats of South Africa; about thirty species are described, but there are probably a good many more still awaiting discovery by anyone who devotes himself to the study of these very interesting little creatures. Representatives of five out of the six usually recognised families are found within our limits, the *Phyllostamatidae* or bloodsucking bats, which are confined to the New World, alone being absent.

There are two fruit bats commonly met with ; *Rousettus collaris*, which is abundant in the neighbourhood of Cape Town and also throughout the whole country; they are specially devoted to loquats, and when this fruit is ripe they assemble in large numbers among the trees during the night time and do a good deal of damage ; next morning nothing will be seen of the bats, but a crop of loquat stones will be found lying underneath the tree. The other species, *Epomophorus wahlbergi*, confined to the eastern half of the Colony and to Natal, is remarkable for the very expansible and pendulous lips of the male ; these appear to be used as a kind of sucking organ for extracting the soft interior of such fruits as figs, on which it chiefly feeds. Of the commoner insectivorous species, the Horse-shoe Bat (*Rhinolophus capensis*), the Slit-faced Bat (*Nycteris capensis*), and the Cape Serotine (*Eptesicus capensis*) are most frequently met with.

The animals which form the next order, the Insectivora, though not very numerous and all of small size and inconspicuous, are of considerable interest morphologically and from the standpoint of distribution. Out of ten families usually recognised, four are represented in our fauna ; two of these, the *Chrysochloridae* (Golden Moles) and the *Macroscelidae* (Elephant Shrews), though not confined to South Africa, are restricted to the Continent, and apparently have their headquarters in the south.

The commonest species of the former family at the Cape (*Chrysochloris aurea*) is abundant everywhere ; in almost every garden its runs, made just underneath the soil, can be seen ; it destroys worms and subterranean insect larvæ, and in this it is of great service, but in the pursuit of its prey it often disturbs bulbs and freshly-sown seeds, so that gardeners are not very fond of it. It derives its name from the beautiful golden metallic sheen on its fur, which is much increased when the creature is preserved in spirit.

Although resembling the true Moles (*Talpidae*) in its habits and general modification for underground life, the members of this family are structurally more closely allied to the Tenrecs (*Centetidae*), a family of Shrew-like animals found in the Island of Madagascar. The Elephant Shrews (*Macroscelides*) are met with mostly among the rocky kopjes and on the dry open Karroo ; they sit up on their hind legs like a kangaroo and progress by leaps. The snout is long and tapering, resembling an elephant's trunk, whence the name.

A single species of Hedgehog (*Erinaceus frontalis*) and some five or six shrews referred to the genera *Crocidura* and *Myosorex* complete the list of South African Insectivora.

The Order Edentata consists of five families, three of which are confined to the New World, while two are exclusively found in the Old. Representatives of both these latter are meet with in South Africa.

The Scaly Anteater (*Manis temmincki*) is not found in Cape Colony proper, but from the Valley of the Orange River northwards is fairly common, though, as it is nocturnal and lives in burrows, it is seldom seen; its food consists of ants and termites, which it obtains by breaking open the ant-hills with powerful claws and catching the outswarming ants on its sticky tongue.

The Aard-vark (*Orycteropus afer*) constitutes with its congener (*O. aethiopicus*) of North-East Africa, a family so distinct from the others of the order, as in the opinion of many to require separate ordinal accommodation. The most remarkable feature of these creatures is the structure of their molar teeth—they have no others; these are made up of a number of columns of dentine, each with its separate pulp cavity, from which radiate outwards the dentinal tubes. These are tightly packed together to form a solid tooth, so that in section the polygonal outlines of the separate columns can be seen. No other Mammal has teeth in any way comparable to the Aard-vark, which stands quite alone in this respect.

This creature is found throughout the length and breadth of South Africa, but is seldom seen or procured owing to its nocturnal habits; it spends the day in very large and capacious burrows, which are a constant danger to the unwary rider, and which owing to the openings being often concealed by bushes, are very difficult to avoid.

Finally, a few words may be added in regard to the marine Mammals which form the order Cetacea, and which are fairly numerous in South African seas. Of Whales, the Southern Right Whale (*Balaena australis*) visits our coasts in June and July for the purpose of calving. It is then often pursued by whale boats of which there are several stationed in both Table and False Bays, and is much valued, as the Baleen is long and of great value. Humpbacks and Finners, as well as the Sperm Whale, are all occasionally met with, though not so often molested.

One of the most curious members of this order is Layard's Beaked Whale (*Mesoplodon layardi*) the jaws of which are edentulous, except for a single pair of strap-shaped teeth springing from the lower jaw and growing upwards and inwards so as to cross each other above the rostrum of the upper jaw. This arrangement must almost entirely preclude the animal from opening its mouth at all, and it is difficult to understand how such a state of things could have originated.

A number of different kinds of porpoises and dolphins, all belonging to the family Delphinidae have been met with from time to time, but very little is known either about their structure or habits.

(*b*) *Aves*.

With the exception of perhaps the Butterflies, the birds form the best known and most studied components of the South African fauna. The number of species hitherto recorded as occurring in South Africa is about 820, and it is hardly probable that many more remain to be discovered, though doubtless the ingenuity of the modern ornithologist will be able to detect a good many new sub-species or geographical races among the more widely spread forms. While, however, our knowledge of the species found in South Africa is tolerably complete, we are still very ignorant of the nidification and migratory habits of many of the birds. With regard to the latter, we have in South Africa two very distinct groups of birds. On the one hand such birds as the Tree Pipit (*Anthus trivialis*), the Lesser Grey Shrike (*Lanius minor*), the Garden Warber (*Sylvia simplex*), the Willow Wren (*Phylloscopus trochilus*), several of the Reed Warblers, the European Swallow (*Hirundo rustica*), the Goat-sucker (*Caprimulgus europaeus*), the Roller (*Coracias garrula*), the Bee Eater (*Merops apiaster*), the Cuckoo (*Cuculus canorus*), and a large number of the Sandpipers and Plovers, are European birds which breed in the Northern Hemisphere during the northern summer, and only come to South Africa during the northern winter (October to March) to escape the cold. With one or two exceptions these birds, although present here in South Africa during the breeding time of other native birds, do not themselves nest here. On the other hand there are a number of birds such as the Stripe-breasted Swallow (*Hirundo cucullata*), several of the Cuckoos (*Cuculus gularis* and *C. solitarius*) which are breeding birds with us during our summer months (October to March), and which disappear altogether in our winter probably into Central Africa.

As is usually the case, the greater number of the South African birds are comprised in the Order Passeres; these species are about 380 in number, divided among twenty-one families. It is only possible in the limited space at my disposal to enumerate a few of the more common or striking members of the larger families.

Among the Starlings or Spreuws (*Sturnidae*) are the curious Oxpeckers, also called Tick birds (*Buphaga africana*), which are usually associated with the larger animals, such as the wild buffalo and antelopes or the domestic cattle and donkeys, whom they benefit by removing the adhering ticks and other parasites. The Wattled Starling (*Dilophus carunculatus*), the male of which has an entirely naked head, from which project huge black wattles, is generally found in large flocks, pursuing the swarms of locusts which devastate parts of the country from time to time.

The other South African Starlings are mostly distinguished by the possession of a beautiful metallic black or purple livery; while the English Starling (*Sturnus vulgaris*) is the only European bird, so far as I am aware, which has thoroughly established itself in South Africa. Unknown six or seven years ago, it is now found throughout Cape Town and the Suburbs in very large numbers, and is rapidly extending its range into the interior.

Another large and very characteristic family are the Weaver birds (*Ploceidae*). The bulk of the representatives of the family are found in the Ethiopian region, and about sixty species in South Africa. The common Cape Weaver bird (*Sitagra capensis*) is a species most likely to be observed in or near Cape Town; it is generally to be found in the neighbourhood of water, and builds its large retort-shaped nests in colonies usually on a willow or other tree overhanging the water; the entrance is a long tunnel pointing vertically upwards, and the work of building falls entirely to the male, the female looking on and criticising, and even, if she disapproves, pulling the nest to pieces and forcing the cock to commence again. To this family also belong the Waxbills, generally known in South Africa as "Rooibekjes." Most of the species are brightly coloured, and as they are all seed eaters they are easy to keep in captivity, and favourite denizens in an aviary.

The commonest species is *Estrilda astrilda*, commonly seen among the cornlands and grass pastures in large and noisy flocks looking for grass seeds. The third group of this family comprises the Widow birds and Bishop birds. Among these the males during the breeding season have a brilliant livery of black usually combined with yellow or scarlet, while the females and the males in the non-breeding season are dull tawny brown and quite inconspicuous. The commonest species in Western Cape Colony are the Yellow and the Red Bishop Birds (*Pyromelana capensis* and *P. oryx*), while on the grassy downs of the Orange River Colony and the Transvaal the Great-tailed Widow Bird (*Coliopasser procne*) is sure to attract attention. It is called "Sakabuli" by the Kafirs and often by the English, and has a tail sometimes reaching a length of 20 inches although the body of the bird only measures three or four. This last-named species is very remarkable in its domestic habits, as it is one of the very few polygamous passerine birds. In the spring each male, accompanied by ten to fifteen females, selects a suitable spot for nesting; here each hen builds a separate nest while the cock watches the proceedings from some vantage point ready to warn the hens of approaching danger and to drive off other intruding cocks. The next family, the true Finches (*Fringillidae*) is not a dominant one in South Africa. It includes the Cape Sparrow (*Passer arcuatus*) which, though closely resembling the familiar English bird in appearance and ways, is really distinct, its back being cinnamon-red without any trace of the darker brown streaks characteristic of the European form. It is exceedingly common in Cape Town and has become completely acclimatised to town life; so much is this the case that the English Sparrow, though it must have been introduced, has never obtained a footing in Cape Colony, so far as I am aware.

The only other member of this family which need be mentioned is the Cape Canary (*Serinus canicollis*), a common resident everywhere in South Africa and a very favourite cage bird. As would naturally be expected, Larks (*Alaudidae*) abound in South Africa on the wide karoo and grassy plains which cover so much of its area. Some thirty species, most of them confined to South Africa, have been enumerated, though none of these appear to possess the sweet song of our English bird.

Pipits and Wagtails are fairly numerous ; the species most often seen is perhaps the little Cape Wagtail or Quickstertje (*Motacilla capensis*), one of the tamest and most familiar birds in South Africa, which can be observed everywhere running swiftly along the ground or taking short flights in search of flies and other insects.

The Longtailed Sugar birds (*Promerops*), two species of which are generally recognised, form a distinct family, the range of which is confined to South Africa. These remarkable birds are nearly coterminous in their distribution with certain plants of the Natural Order Proteaceæ which form a very characteristic feature of the south-western districts of South Africa and are found elsewhere only in Australia. The Cape Long-tailed Sugar Bird (*Promerops cafer*) is very common about the slopes of Table Mountain and can be seen flitting about in small companies of about a dozen or more among the Protea bushes and Silver trees which clothe the hill-sides. They have very long tails, which they flirt up and down during flight, and long bills by means of which they suck the honey from the Protea blossoms ; this, together with insects, forms their food.

Closely allied to the last-named family are the Sunbirds (*Nectariniidae*), distinguished by their bright metallic plumage and rivalling in their gorgeous colouring the humming birds of the New World. Some sixteen species of the family inhabit South Africa, the commonest and one of the most beautiful being the Malachite Sunbird (*Nectarinia famosa*), which is spread all over the country south of the Limpopo and which is distinguished by its pure metallic green plumage.

The Shirkes (*Laniidae*) are a fairly numerous and conspicuous family. The Fiscal or Johnny Hangman (*Lanius collaris*), with its sombre livery of black and grey, is found everywhere, and is a bloodthirsty and rapacious criminal. It impales its prey on thorns or even on a barbed wire fence until it has acquired sufficient flavour for its palate. The Bush Shrikes, on the other hand, are much less formidable, but are frequently brightly coloured ; the best known species, the Backbakiri (*Laniarius gutturalis*), derives its name from its loud, clear note ; the male and female are seldom apart and constantly answer one another's call ; they can be heard at a great distance.

The Warblers (*Sylviidae*) comprise a number of birds generally of small size and plain plumage ; they are very abundantly represented in South Africa, both by European migrants and local residents, to the number of over sixty species.

The remaining families of the Order Passeres, the Thrushes (*Turdidae*), the Flycatchers (*Muscicapidae*), and the Swallows (*Hirundinidae*) are all adequately represented in our fauna, the last-named particularly so.

The second order of birds, the Picarians, contains a number of well-marked families, and are mostly distinguished for their bright plumage or grotesque and bizarre forms. The South African species, about one hundred in number, are comprised in sixteen families, among which the Swifts, Nightjars, Rollers, Bee-eaters, Kingfishers, Mousebirds, Hornbills, Woodpeckers, Cuckoos and Plaintain-eaters predominate.

Among the more interesting forms is the Standard-wing Night-jar (*Cosmetornis vexillarius*), the male of which has the ninth primary feather of the wing enormously elongated to about three times the length of the whole bird forming a kind of streamer or standard ; only the males carry this curious adornment and they only in the breeding season. This species is not found in the Colony but only further north in Rhodesia, where it is by no means uncommon.

The Rollers or Blue Jays, as they are generally called by the Colonists, are very conspicuous birds in the more tropical portions of South Africa such as the northern part of the Transvaal and Rhodesia ; in addition to the European species (*Coracias garrula*), which only visits South Africa in the southern summer season and does not breed with us, there is Moselikatze's Roller (*C caudatus*) with its elongated tail feathers, bright plumage and bold ways, very commonly seen throughout Rhodesia.

Of Kingfishers we possess one of the largest species (*Ceryle maxima*), about 17 inches in length with a handsome livery of black and white ; it is found along most of the larger rivers and even on the sea coast, where it can be seen poised in the air quite stationary to all appearances, with its head and beak pointing straight downwards ready to strike like an arrow on the fish below. A contrast to this is the little Natal Kingfisher (*Ispidina natalensis*) with coral red legs and beak contrasting with its metallic ultramarine plumage ; it haunts the bush and forest, and feeds chiefly on insects, which it captures on the wing.

A small though interesting family is the *Coliidae* or Mousebirds, strictly confined to the Ethiopian region, and remarkable for their pamprodactylous toes—that is, all four toes are normally turned forwards, although both hallux and fourth toe can be turned backwards at will. All three species of Mousebird (*Colius striatus*, *C. capensis* and *C. erythromelon*) are found about Cape Town, and can often be seen in small parties of six or seven birds flying from tree to tree in the gardens of the suburbs, especially when the fruit is ripe, to which they do a good deal of damage.

The Hornbills (*Bucerotidae*) are often mis-called "Toucans" by the Colonists, a name properly applicable to a purely American family, but which share with the true Hornbills the character of a grotesque and enlarged bill. A curious habit among these is that the male at the breeding season plasters up the female inside a hollow tree ; only a small aperture is left, through which protrudes the bill of the imprisoned female ; through this hole the male feeds her, and here she remains and moults her feathers for some six weeks until the eggs are hatched and the young ones have assumed their feathers. One species (*Lophoceros melanoleucus*) is common enough in the eastern half of Cape Colony, while there are several others found further north in Bechuanaland and Rhodesia.

Of Woodpeckers (*Picidae*), South Africa possesses a sufficiency ; perhaps the most curious modification is the Ground Woodpecker (*Geocolaptes olivaceus*), a species which, unlike all other woodpeckers, lives almost entirely on the ground; it is usually seen on the mountain sides and tops, wandering about in small parties among the rocks and boulders.

An interesting family are the Honey guides (*Indicatoridae*), several species of which are widely spread throughout South Africa; of dull plumage and appearance, they are remarkable for the fact that they will lead the traveller to the situation of bees' nests in the hope of sharing with him some of the spoil in the shape of honey or wax. In addition to this they are undoubtedly, like Cuckoos, parasitic in their breeding habits, and deposit their eggs in the nests of other birds.

The English Cuckoo (*Cuculus canorus*) visits South Africa during the northern winter months, though seldom coming so far south as Cape Colony, where however, its place is taken by other species, and especially by the Red-chested Cuckoo (*C. solitarius*) called the " Piet myn Vrouw " by the Dutch from its voice, which consists of three clear notes in the descending chromatic scale. Mention must also be made of the beautiful green Cuckoo (*Chrysococcyx*), of which there are three species, all with an intense metallic green or bronzy green dress.

The last family of the Picarian birds are the Plantain-eaters or Touracos (*Musophagidae*). The commonest species (*Turacus corythaix*), commonly known as the "Lourie," is a green-plumaged bird with a fine white-tipped crest; the wing feathers are bright crimson, and the pigment causing this colour named Turacin by Prof. Church, is of great interest for two reasons; in the first place it is soluble in water, so that when it rains, the bird, unless it obtains a good shelter, is liable to have its colouring matter washed out, and in the second place the pigment contains a very large proportion of copper (about 7 per cent.) in its composition, a substance very seldom met with in organic compounds. It has always been a mystery whence the Lourie obtains its supply of this metal.

South Africa is badly off for Parrots, there are only some half dozen found within our limits, and there are none of these common.

The next order—the Accipitres—containing the diurnal Birds of Prey, forms a very marked feature of our fauna. While many of the familiar European genera are represented by similar or closely allied species, there a number of distinct and peculiar forms confined to the Ethiopian region. Among the former are the Peregrine, Hobby, Kestrel, Red-legged Kestrel, Tawny Eagle, Lammergeyer, Buzzard, Kite, and several species of Sparrowhawk and Harrier. Conspicuous among the latter group is the Bateleur (*Helotarsus ecaudatus*), common enough north of the Limpopo, but not so often met with in Cape Colony; it can easily be recognised even when on the wing, by its short stumpy tail and its coral-red legs. It is an exceedingly handsome bird with a black head and underparts, and a rich maroon-chesnut back and tail. Verreaux's Eagle (*Aquila verreauxi*) is also a handsome and powerful bird, black throughout, except for a white patch in the centre of the back; it is not at all uncommon in mountainous districts. I was once fortunate enough to come upon three or four within 20 yards of me at Smitwinkel Bay, a few miles south of Simonstown. Contrasting with the Eagles is the Pigmy Falcon (*Poliohierax semitorquatus*), a little bird hardly larger than a Sparrow. A curious feature of this species is that the female is distinguished from its mate by having a patch of rich maroon red in the centre of the back.

Vultures are represented by seven species, the commonest of which is Kolbe's (*Gyps kolbii*), while one species (*Lophogyps occipitalis*) is the unique species of the genus which is confined to tropical and South Africa.

The Secretary bird (*Serpentarius secretarius*), though very unlike one's idea of a Hawk, is undoubtedly an aberrant member of the Accipitrine Order. Only the single species is known, and it ranges over the greater part of the Ethiopian region and forms a special family.

The Secretary bird has long had a somewhat undeserved reputation as a destroyer of snakes, and is popularly supposed to be strictly preserved by the law of the land. This, however, is not the case, indeed many sportsmen would like to see the extinction of the Secretary bird encouraged, as it undoubtedly destroys numbers of the young of partridges and hares; indeed its appetite is varied and somewhat indiscriminating; the stomach of a female specimen killed not long ago on the Cape Flats was found to contain one tortoise (*Homopus*), eight chameleons, twelve lizards of two species, three frogs, one adder (*Bitis inornata*), two locusts, two quails, besides other less recognisable remains.

South Africa possesses an average allowance of Owls though none of them present any very special features of interest. Perhaps the commonest species are the nearly cosmopolitan Barn Owl (*Strix flammea*), and the Spotted Eagle Owl (*Bubo maculosus*), while the Swamp Owl (*Asio capensis*) is often seen about in broad daylight.

One of the most characteristic sounds in Cape Town, and more especially in the wooded suburbs, is the monotonous and wearisome coo of the Cape Turtle Dove (*Turtur capicola*), a handsome species with a distinctly marked black collar round its neck. The little Laughing Dove (*Turtur senegalensis*) is also common in places, especially in the Municipal Gardens in Cape Town; its coo is much more musical than that of the Cape Turtle Dove, and closely resembles a human laugh.

In addition to these, South Africa possesses one Green Pigeon (*Vinago delalandi*) found in the forest districts, and several other species, the most noticeable of which perhaps is the Namaqua Dove, in which, contrary to what is usually the case, the sexes differ from one another, and which are very common on the Karoo and the "high veld" of the interior.

Of the Game birds, the largest genus is *Francolinus*, containing about ten species in South Africa alone. In the south-western part of Cape Colony two of these commonly occur, a larger one (*F. capensis*) commonly known as the Cape Pheasant, met with in bushy localities; and a smaller one (*F. africanus*) generally known as the Partridge, which frequents open country, especially the sides of the hills.

The Guinea Fowl (*Numida coronata*) is also found throughout South Africa, except in the south-western districts, and is common along the river valleys where there is a good shelter of thick bush. The domesticated race appears to have been originally derived from the allied West African species, and can generally be distinguished by its white wing feathers. The only other Game-birds which need be mentioned are the Sand-grouse (*Pteroclidae*), by some authors considered to be sufficiently distinct to form a separate order. Of these typical desert-haunting birds we possess four species, the commonest of which is the co-called Namaqua Partridge (*Pteroclurus namaqua*) often seen in enormous flocks in the dryer districts.

Restriction of space hardly allows me to do more than mention the remaining Orders, the Geranomorphae, with three handsome species of Cranes, the Wattled (*Bugeranus carunculatus*) the Mahem or Crowned Crane (*Balearica chrysopelargus*), and the Blue Crane (*Tetrapteryx paradisea*); while the Bustards (*Otidae*) are represented by no less than twelve species, ranging from the large Gom Paauw (*Otis kori*), the male of which sometimes weighs as much as 40 lbs. to the smaller Knorhaan (*Otis afra*), about the same size as a partridge.

Among the Waders are a considerable number of European species, migrants from the north only visiting our shores during the southern summer; such are the Grey Plover, Ringed Plover, Curlew, Whimbrel, Ruff, Little Stint, Sanderling, Common Sandpiper, Greenshank and Green Sandpiper.

Only two Gulls are found about our coasts; these are the Southern Blackbacked (*Larus dominicanus*) and Hartlaub's (*L. hartlaubi*); both are very common in Table Bay, and the latter can at once be distinguished by his pure white dress and smaller size.

The Petrels (*Tubinares*) are essentially birds of the Southern Ocean and are numerous in Cape seas though, so far as I am aware, not a single species nests on our coasts; among them are the gigantic Wandering Albatross (*Diomedea exulans*), sometimes reaching as much as 12 feet across the wings, and the other rather smaller species known locally as the Mollymauk (*Diomedea melanophrys*); the former is not often seen near the coast, but the latter is very common about bays and harbours and is a magnificent spectacle when soaring along behind a ship seeking for refuse thrown overboard. Passing over the *Herodiones*, *Steganopodes* and *Anseres*, we come to the last two orders, both highly characteristic but both only represented by a single species.

The Jackass Penguin (*Spheniscus demursus*) is quite common along our coasts and nests in the numerous rocky and sandy islands especially off the south-western shores of Cape Colony. So numerous is it, that its eggs, which are collected specially for the purpose, form an appreciable addition to the foodstuffs of the poorer classes of Cape Town. The Order *Impennes* to which the Penguins are referred, is entirely confined to the southern seas.

Finally, South Africa contains one representative of the *Ratitae* or wingless birds—the Southern Ostrich (*Struthio australis*), apparently confined to Africa south of the Zambesi and Cunene rivers; north of this line, so far as is known, no ostrich occurs till the Rufiji River, about 7° S. lat. in German East Africa, is crossed, beyond which occurs *Struthio massaicus*, distinguished by it reddish neck.

The Ostrich is now a domesticated bird throughout the greater part of Cape Colony, and is bred and kept for the sake of its plumes, which are annually pulled or cut. In 1903 nearly half a million pounds of feathers were exported, valued at £945,000, and the amount and value seems to be slowly increasing year by year.

(*c*) *Reptilia.*

In a list of the South African reptiles drawn up a few years ago some 250 species were included; to these a certain number of additional species since described must now be added.

Of the Crocodiles only one species has been met with; this is the common *Crocodilus niloticus* of the Nile and other parts of tropical Africa. It is confined to the rivers flowing eastwards into the Indian Ocean, from the Zambesi to Pondoland, and never seems to have reached the south and westwardly-flowing streams. It is stated to reach a length of 20 feet, but probably its size has been a good deal exaggerated. There is an example in the South African Museum from Mozambique, measuring between 14 and 15 feet, and this appears to be a very large example.

The Chelonia number nineteen; fourteen of these belong to the *Testudinidae*, of which the common land tortoise of South Europe may be taken as a type. The largest of them is the Leopard Tortoise (*Testudo pardalis*), which attains a length of about 2 to 3 feet, not a great size as compared with the giants of the Aldabra and Galapagos, but the largest of all the continental terrestrial forms. This species and some of the others belonging to the same family are frequently to be seen wandering about on the Karroo and are often kept as pets by the farmers, who call them "schild pad." In addition to these there are two fresh-water tortoises not infrequently found in the streams and pools—*Sternothaerus sinuatus* and *Pelomedusa galeata*—both included in the family *Pelomedusidae*; the first-named of these remarkable for the fact that the front part of the plastron is hinged and can close up the front opening of the bony box into which the head and limbs are retracted.

Three of the marine Turtles have occasionally been met with on our coast—the Leathery Turtle (*Dermochelys coriacea*), the Hawksbill Turtle (*Chelone imbricata*), and the Loggerhead

(*Thalassochelys caretta*), but none of these are anything but occasional visitors.

The lizards are the most numerous in species of the South African orders of reptiles. One hundred and eighteen are included in the list drawn up by the writer in 1898. They are referred to ten families out of the twenty-one recognised by Mr. Boulenger in his catalogue.

Geckos are numerous, especially on the Karroo. As would be inferred from their narrow, vertical pupils they are mostly nocturnal in their habits, while a large number of the species have their toes swollen and provided with adhesive lamellæ on the lower surface which enable them to cling to vertical or overhanging rocks. One species (*Ptenopus garrulus*), common on the Karoo, has a curious dry, monotonous note to which it gives vent when seated at the mouth of its burrow.

The *Agamidae* have eight representatives, all assigned to the typical genus; they are spiny lizards and bask in full sunlight on smooth rocks often nodding their head, and have thus gained the name of "Kokkelmanetje" or Little Bowing Man among the Dutch.

Among the *Zonuridae* we have the large and formidable-looking *Zonurus giganteus* which attains a length of from 2 to 3 feet; the body is covered with bony plate-like scales the horny coverings of which are produced into sharp spikes especially about the back of the head and on the tail. This species is common in the northern portion of the Orange River Colony and lives in burrows underground; large numbers of them were obtained when the railway was being extended between Bloemfontein and the Vaal River. Another interesting form of the same family is *Chamaesaura* with its long snake-shaped body and tail; among the species of this genus there is an interesting progressive degeneration from *Ch. ænea*, which has both pairs of limbs present and pentadactyle though small, through several intermediate forms where the limbs are reduced to mere stumps, to *Ch. macrolepis* where they are altogether absent. The members of this family are confined to tropical and South Africa.

Among the *Varanidae* are to be found the largest of existing lizards, some of which attain a length of from 6 to 7 feet; two species only inhabit South Africa, the larger *V. niloticus* and the smaller *V. albigularis*; the former is the largest of the two, and haunting as it does the banks of rivers, is often mistaken for a crocodile; both species are generally known among the Dutch by the name of Laguvan or Leguan, a corruption of Iguana, a term more usually applied to the members of an American family, the *Iguanidae*.

The curious worm-shaped lizards known as Amphisbaenas are more numerous in tropical Africa, but two or three species do occur within our limits; they are remarkable worm-like creatures, covered with soft skin which forms numerous rings each of which is again divided into a number of little squares; the eyes and ears are concealed and the limbs absent. These lizards are entirely subterranean and are generally found in ant-heaps.

The *Lacertidae* comprise a number of Old World genera of no very special interest; there are about seventeen species found in South Africa. The next family, *Gerrhosauridae* are somewhat intermediate between the *Lacertidae* and the *Scincidae*; as in the latter family, the scales are underlaid by bony plates, but, on the other hand, they have a slightly-forked tongue and a row of femoral pores; the *Gerrhosauridae* are strictly confined to the Ethiopian region, while one genus *Tetradactylus* is purely South African.

The Scinks (*Scincidae*) form the largest single family in South Africa, some twenty-eight species being recorded. They are typical sand lizards, being found abundantly on the dry and rocky Karoo of South Africa. This family also offers an example of the gradual reduction from a fully developed and functional pentadactyle limb to a complete absence of those appendages; this is specially the case in the genus *Scelotes*, while *Acontias meleagris*, a common species usually found under rocks and stones, has all the appearance of the English slowworm.

The last family of the Lizards are the Chameleons, one of the most characteristic of African types; though extending beyond the limits of Africa to Southern Europe and Asia, the bulk of the forms are confined to the Ethiopian region proper, including Madagascar. So markedly do they differ from other lizards that many authors are inclined to place them in a separate Order of Reptiles. Very characteristic are the compressed body, the prominent crests and tubercles on the head, the club-shaped projectile tongue, the prehensile tail, the curious grasping feet, in which two of the toes are opposed to the other three; in the fore limb the outer two are opposed to the inner three; while in the hind limb the outer three are opposed by the inner two.

Nine species are known to inhabit South Africa. About Cape Town the little *Ch. pumilus* is the commonest form; unlike most of the other species it is viviparous, producing as many as thirteen fully formed young ones at birth; whereas the larger *Ch. parvilobus* of the Transvaal and Rhodesia lays eggs. Most Chameleons are arboreal in habits, but one South African species *Ch. namaquesis*, is specially modified for "Karoo life;" its limbs are stouter and it is more active on the ground, while its colour is an inconspicuous greyish brown, and shows no trace of the prevailing greens of the other forms.

South Africa certainly contains its fair share of snakes, eighty-one species are recorded, out of which twenty-two are reported to be poisonous. Five of the nine families recognised by Boulenger are repre ented, though as is generally the case, far the greater proportion of the species, about fifty-seven, belong to the great family *Colubridae*.

The worm-like burrowing Snakes of the families *Typhlopidae* and *Glauconiidae* are fairly numerous though not often met with. One of the largest species is *Typhlops schlegelii*, which attains a length of more than two feet; it is found at Delagoa Bay and further north in the low country. Both these families are probably degenerate descendants of formerly cosmopolitan and rather archaic snakes, which have adopted a burrowing life and insectivorous diet.

Contrasting very strikingly with these degenerate forms are the powerful Pythons and Boas (*Boidae*). A noticeable character of this group is the presence of the extremities of the rudimentary hind limbs on either side at the base of the tail. Only one species occurs with us (*Python sebae*), by far the largest of our native Snakes, often attaining a length of fifteen feet, and said sometimes to reach twenty to twenty-five. The Rock Snake, as it is often called, is confined to the Natal, Zululand, and the low country of the Transvaal and Rhodesia; it is not met with in Western Cape Colony or on the high veld.

The immense family of *Colubridae* is conveniently divided into three parallel series. First, the *Aglypha*, with all the teeth solid and non-poisonous; and secondly, the *Opisthoglypha*, with some of the hinder maxillary teeth grooved and poisonous to a certain extent, as they paralyse their prey before deglutition, but not dangerous to man; thirdly, the *Proteroglypha*, with the anterior maxillary teeth grooved or perforated, and distinctly venomous. To the *Aglypha* belongs the common Water Snake (*Ablabophus rufulus*) found always near streams and vleis, the Aurora, of somewhat similar habits, and at once known by a bright yellow narrow line running down the back,and the Mole Snake (*Pseudaspis cana*) mottled when young, but becoming a uniform blackish when older, and often attaining a length of 6 or 7 feet. Forming a distinct sub-family is the Egg-eating Snake (*Dasypeltis scabra*) widely distributed in Africa. The teeth in the jaws and on the palate are much reduced and degenerate, while some of the vertibrae of the lower neck have strongly developed hypapophyses, which are directed forwards and pierce the aesophagus and are tipped with enamel substance. The egg is swallowed whole, but on reaching the hypapophysial teeth is broken and crushed; the sucked-out egg shell is then vomited out as a crumpled up mass.

Among the *Opisthoglypha*, the commonest forms are the so-called night adder (*Leptodeira hotamboeia*), easily distinguished by the black patch on the sides of the head, and the Schaap-stikker or sheep stinger (*Trimerorhinus rhombeatus*), a handsome species with rhomboid brown markings on the back and sides. Its vernacular name is quite undeserved, and it probably has gained it through its active habits.

Among the truly venomous Snakes are included the curious Sea Snakes, forming a distinct sub-family, *Hydrophiinae*. Most of the species are found along the tropical shores of the Indian and Pacific Oceans; one, however, the wide ranging *Hydrus platurus* has been occasionally met with in both False and Table Bays. These Snakes may be known by their curious flattened oar-like tails and greyish blue colour, and are all excessively poisonous though they naturally do not often have an opportunity of exercising their dangerous powers on human beings.

The other sub-family, the *Elapinae*, include the Cobras and their allies; the commonest species is *Naia flava*, the Yellow Cobra, widely distributed throughout South Africa and common enough in the neighbourhood of Cape Town. Like the more familiar Indian Cobra the neck region can be flattened out and widened to form the so-called hood, but it can be at once distinguished by the absence of the so-called spectacle marks. This species not infrequently attains a length of ten feet, and needless to add its bite is almost invariably fatal. Closely allied to it is the Ringhals (*Sepedon haemachaetes*), a very handsome Snake with black and yellow mottled back, and black below with yellow transverse bands near the neck. It is hooded like the Cobra, and when roused, it not only strikes but spits out to a considerable distance a very acrid saliva, with which a certain proportion of venom is probably mingled. This habit has gained for it the name of the "Spugh-slang" among the Dutch farmers.

The justly-dreaded Mamba (*Dendraspis angusticeps*) is only found in Natal and the low country in the east. It is more of a tree-snake than the others, and sometimes reaches a length of 10 feet. The younger specimens are green, but as they grow older they get darker; there is no ground, however, for distinguishing the black from the green Mamba specifically. The other common Elapine Snakes, the larger and smaller Garter Snakes (*Aspidelaps lubricus* and *Homorelaps lacteus*) are sluggish and have very small mouths and fangs. They are probably not very dangerous; they are conspicuous forms the coloration consisting of alternate rings of black and red.

The other poisonous snakes belong to a distinct family, the *Viperidae*, in which there is only one maxillary tooth, the large and perforated poison fang. The most common South African member of this family is undoubtedly the Puff Adder (*Bitis arietans*), an ugly brute of yellowish and orange brown, with regular chevron shaped dark markings on the back; it seldom reaches a length of more than 4 feet, but is of very stout girth; it is inert and sluggish, but is justly held in great fear on account of its generally fatal bite. Other species are the Berg Adder (*Bitis atropos*) and the Horned Adder (*B. cornuta*); while *Causus rhombeatus*, the Night Adder, is not uncommon in the eastern portion of Cape Colony.

(*d*) *Batrachia.*

South Africa is not rich in Batrachians. Of the three Orders only the Anura are represented. They number thirty-four species, distributed in four families, *i.e.*, *Ranidae* with twenty-three, *Engystomatidae* with six, *Bubondae* with four, and *Dactylethridae* with one species respectively.

The largest of our South African frogs is *Rana adspersa*, which sometimes reaches a considerable size; an average specimen in the South African Museum measures between 7 and 8 inches in length.

It is common in the eastern half of Cape Colony and in the Transvaal, and has a very loud voice. Like other large species in other parts of the world it is generally known as the Bull-frog. The commonest representative of the curious digging family *Engystomatidae* is *Breviceps gibbosus*, commonly known as the "regen padda." It is the most comical little figure imaginable, with its globular body, very short stout legs and blunt little face hardly projecting beyond the general rotund outline. It is generally found below a damp sod, and gives out a weird and shrill squeak when handled.

Of the Toads (*Bufonidae*) South Africa possesses four species. The commonest, *Bufo regularis*, a large and extremely handsome form with bright yellow spots and markings, is generally known as the leopard toad.

Finally, the last family, *Dactylethridae*, are sufficiently distinct to form a separate sub-order ; they have no tongue, and are further unique in possessing claws on three of the hind toes. Only one species *Xenopus laevis* extends to South Africa, where, however, it is very common throughout the country, flourishing in almost every pool. It is far more aquatic in its habits than any other frog, and seldom leaves the water. The Orders of Tailed and Limbless Batrachians (*Urodela* and *Apodi*) are not, so far as we know, represented in South Africa.

III. Zoogeographical Relations of the South African Fauna.

South Africa, which, for the purpose of this article, is taken to mean that portion of the continent lying south of the Zambesi and Cunene rivers, forms part of the Ethiopian region as now generally understood by students of the geographical distribution of animals. The splitting up of this region into sub-regions is, however, a difficult task and is a subject on which authors have differed considerably. Some time ago I divided the Ethiopian region into four sub-regions. These were the Saharan, West African, Malagasy and Cape sub-regions respectively. South Africa, as defined by me for the purpose of this article, is rather a political than a natural section of the continent, and in the work above referred to the Cape sub-region extended north of the Zambesi Valley as far as the Congo watershed on the west and the Tana watershed on the east. Whether this line forms a really natural faunal boundary is at present uncertain, as our knowledge of the distribution of the faunal elements of those regions is at present in a very vague state, but there can be no doubt that a good many genera and even families formerly supposed to be confined to South Africa proper have of late years been met with much further north, and it is increasingly difficult to draw any dividing line between the Saharan and Cape sub-regions. On going through the revised lists of the vertebrate land fauna of South Africa, the following figures of the percentage of peculiarities result :—

		Mammals.	Birds.	Reptiles.	Batrachians.
Total number of Families	..	35	67	18	4
Total number of Genera ..	..	96	315	82	14
Number of Peculiar Genera	..	7	15	19	2
Percentage of Peculiarities	..	7	4	23	14

Only one family, so far as I am aware, is strictly confined to South Africa—the *Promeropidae* or Long-tailed Sugar Birds, which have never been found hitherto north of the Limpopo.

The following are the peculiar genera :—*Cynictis* and *Suricata*, the Meerkats among the Carnivora ; *Pelea* the Rhebok and *Antidorcas* the Springbok, among the Antelopes ; *Malacothrix*, *Bathyergus* and *Petromys*, among the Rodents. Of the birds, *Alario* (*Fringillidae*), *Callendula Spizocorys*, *Hetercorys* and *Certhilauda* (*Alaudidae*), *Promerops* (*Promeropidae*), *Anthrobaphes* (*Nectariniidae*), *Urolestes* and *Laniotūrdus* (*Laniidae*), *Phlexis*, *Euryptila*, *Pinarornis* and *Chaetops* (*Sylviidae*), *Emarginata* (*Turdidae*), *Geocolaptes* (*Picidae*) ; among the Reptiles—*Ablabophis*, *Lamprophis*, *Pseudaspis*, *Macrelaps*, *Sepedon*, *Aspidelaps* and *Homorelaps* (*Ophidia*), *Chondrodactylus*, *Ptenopus*, *Homopholis*, *Colopus*, *Rhoptropl[ius]*, *Pseudocordylus*, *Platysaurus* *Chamaesaura*, *Tropidosaura*, *Tetradactylus*, *Cordylosaurus* and *Herpetoseps* (*Lacertilia*) ; and finally *Helophryne* and *Cacosternum*, among the Batrachia.

From these lists and figures it is quite evident that South Africa has not such a specialised fauna as was formerly attributed to it, and that it has comparatively little to distinguish it from the rest of the Ethiopian region, which however, as a whole, presents a number of very interesting problems to the student of geographical distribution.

The recent discovery in deposits of Eocene age in the Fayoum of Upper Egypt of the remains of a number of extinct mammals has introduced into the problem of the origin of the African mammal fauna an entirely new set of data. What may be called the Huxleyan theory of radiation has hitherto held sway. According to this theory the Ethiopian region has been colonised from the north by two great immigrations ; the earlier one in eocene or early miocene times while Madagascar still formed part of the continent, brought in the Lemurs and other primitive forms which make up the present fauna of that island, while only a few scattered remnants have survived in Africa proper ; while a later one which took place in pliocene times, introduced the Antelopes, Hippopotamus,Rhinoceros, Zebras, Ostriches, Apes and higher Carnivora which now form so conspicuous a feature of our fauna, and which have still living, or but recently living, representatives in Southern Asia. Most of the ancestors of these forms have been traced back in the earlier tertiary deposits of the Northern Hemisphere, but hitherto no ancestral forms of the Proboscidea have been met with of earlier date than the Mastodons of miocene and pliocene times, which have been found in South and North America as well as in Europe and Asia.

Recent exploration in the Fayoum district in Egypt by Mr. Andrews of the British Museum has resulted in the discovery of a number of interesting eocene mammals which throw a good deal of fresh light on the earlier evolutionary stages of several mammalian orders. Perhaps the most remarkable form is one named by him *Moeritherium*, a very generalised type of Proboscidean with a full series of front teeth and an almost complete set of molars all in use at the same time, thus differing widely from the modern living forms. Nevertheless the modern type is foreshadowed not only in the shape and structure of the teeth but also by the enlargement of the second pair of incisors in each jaw; an enlargement which continues to be more and more marked until it culminates in the tusks of the modern elephant.

From these and other facts it appears probable that although some components of the Ethiopian fauna may have been evolved in the northern continents and have reached Africa by migration, other groups such as the Proboscidea have probably originated in Africa itself.

Hitherto except for this recent discovery in the Fayoum, no tertiary mammals have, so far as I am aware, been unearthed in Africa. In fact, apart from the reptiles of the Karoo beds of Cape Colony, which are dealt with in a special chapter by Dr. Broom, we know nothing of the Palæontological history of South Africa, and until our knowledge in this respect is largely increased no comprehensive theory of the origin and derivation of the African fauna can be arrived at.

IV. Literature.

(*a*) *General.*

1849. Smith, Sir A. Illustrations of the Zoology of South Africa. Vol. I., Mammalia, with 53 plates; Vol. II., Aves, with 114 plates; Vol. III., Reptilia, with 78 plates; Vol. IV., Pisces, 31 plates, Invertebrata, 4 plates. London. 4to.

1900-1905. Sclater, W. L. [Edited by]. The Fauna of South Africa. Mammals by W. L. Sclater, in two volumes complete; Birds by the late Dr. A. C. Stark and W. L. Sclater, in four volumes. London. 8vo.

(*b*) *Mammals.*

1832. Smuts, J. Dissertatio Zoologica, enumerationem Mammalium Capensium continens. Tribus tabulis adjunctis. Leyden. 4to.

1862. Layard, E. L. Catalogue of the Specimens in the Collection of the South African Museum. Part I., Mammalia. Cape Town. sm. 8vo.

1894–1900. Sclater, P. L., and Thomas, O. The Book of Antelopes. 4 volumes. London. 4to.

1899. Bryden, H. A. [Edited by]. Great and Small Game of Africa. London. 4to.

(*c*) *Birds.*

1799. LEVAILLANT, F. Histoire naturelle des Oiseaux d'Afrique. 6 volumes. Paris. 4to.

1867. LAYARD, E. L. The Birds of South Africa. A Descriptive Catalogue of all the known Species occurring south of the 28th Parallel of South Latitude. Cape Town. 8vo.

1872. ANDERSSON, C. J. Notes on the Birds of Damara Land and the adjacent countries of South-West Africa. Edited by J. H. Gurney. London. 8vo.

1875–84. LAYARD, E. L. The Birds of South Africa. New edition thoroughly revised and augmented by R. Bowdler Sharpe. London. 8vo.

1896-1905. SHELLEY, G. E. The Birds of Africa. Vols. I., II., III. To be completed in six volumes. London. 8vo.

1900-1905. REICHENOW, A. Die Vögel Afrikas. Vols. I., II. and III. Neudamm. 8vo.

(*d*) *Reptiles and Batrachians.*

Apart from Smith's Illustrations, already alluded to, no special works on South African Reptiles and Batrachians have hitherto been published. Reference must be made to the series of British Museum Catalogues of the groups prepared by Mr. G. A. Boulenger.

2. A BRIEF SKETCH OF THE SOUTH AFRICAN INSECT FAUNA.

By L. Péringuey, Assistant Director, South African Museum.

South Africa is taken here to mean that part of Africa lying south of the sixteenth parallel. The collections made of late years prove that this is the natural limit dividing South Africa from the other two great African sub-regions (western and eastern), as nearly as conterminous lines, without marked natural boundaries, can prove to be a natural limit. This fauna assumes a much more distinct character the further south it goes, but from that northern limit must be excluded the coast belt of low land extending in the east as far as Beira, and probably further south, because this belt belongs unmistakably to the *eastern* sub-region; in the north-west such is not the case, and the fauna of Omrromba, Umbe, Umpata is much more closely related to that of N'Gamiland than to that of Angola. There is, on the whole, no well-marked natural boundary, because there are no insurmountable physical barriers. In Natal the insect fauna of the tropical coast belt is undoubtedly of a more Ethiopian character than that of the high veld of that Colony or of the Transvaal, but it is not more Ethiopian than that of the low country of the Transvaal. If we compare the fauna of Namaqualand and that of Natal, lying both along the thirtieth parallel, the difference is indeed striking, and it is doubtful if more than one genus in ten, or one species in fifty are denizens of both these localities, yet there are no insurmountable barriers between them. But in Namaqualand the climatic and physical influences of the adjoining sandy and stony desert localities make themselves felt; while in Natal the forest and thorn bush, the more humid climate and greater rainfall have a distinct influence. The penetration westward of the ultimately mingling yet gradually modified fauna is in the north, along the Zambesi and through the Transvaal, and southward along the Drakensberg range. The distribution of the different orders of insects does not, however, proceed on quite similar lines, and one should not lay hard and fast rules for all of them; but the limitation of this South African sub-region holds good for two of the best known orders, the *Coleoptera* and the diurnal *Lepidoptera*, orders so diametrically different in habits as well as mode of locomotion; it is a somewhat doubtful one for the *Orthoptera*, unless endemic species only are taken into consideration; it does not apply to the *Hymenoptera*, mostly all great rovers; certainly not to the *Odonata*, which dwell along water courses, nor strictly speaking to the remainder of the *Neuroptera;* and it cannot be said to be a true one for the *Hemiptera-Homoptera*, and yet, taken as a whole, the insects of this sub-region have a much more varied facies of their own, and are much less homogenous than those of the eastern and western sub-regions of the Ethiopian fauna. This character, totally wanting in the two sub-regions aforesaid, is due to the presence in this South African sub-region of a fauna, or faunule, which may be termed the Cape or Karrooid fauna, and is restricted to that part of the Cape Colony bounded on the east by the twenty-sixth meridian, on the north by the thirty-third parallel, extending westward along the Roggeveld mountains as far as the Kamiesberg, and ending in the neighbourhood of Port Nolloth; beyond this limit the influence of the Kalahari region predominates. To this Cape fauna are restricted *most of the endemic forms*, generic and specific, of the *Coleoptera*, *Lepidoptera*, *Orthoptera*, and of many *Neuroptera* and *Hymenoptera*.

To correctly estimate the number of species of the insects inhabiting the South African sub-region will be impossible for many years to come; but from records and observations made by the author during the last thirty years, taking as a basis the ratio of increase in the number of published species, as well as that of the non-described species known to him; remembering also that minute or obscure species have been, and are still completely neglected by the collector or the specialist, he is of opinion that this number will prove to be more than 40,000, of which the *Coleoptera* alone will have more than 15,000 representatives.

The habits, distribution, and number of species of such a host are so varied that it is considered best to take the different orders systematically, and to give of each as brief an account as possible.

Orthoptera.

Blattidae.—The collecting of these somewhat fragile and not specially inviting insects has been considerably neglected, and the number of South African species, which is, however, considerable, will be probably greatly increased. When comparing the South African kinds with those recorded from Abyssinia, the Galla country and Somaliland, or neighbouring parts, one is greatly struck by the great conformity in the distribution of the genera; the species are also closely allied, and in many cases identical. One hundred and thirty-two South African species included in forty-two genera are described, but the differences in the sexes have probably caused in several instances the same species to be described anew, and larval forms have been taken for adults. The proportion of species belonging to genera, in which the adult male alone bears wings, while the female is without any rudimentary traces of them, is a peculiar feature of the South

African *Blattidae*. In the *Perisphaerini*, of which forty-nine kinds of females, probably half the number of the existing ones, are known to the author, the males have retained their Blattidous appearance, but not so the females which have undergone such a striking alteration in the shape of the prothorax, that it is not safe to ascribe a male to a female unless the two have been taken together. Near seaports are found such ubiquitous species as *Periplaneta americana* and *Dorylaea rhombifolia ; Blatta germanica* is also here with us. In the *Phyllodromiinae*, the genera *Ectobia* and *Aphlebia* have representatives, and the delicate species belonging to *Phyllodromia* and *Ceratinoptera* are far from uncommon ; *Ischnoptera* has four representatives known to the author: *Deropeltis* numbers several species ; *Oxyhaloa deusta*, first described from the Cape by Thunberg, reaches Abyssinia ; in the tufts of reeds (*Restio sp., sp.*) dwells *Aptera cingulata*, the large apterous female of which stains the captor's fingers with a fluid which, as in other cases, may prove to be its blood. This remarkable insect, which the author suspects to be viviparous, does watch over and rear its young. Under stones, or under the accumulated leaves of bushes are met the numerous representatives of the genera *Pilema*, the males of which have the appearance of winged termites, of *Stenopilema*, *Cyrtotria*, *Glomeris*, *Melanoblatta*, *Derocalymma*, *Poeciloblatta*, etc., etc. *Thlyptoblatta* is perhaps the flattest of all Blattidae, and was discovered in Namaqualand by the author, not under bark, as its depressed appearance might lead one to believe, but under stones.

Mantodea.—Numerous are the representatives of this family: i.e., 102 species included in forty-six genera. It is doubtful if this number will be materially increased; many species have a wide range, and I think that very few are restricted to the limits of the South African area. These wolves in sheep's clothing are marvellously adapted to the colour of their surroundings, and some have assumed fantastic shapes, always more striking, and presumably more effective in the female. Both sexes of *Pyrgomantis nasuta* have the facies of a harmless herbivorous Pyrgomorphid insect ; *Solygia sulcatifrons* is almost the reproduction of a pacific Phasmid, *Bactrodema* by name ; *Popa undata* is not to be distinguished from broken bits of dry greyish wood ; *Oxypilus nasutus* harmonises so well with the grey and white sandy soil over which it roams, that it is undistinguishable when not in motion ; *Ameles meridionalis* and *Empusa delalandei* are the colour of the plains ; in these three species the females are apterous, hence their assimilation to the colour of the soil, and it is useless to search for them where other colours prevail, because they are not to be found there, any more than the green-robed species of the genera *Mantis*, *Hierodula*. *Polyspilota*, *Miomantis* are to be met with anywhere else but in a green bowery. On the white and grey flowers of umbellifers is to be seen *Harpagomantis tricolor* harmonising so well with the surrounding tints that it is difficult of detection even to the practised eye ; *Galinthias amoena* is quite its equal in that respect ; and *Pseudocreobotra wahlbergi* surpasses even these two at that kind of dissimulation, having had developed on each wing a large circular yellow ring edged with black with a green border, imitating absolutely the corolla of a yellow flower, but it is surpassed by the disguise of *Phyllocrania paradoxa*, which looks so much like a partly eaten withered leaf, as to call forth an expression of admiration and wonder at the disguise. Add that the young of the species of the *Phyllocranini*, *Harpagini* and *Empusinae* have a differently coloured foliated abdomen which they carry flat over their back, the better to imitate a flower or a bud, that they, like the adults, keep a pendulous motion like that of a leaf agitated by the wind, and it will thus be seen that the mimicry of surroundings for predaceous purposes is as well illustrated in South Africa as in any other part of the world.

Phasmodea.—Not numerous here are the genera and species of these harmless creatures, the Stick Insects, but the author knows of several undescribed species. They cannot compare in quaintness of shape with those occurring in the east, although they are most marvellously protected by their twig-like or herbaceous appearance. *Bactrodema tiaratum* and *B. aculiferum* are the largest South African representatives of this family; *Clonaria*, *Maransia* and *Macinia* have several representatives, some of them very large, but all slender.

Gryllidae.—The Gryllidae are fairly numerous, especially the troglodytous forms, but not so the kinds occurring in foliage or trees.

Locustidae.—Not very plentiful either in species or genera are the green, leaf-like members of this family, and these are, of course, to be found only where green vegetation abounds; some genera of the *Phaneropteridae*, *Horastophaga*, *Terpnistria*, *Stilpnothorax* are, however, peculiar to South Africa, and *Arantia* and *Cymatomera* are as good instances of verisimilitude to a green or brown leaf as any found in the East, or in South America. Very few are the representatives of the *Decticinae*, but the *Conocephalinae* number several species; numerous in kinds, as well as in individuals, are the *Hetrodinae* with their obese appearance enhanced by the complete obliteration of wings; more singular are the also wingless local members of *Stenopelmatinae*, these pugnacious dwellers in caves which have completely lost the power of producing music, although they still retain on the forelegs an auditory organ. It is this fighting instinct which has probably led to the enormous development of the head and jaws of the males, and if we take their size into consideration, nothing in the animal kingdom can be said to look so formidable as the male of *Mimnermus monstrosus*, *M. pattersoni*, or of *Nasidius truncatifrons*, and *Platysiagon signatifrons* is not much inferior to them in that respect. The *Gryllacrinae*, so numerous elsewhere, have very few representatives in South Africa, where, however, the sanguinary *Saginae* are represented by four species of *Clonia*, the rod-like *Peringueyella jocosa*, and the curious *Hemisaga praedatoria*.

Acrididiodea.—It is when we turn to this numerous family that the peculiar features of the South African Orthopterous fauna become apparent. To this part of the African continent are restricted these extraordinary insects, included in the genera *Cystocaelia, Bulla, Pneumora*, forming the sub-family *Pneumorinæ*, and in the males of which the abdomen has become distended into a large vesicle, the better to act as a sounding board, while the female, normally shaped, but wingless or incapable of flight, is usually maculated with silvery patches which break in the twilight the contour of the body to enable her to escape detection more effectually. No less than thirty-six species of *Xiphocera*, *Acocera* and *Haplolopha*, genera belonging to the *Pamphaginae*, are recorded from South Africa; these genera do not seem to reach westward higher north than Angola, but eastward they occur as far as Abyssinia, yet it would seem that there is no connecting link in the distribution of the European or circa-Mediterranean representatives of this sub-family, as they are not known to have been met with beyond Egypt proper.

Few Orthoptera are more singular in their appearance than the apterous *Schinzia horrida*, *Geloiomimus nasicus*, *Thrinestropis caffra*, *Charilaus brunneri*, all peculiar to South Africa, and inhabiting the arid localities of Namaqualand and the Karroo. Peculiar also to South Africa are the representatives of *Eremobiinae*, belonging to the genera *Batrachornis*, *Batrachotettix*, *Methoue*, the so-called Toad-locusts, the adaptation of which to the contour and colour of the soil is so perfect that it attracted the attention of Burchell so far back as 1811. Most of the species are restricted to the Karroo, but the enormous *Methoue andersoni* is also met with as far as Walfish Bay, and the wastes of N'Gami land will probably be found to harbour more new species.

When Orthopterous insects are so gorgeously coloured that they can be discerned at a great distance by man or beast, when they display richly-coloured under wings in their slow, lazy flight, or hop clumsily and without haste before you, one may at once conclude that for one or more reasons these insects are protected against molestation. These colours are, in fact, danger signals, and they give warning that the owners are malodorous or unpalatable. South Africa possesses more species of these peculiarly-endowed *Phymatinæ* than occur in the other parts of Africa, Madagascar and India. *Phymateus morbillosus* with its vermillion thorax and legs and red under wings, *P. leprosus* with its green, tessellated wings, are conspicuous in the western and midland parts of the Cape Colony, while the several species of *Pœcilocera* and *Zonocerus* are quite as conspicuous objects in the eastern parts of the Colony, in Natal or in the Transvaal. *Petasia spumans* is a most clumsy insect with aborted wings; it is also conspicuously marked, but its means of protection is the fetid foam-like spittle, which it exudes in profusion when seized. Numerous are the South African *Œdipodi*, but they do not call for any special comment.

Neuroptera.

Most interesting perhaps of all the Neuropterous insects are the *Termitidae*, not only on account of their social habits, but also owing to the character that the large or moderate sized mounds made by most of them impart to the South African landscape. All the species are not mound-builders, but the Termitaria prove very important factors in the economy of many other insects which feed upon them, which are attracted by the fungus beds which certain species are known to cultivate, or which undergo their development in the accumulation of fœces or detritus carefully brought outside the abode of the colony.

Formicaria are also known to be attractive to certain commensals, or mess-mates, which, however, are in many cases turned to advantage by the host; but it is doubtful if the Termites derive any benefit from these Termitobious animals, the list of which is increasing daily. Other animals, besides the Cape Ant-eater and the Cape Armadillo, feed on them in the Termitaria; several examples of the huge "blind snake," *Typhlops schegelli*, probably the larger of its kind (it reaches 70 cm.), were found together in Rhodesia in the heart of a termite-mound, *across* which it was found necessary to make a railway cutting. Only those who have witnessed the swarming out, after the early summer rains, of the countless myriads of winged termites can realise the importance of a termite colony. As already said, certain species cultivate fungus beds. The royal cell of *Termes natalensis* is an oblong chamber varying in length from 11 to 14 c.m., with a flat floor and an arched roof from 4 to 6 c.m. at its highest point, enclosed in a large lump of compressed clay perforated with numerous narrow galleries, and situated in the termitarium immediately above the fungus bed. All the species do not, however, have a royal chamber: such are *Termes hastatus*, *T. trinervius*, etc. Termites are as a rule eyeless and lucifugous, but we have here also, and ranging from east to west, a subterranean, eyed, grass or twig-cutting one, *Hodotermes viator*, which works in the open in the daytime. Owing to its habit of piling up at the entrance little heaps of twigs of grass or dry wood cut to a short length, it has received here the cognomen of "Hout-kapper," or wood-cutter. Its underground nest is of considerable extent, but I am not aware that the queen's quarters have as yet been discovered; it does not build mounds, although it occasionally takes possession of those made by another kind. One species, also a subterranean eyeless one, builds hollow, cylindrical towers above the ground, etc., etc.

The South African *Odonata* or Dragon Flies are not very numerous, nor varied, and they do not differ much from their congeners elsewhere. *Palpopleura lucia*, *P. portia*, *P. jucunda* throw a gay note on the neighbourhood of running waters. *Orthetrum sub-fasciatum* is probably the most common of our local species; *Pantala flavescens* prefers copses, but not very far from water; huge species of *Anax* soar high in the sky, and the slender, fragile-looking *Allocnemis nigrosticta*, *Chlorolestes conspicua*, *C. tessellata*, etc., are found wherever brooks are babbling. *Ephemeridae* or May-Flies are never abundant, either in species or in individuals, nor are the *Sialidae* or Alder-Flies. A large *Corydalid*, a genus recorded from South America, is apparently very rare. But if unlike what obtains in the Palæarctic Region, the representatives of these two families are neither numerous nor particularly singular; the same cannot be said of the *Hemerobiidae*, the Ant-Lions and the Lace-wing Flies. From among the tufts of "reeds" (*Restio*) occurring so frequently in the sandy soils of the south-western parts surges suddenly, when alarmed, the yellow and black winged species of *Palpares*, their short, jerky, bizarre, noiseless flight making you wonder as to the identity of the insect that you have flushed. It has not gone far, and you can perceive it clinging flat against the reed, its long, hairy wings folded convexly above the body. Plentiful in such locality are the sand pits at the bottom of which its huge larva awaits its victims. To the light of houses, to the camp fires, come numerous species of *Acanthaclysis*, *Myrmeleon*, *Creagris* and *Formicaleo*; but they, unlike *Palpares*, *Tomaderes*, and *Panexis* which, being diurnal, have a yellow and black livery, are modestly clad in grey. *Glenurus excentrus* is an exception in that respect. On the white walls of houses one meets in the morning several species of *Ascalaphid* which, so far as known to the author, are crepuscular or nocturnal. *Proctarrelabris* has three species, *Nephoneura* three, *Encyoposis* and *Melambrotus* several, some of which are still undescribed. *Tmesibasis lacerata* is brightly coloured, and may prove to be less crepuscular in its habits than its congeners from which it differs also in not having the long antennæ knobbed at tip. Characteristic of the South African Neuropterous fauna as are the *Ascalaphidae*, they must nevertheless take second place to the *Nemopterides*, not that the genus *Nemoptera* is restricted to that part of Africa, but owing to the quaintness and also to the number of species of its local representatives. In the genus *Nemoptera*, which some purists would have us write *Nematoptera*, the hind wings have been reduced to a long narrow appendage, sometimes absolutely filiform (*N. setacea*), shaped like an oar at the end (*N. africana*, *remiformis*, *bacillaris*) or spatulate and bi-sectate before the apex (*A. dilatata*, *egregia*, etc.). Although mostly caught at the lights, I have seen in early morning *Nemoptera africana* skipping along in the manner of a Daddy-Long-Legs, and the lacteous end of the hind wing only was visible. Three kinds of *Mantispa* occur in South Africa. The habits of one, *M. grandis* are not quite those of the European *M. styriaca*, for the larva undergoes its *whole* metamorphosis *inside* the egg-bag of a spider of the genus *Palystes*, and there are *two* *Mantispa* cocoons in the said bag. The South African *Hemerobiidae* and *Phryganidae* are, as yet, very little known.

Hymenoptera.

A typical feature of the South African *Hymenoptera sessiliventres*, is the complete absence of the *Siricidae*, while the *Tenthredinidae* or Saw-flies are represented by very few species of *Arge* (*Helitoma*) which are extremely rare in the western and midland parts of the South African area, but are found more numerously in Natal, the Transvaal and Rhodesia, where vegetation is more abundant. *Ichneumonidae* are fairly plentiful, and *Braconidae* very numerous. The local representatives of these two families have not as yet been systematically worked out, and the inference of the author is based mainly on the contents of the collections of the South African Museum.

If we turn, however, to the *Hymenoptera petioliventres*, we find that on the whole they are of a purely African type, yet they present characteristics which, although they are not as strongly distinctive as in the South African Coleoptera and certain Neuroptera, have still a certain imprint of their own. In the *Anthophila*, both the honey bees *Apis mellifica* and *A. caffra* occur everywhere, and in the Western Transvaal a minute honey-bee of the genus *Trigona*, possibly identical with *T. madecassa*, is met with ; *Halictus*, *Andrena*, *Nomia* are fairly abundant ; *Megachile* are numerous in species ; *Chalicodoma* is represented by two kinds ; the nests of the sixteen species of *Anthidium* known to the author are seemingly different in shape, size and material, according to the species ; *Podalirius* (*Anthophora*) makes here the same shrill humming noise as elsewhere, and although far less numerous individually than their congeners in Northern Africa (Algeria) they are equally well adapted to the fertilisation of flowers by means of the long, shaggy hairs with which their body is clothed, or their broadly dilated, thickly hairy legs, and *Anthophora advena*, *plumipes*, *bi-partita*, *basalis*, stand second to none in that respect. Bumble-bees (*Bombus*), entirely wanting in the Ethiopian region, are replaced here by the Carpenter Bees (*Xylocopa*). These, the largest and most powerful of bees, have a very wide distribution. They make their nest mostly in dry stumps of trees or fencing poles, but *Xylocopa sicheli*, and perhaps more South African species, use the stems of Aloe plants for that purpose. In spite of their hairy covering, these bees are as often as not useless for fertilisation purposes, as they bite off the flower above the nectar when their tongue is too short to lap it.

Eumenidae.—The solitary wasps are fairly numerous. The genera *Rhaphiglossus*, *Smithia*, *Zethus*, *Eumenes*, *Synagris* have some thirty kinds of representatives. *Eumenes caffra* and *E. tinctor*, especially the former, builds a nest made of clay, somewhat resembling that of *Synagris calida*, but sometimes made, by the former, of quartz pebbles cemented together; *Synagris mirabilis* and *S. calida*, range from the Cape to Abyssinia, but the local number of *Odynerus* species is considerable, and *Pterochilus insignis*, *P. capensis*, etc., are among the most conspicuous insects of this sub-family. Social Vespidae are not many; *Belenogaster junceus* and *B. rufipennis* are probably most in evidence. The papyraceous nests of the latter consist only of half a dozen cells ; those of *Polistes marginalis* and of *P. rubidus* are multicellular, but never attain a great size. The true hornet (genus *Vespa*) has no African representative, but those of the *Masaridae* are numerous. The genera *Ceramius*, *Quartinia*, *Masariella*, *Coelonites*, *Masaris*, are a distinct feature of the Hymenopterous fauna. The first three genera are also represented on the circa-Mediterranean fauna, but their habits do not seem to be better known there than those of their congeners here. The author has as yet met with only one species of the *Masaridae* outside the Karrooid part of the Cape Colony, Namaqualand, and Western Damaraland. The number of species of *Larra* and *Stizus* is somewhat large; *Larra fenestratus*, *L. fuscipennis*, *L. grandis*, *L. atrox* are very conspicuous, but somewhat rare in individuals; representatives of *Gorytes*, *Nysson* are also to be met with. Among the *Fossores*, species of the genera *Liris*, *Tachytes*, *Miscophus* are very numerous, and the number of described species probably does not represent a twentieth of the existing ones; the genus *Palarus* has several species, one of which, *P. latifrons*, makes in places apiculture impossible in the western part of the Cape Colony. *Ammophila* shows a great variety of forms from *A. capensis* to *A. hottentota*. Very common indeed is *Pelopaeus* (*Scelifrons*) *quartinae*, and its mud nest, stored with caterpillars, is to be seen almost everywhere. From one the author has bred no less than three kinds of parasites; the steel-blue species *C. chalybæus* and *C. tibialis* are handsome representatives of this genus. The species of the genus *Bembex* are more than fairly common, the resemblance in the livery of the South African species to that of the European ones is indeed extreme. *Crabro*, *Cerceris*, *Philanthus* occur in plenty; and *Oxybelus*, with its curiously shaped metanotum has several representatives. *Ampulex* and *Pronaeus*, *Sphex* and *Harpactopus* are individually fairly numerous. *Harpactopus tyrannus* has been found storing its nest with a very large Orthopteron of the genus *Acridium*. It is not certain that all the local species of *Ampulex* store theirs with *Blattidae*. More conspicuous perhaps than any other kind of Hymenoptera are the *Ceropalidae* (olim *Pompilidae*), these keen hunters of spiders. Great indeed is the variation in size between the small *Ctenocerus vitripennis* and the huge *Mygnimia capensis*, or *M. vindex*, but they are all equally fearless, and attack and paralyse, when successful, animals superior in size, and of great ferocity; the smaller kind choose *Lycosids*, the larger the huge ground-spiders of the genus *Harpactira*. But it is when we consider the great number of South African species of the *Scoliidae* and *Mutillidae*, all inquinal (parasitic) Fossorial Hymenoptera, that we can realise how very numerous and varied must perforce be the number of their victims. The *Mutillidae* alone number more than 240 kinds, and it is not at all unlikely that every species sticks to one kind of host. Considerable also is the number of *Scoliidae*, especially the species of *Mezia* and *Cosila*, the two sexes of which are so seldom taken together, the huge *Scolia* and the less sombre *Elis*, but in a country where the Coleopterous *Cetoninae* and some kinds of *Dynastinae*, which are the ordinary prey of *Scolia*, abound, it is not surprising to meet with such a variety in kinds, and such an abundance in individuals.

Formicidae.—Noticeable among the ants are *Camponotus maculatus* and *C. fulvopilosus*. The former is seldom seen outside its galleries; the latter with its large fulvous abdomen is always a conspicuous object; abundant everywhere is *Plagiolepis natalensis*, which is so hospitable to many sorts of mess-mates. In Natal we have a species of the same genus, *Plagiolepis trimeni*, which imitates the "honey-pot" ant of the United States and Mexico. A number of the workers are so gorged with a sort of honey that the abdomen is inflated into a large sphere; it is not, however, in the abdomen, but in the gizzard of the ant that the honey is stored, and the insect is nothing less than an ambulating honey-pot, disgorging at will its sweet contents. The *Ponerinae* are well represented by *Paltothyrea pestilentia, Plectrotena mandibularis, Bothroponera pumicosa*, and others; in the *Myrmicinae, Tetramorium, Monomorium, Cremastogaster* have several representatives, the papyraceous nests of the latter being often very abundant; the herbivorous *Aphænogaster barbara* treads slowly here the narrow paths which it makes in search of provisions, just as it does in Northern Africa; the huge females of *Carebara vidua* emerge in great numbers after rains have begun. To the street lamps in Cape Town, fly countless numbers of *Dorylus helvolus*, and of *D. badius* in the Transvaal, Natal and Rhodesia. Strikingly singular is the male of these species in general appearance, but it is much less extraordinary, however, than that of the large, eyeless, almost termite-like female; both are again ridiculously different from the workers, which are nothing less than one sort of the African "driver-ants," but with a much less evil reputation than that of their congeners of the West Coast. This *Dorylus helvolus* has a retinue of many species of Coleopterous *Staphylinidae* of the most extraordinary and degraded, or perhaps appropriate, forms.

Tubulifera.—Only thirty-six kinds of Chrysidae are known to the author. *Stilbum amurum*, which has spread all over the world, is here a parasite of *Scelifrons quartinae* or *S. spirifex*, which have themselves a very wide range; *Parnopes fischeri* is met with in Egypt as well as at the Cape. On the whole the South African species of Ruby-tailed Flies are not as brilliantly coloured as their European congeners, but it is worthy of note that the species occurring in the western part of South Africa are more gorgeously dressed than those met with in the eastern part.

The *Bethyllidae* and other kindred minute South African *Hymenoptera* are very little known as yet, but a species of the curious genus *Gonatopus* has lately been discovered.

Coleoptera.

Cicindelidæ.—The species of the genus *Mantichora*, the largest and most powerful of all Cicindelidae, were until lately looked upon as being restricted to the South African sub-region, but one kind has been met with in Angola and the Congo Free State, and *M. latipennis* occurs also in Nyassaland. Their appearance is of very short duration, and they roam on the Karroo plains of the Cape Colony as far south as Robertson, but they are not found in the western belt of the Colony where winter rains occur. The plains of Griqualand West, Bechuana and the Transvaal teem with them at times; rare in Southern Rhodesia, they are plentiful in the eastern part of Mozambique, but they are not known to the author to have been found in Natal. *Platychile pallida*, a nocturnal species, like those of *Megacephala*, hides in the daytime in the sand-dunes, from Cape Town to Mossamedes, but it has not been met with as yet on the eastern littoral; *Styphloderma*, the Central African form of *Tetracha*, penetrates into the South African sub-region through Mashonaland; four species of *Megacephala*, one of which ranges from east to west, are recorded. *Cicindela regalis*, *C. dongolensis*, *melancholica*, *vicina*, *nilotica*, *luxeri*, are found in Senegambia as well as in South Africa, but an important feature of the Cicindelidae of this sub-region is the great number of the wingless species of the genus *Dromica* (*Cosmema*, *Myrmecoptera*) which may be said to vary in sculpture and colouring in every district where they occur. They only appear for a very short period, and they are very agile; a good number of species of this genus have been found in eastern Africa, where they are also very local, but they have not been met with in Senegambia.

Carabidae.—The carabidous fauna is essentially an African one, except in the sub-family *Scaritinae*, in which the genera *Ophthalmus*, *Haplotrachelus*, *Passalidius*, *Pachyodontus* and *Acanthoscelis* are endemic. *Pachyodontus* inhabits the high mountain ranges of the south-western part of the Cape Colony, and *Acanthoscelis* is found only under the decaying sea-weeds washed along the shores on the western side, as far as Walfisch Bay. The *Lebiinae* are very numerously represented, especially the genus *Phlœozetus* which, however, was founded on a species from Egypt; in the *Cymindinæ* the genus *Hystrichopus* seems to be endemic, and certain species are met only at very high altitudes. *Orthogonius* is not restricted to Africa, but the author strongly suspects the five local species to be termitobious. The great number of species of *Graphipterinæ* is the principal feature of the South African Carabidæ; they are found everywhere, from the immediate neighbourhood of Cape Town to the confines of the sub-region, and ninety species are now recorded; in the *Anthiinae* the species of *Polyhirma* are also very numerous (31), but this genus is still more numerously represented in the eastern sub-region, where forty-one species are found; they do not, however, occur in the western part of the Cape Colony comprised between Long. 26° and Lat. 31, where the genus *Microlestia* takes its place, and where one meets also with the white spotted *Anthia decemguttata* and its endless varieties; spread from east to west are the large *Anthia maxillosa*, *thoracica*, *circumscripta*; more local is *A. pachyoma*; *A. andersoni* occurs only in the Kalahari region; the true *A. burchelli* would seem to be limited to the grassy plains of Bechuanaland, while *A. petersi* inhabits Rhodesia and Mozambique. Numerous are the *Chlœniinæ* which comprise also a small number of species originally described from Senegambia; the singular *Rhopalomelus angusticollis*, which would seem to be an aberrant form of this sub-family, is a termitobious species. Among the *Pterostichinae* are very local forms such as *Pterostichus undulatorugosus*, *Teratotarsus schouberti*, and other species with a facies not unlike that of some European species of the genus *Abax*. *Abacetus* are comparatively scarce in the western part, but they become more numerous as Natal and the eastern part are reached, and the same may be said of the *Platyninae* and the *Panagæinæ*, these denizens of moist, low-lying lands which are found more numerously eastward than to the west of the 28th parallel.

Dytiscidae.—The Dytiscid and Gyrinid fauna presents no peculiarity, and is hardly different from that of the other two sub-regions.

Paussidae.—The representatives of this singular family, all the members of which would seem to be myrmecobious, are very numerous. They belong to the genera *Cerapterus*, *Arthropterus*, *Pleuropterus*, *Pentaplatarthrus*, *Paussus* and *Hylotorus*. *Pentaplatarthrus* is found in great numbers in the galleries of the ant *Plagiolepis natalensis*. In the nest of the ubiquitous *Pheidole* ants several species are met with. *Paussus lineatus* is captured in the formicarium of *Acantholepis capensis* only. Owing, it is presumed, to their mode of life, most of the species are greatly localised, yet such species as *Paussus curtisi*, *Afzelii*, etc., are also inhabiting Abyssinia, and *P. spinicoxis* has a very wide range. The South African species total fifty-two, but that number will be probably increased.

Staphylinae.—The species of this family are much less numerous than in the Palæarctic region, but they have not been much studied as yet; myrmecobious and termitobious species of *Myrmedonia* are fairly abundant; the large, handsome *Hasumius validus* has been found living in Termites' nests; *Staphylinus fauveli* or *S. erichsoni* have as handsome a livery as any of their congeners, and they may also prove to be termitobious.

Pselaphidæ.—These minute beetles have not yet been collected in a sufficient number of localities to afford a true appreciation of their distribution; so far as is now known the species number 106, included into 29 genera, 17 of which are endemic.

Scydmænidae.—The Scydmænids await a patient worker. The species are fairly numerous, although their collecting has been greatly neglected. *Mastigus* in particular is numerously represented.

Histeridae.—The distribution of many of the species is extremely wide in Africa, but to the South African sub-region seems to be restricted the genus *Monoplius* with several species, the adult and larvæ of which are found nowhere else but in the accumulation of detritus heaped outside the termitarium of *Hodotermes;* the very large *Hister validus* has been found devouring the burrowing dung-beetle *Onitis alexis.*

Scarabaeidae.—In a country where numberless herds of ruminants or other herbivorous animals used to roam, and are now replaced by domestic kinds, it is to be expected that coprophagous beetles will be numerous, and truly plentiful in kinds as well as in individuals are the species of *Scarabæus*, *Gymnopleurus*, etc.; but to the western half of the South African region are restricted the wingless species of *Pachysoma;* still more local is *Circellium bacchus; Epirinus* is also endemic. Near Cape Town is found a minute *Epilissus*, the habits of which differ, however, from those of the Madagascar species; plentiful in species and individuals is the genus *Onitis*, and *Neonitis porculus* and *Cheironitis* are endemic forms; the genus *Onthophagus* numbers some 150 species, which cannot, however, be said to have special features of their own; the kinds are very rare in western South Africa, south of the Orange River, but they become more numerous towards the eastern part where they are gradually connecting with the Central African and Abyssinian species. *Heliocopris* abound, and the species of *Copris* and *Catharsius* are without end; *Odontoloma* is an endemic genus, and so are *Saproecius* and *Heteroclitopus*, the nearest ally of which is *Onthocharis*, inhabiting Brazil, and this is also the case with *Parapinotus dewitzi*, a Natal species. Strictly South African are the species of *Macroderes*, which the author suspects to be termitobious. *Aphodiinae* swarm almost everywhere, but *Harmogaster* and *Coptochirus*, *Liparochirus*, *Drepanocanthus* are endemic genera of that old-world spread family, and there is also here a representative of the singular termitobious genus *Corythoderes*. *Trox* abound, and *Bolboceras* are numerous, but rare individually. In the *Dynastinae* several species are known to be termitobious in their early and adult stages, such as *Pycnoschema* and *Pseudocyphonistes*, *Syrichthomorphus* and *Syrichthus*; *Oryctes monoceros* of Senegambia reaches Natal and even the Cape Colony, and the west coast genus and species *Archon centaurus* has been also met with in Natal. *Adoretus* and *Anomala* have extremely numerous representatives, all of them uncommonly alike. It is, however, in the *Hopliinae* that the number of endemic genera and species give to the coleopterous fauna of the South African sub-region such a distinct character of its own. *Chasme*, *Anisonyx*, *Peritrichia*, *Lepitrix*, owing to their shaggy clothing, are especially adapted to the cross-fertilisation of flowers, and during the period of their appearance they are most abundant individually. *Eriesthis* is also shaggy, but it is no longer a suctorial insect only, nor are the numerous species of *Pachycnema*, the males of which have such extraordinarily-developed legs that they can be rivalled in that respect only by those of the also endemic, anomalous genus *Hoplocnemis*, which is probably termitobious. It is as one proceeds towards Namaqualand within the belt which winter-rains reach, that one meets with an almost incredible number of species and varieties of this group; beyond this boundary two or three species only are recorded from Great Namaqualand and Damaraland, while eastward two species only occur in Southern Rhodesia. The long series of species of the genera *Dichelus*, *Heterochilus*, *Monochelus*, *Omocrates*, *Goniaspidius*, *Dicranocnemus* are spread over east and west, *Monochelus* being, however, more numerous in species in Natal and the Transvaal; in the second group of this sub-family the affinities of nearly all the genera are with the Madagascar fauna, and it is worthy of note that most of the species of which this group consists are found to be restricted to the eastern part of the South African sub-region.

Numerous are the genera and species of the *Cetoninae;* certainly as handsome as any of the Western and Eastern African Goliathid beetles are *Amaurodes passerinii*, *Eudicella smithi* the numerous varieties of which reach Abyssinia, *Ceratorrhina burkei*, *Dicranorrhina derbyana*, *Ranzania petersii*: the limit of distribution of some of these species is, however, as yet uncertain, even *Hypselogenia geotrupina*, which of all the Goliathid beetles is the only one occurring also in the western parts of the Cape Colony, is now found to have a congener, if not a varietal form, in German East Africa. Owing to their diet, which consists of sap or gum exuding from trees or climbing plants, these insects resort to where forests or agglomeration of trees occur; on the south-western part, in the Karroo, where trees are very rare, one meets with the curious species of that purely-endemic genus *Ischnostoma*, one species of which reaches, however, British Bechuanaland; *Rhinocœta cornuta*, belonging also to a genus restricted to South Africa, lives in kraal dung, in the manner of *Copris*, and is also crepuscular; *R. cornuta* and *R. armata* have probably the same habits. *Xiphoscelis gariepina*, belonging to the most distinct of all the South African endemic genera, is termitobious, and so is probably its congener *X. hopei*, the habitat of both these species does not seem to extend beyond the boundaries of the Cape Colony, and *Odontorrhina hispida* and *O. pubescens*, the two species of a purely endemic genus, are restricted like the two species of *Xiphoscelis* to the Cape faunule; *Anoplochilus rusticus* and *A. variabilis* drag themselves clumsily on the ground more in the manner of a Dynastid than of a floricolous insect, which their local congener *Anoplochilus tomentosus* is. Rose-chafers do not necessarily take to flowers or juicy exudation only for food, thus *Diplognatha gagates* is now known to breed in the nests of hawks, the larvæ feeding on the fœces and making their cocoon of the same material. *Spilophorus lugubris* breeds also in the nests of birds; this latter species belong to the *Cremastochilides*, many members of which, like all the species of *Trichoplus* and *Scaptobius*, and possibly also *Trogodes* and *Lissogenius*, are known to be myrmecobious; some kinds of *Coenochilus*, an allied genus, are also myrmecobious, while others are termitobious; the genus *Stegopterus* is purely endemic, and most of the species of the genus *Agenius* are indigenous.

Buprestidæ.—A notable feature of the South African entomological fauna is the great number of species and varieties of the genera *Julodis* and *Neojulodis*, the great majority of which belong to the Cape faunule, but unlike their congeners of the Palæarctic region, from which they are separated by enormous distances, they have a strikingly different livery. The genus, if it can be termed so, *Neojulodis* includes species absolutely restricted to the Cape fauna, but one kind, *N. vittipennis*, is distributed all over Natal, the Orange River Colony, the Transvaal and Rhodesia, but is replaced from Beira to Nyassaland and probably to Central Africa by its close ally *N. sub-vittata.* The genera *Oedisterna* and *Aristosoma* are strictly endemic, and as such, limited to the Cape fauna; in the case of the former, the larva lives in the fleshy stems of *Mesembryanthemum.*

Elateridae.—The Elateridae present no special feature. The giants of these "click-beetles," *Tetralobus, flabellicornis, rondanii rotundifrous*, range from Abyssinia to Port St. John, in the Cape Colony, wherever dying or decomposed timber is to be found.

Rhipiceridae have for representatives several species of *Sandalus*, and also the endemic genus *Ptyocerus*, belonging to the Cape fauna. Among the *Malacodermidae* the *Lycini* are most numerous, and their palliate elytra assume a diversity of forms; the *Lampyrini* have a fair number of representatives; the *Telephorini* are abundant, and in the *Melyrini*, the species of which are very numerous and varied, the sexual differences are as great as in the Palæarctic species, and their livery equally brilliant in many cases.

Cleridae are known to have a wide range, and thus the South African ones have, with a few exceptions, no special feature of their own, but *Notostenus* is also a Cape fauna endemic form, and is to be found only in the white spathe of the aroid plant *Richardia aethiopica.*

The *Ptinidae* have several representatives, not the least interesting perhaps being the myrmecophilous *Damarus singularis*, and *Diplocotidus formicola*, the latter being most closely allied to an Australian genus.

The *Bostrichidae* being all lovers of wood, have a wide range in Africa, and therefore no very distinctive characters of their own in the South African sub-region.

The *Tenebrionidae*, which number here 1,099 described species distributed into 152 genera, have, even in the genera which are represented elsewhere, a facies peculiarly South African. Being in the majority of cases wingless and mostly of slow motion, they do not mingle much with their congeneric neighbours, and have thus crystallised into local forms. This is strikingly illustrated in the genera *Moluris* and *Psammodes* which comprise together 228 species and seem to be as abundantly represented in the west as in the east or intervening parts. On the sand dunes extending along the western coast run with extreme rapidity a number of species of *Adesmia*, all long legged and armed with very long tibial spurs; some are black, others have white elytra but black thorax. Many of the arenaceous species are covered with a pulverulence similar to that of the soil on which they run, and *Zophosis testudinaria* or *Trachynotus lightfooti* have altogether a different aspect when this protective cover has come off.

Mylabridae.—The species of *Mylabris* and *Lytta* are extremely numerous and varied; *Meloe*, of which four species are South African, is occasionally seen dragging its tumid body along the ground; *Horia*, a parasite of the Carpenter-bees (*Xylocopa*) has two local representatives.

Curculionidæ.—It is a moot point if the Weevils are not more numerously represented in South Africa than any of the other families; the ground weevils are probably in majority. Typical of South Africa is the great number in species of the genera *Brachycerus, Episus, Microcerus, Sciobius;* the *Hipporrhinides* are divided into five genera, three of which are confined to the Cape Colony, but *Hipporrhinus* has a range extending on the eastern side from Natal to Abyssinia, and on the western from Cape Town to Angola; this genus numbers now 137 South African species. It is worthy of note that the nearest allies of both *Hipporrhinus* and *Somatodes* are Australian genera.

The *Zygopinae, Baridiinae, Cryptorrhynchinae* are more numerous towards the eastern side than in the western, where trees are much rarer, and lately some curious forms belonging to degraded *Tanyrrhynchidae* and *Cossoninae*, and closely allied to genera occurring in St. Helena, have been met with near Cape Town.

Anthribidæ, being lovers of timber, are rare in kinds and individuals in the western part, but fairly common in the eastern.

Longicornia follow the same rule, and the species found in the south western part, south of the Orange River are very few, the most notable being *Zographus oculator*, 3 kinds of *Ceroplesis*, the beautiful *Dorcasomus ebulinus*, also rare examples of *Cacosceles aedipus*, and on the banks of the water-courses where some trees are still to be found a few Prionids are met with, but in Natal and the Transvaal, in Rhodesia and Mozambique species abound, especially the *Callichrominae;* yet on the whole, very few genera are restricted to South Africa.

Chrysomelinae.—The extreme abundance of *Clythrinae* and *Cryptocephalinae*, of *Galerucinae, Halticinae, Cassidinae*, etc., seem to be a distinctive feature of the eastern part of the South African subregion, but this is possibly due to more attention having been paid lately to the collecting of the representatives of this family.

Lepidoptera.

The day-flying Butterflies (Rhopalocera) are the best known of all the sub-divisions of the South African insects, and it is very doubtful if subsequent researches or discoveries will materially alter the character of the fauna or the number of genera and species. Mr. R. Trimen, in his well-known work on the South African Butterflies took the tropic of the Capricorn as a northern limit. The country lying to the north of this line was then very little known, but subsequent investigations have shown that this arbitrary line did not give a true idea of the real distribution. Aurivilius, in his *Rhopalocera aethiopica*, after dividing the continent into four sub-regions, the West African, East African, Madecasse and South African, limits the latter eastward to the upper reaches of the Limpopo, where it emits, however, a broad slanting spur into Mashonaland, as far as Salisbury, and curves westwards from the Victoria Falls to Mossamedes; this curve includes the upper reaches of the O'Kovango River.

This zone of distribution is a very natural one, and if carried eastward a little further north it would apply to almost all the orders of South African insects. Although the configuration of Aurivilius' area differs much from that of Trimen, the number of endemic genera and species is very little modified. The genera known to be restricted to the South African region were *Meneris*, *Coenyra*, *Capys*, *Arrugia*, *D'Urbania*, *Deloneura*, and to these six Trimen added later on two more, viz., *Desmolycæna* and *Erikssonia*, but as *Capys* has since been met with north of the African limit, and as on the other hand the species of the genus *Phasis* (*Zeritis*, part.) are pronounced to be all South African, the number of purely endemic genera is now nine. If we exclude the *Hesperidae* from the *Rhopalocera*, a view which is now partially accepted, we find that Trimen, in the work quoted, gave the number of genera at sixty, and that of the species as 344. Aurivilius, in 1898, gives it at seventy-one genera, and 361 species, and only very few species have been described from that time. Of this number, forty genera, including 125 species he calls endemic, and thirty-one genera with 236 species non-endemic. Further, the proportion of species occurring in the West African region is 146, in the Eastern African 218, and in the Madecasse 18. It is thus with the East African region that the greater affinity of the South African region lies. The most fully represented among the endemic forms are the *Lycænidae* (178 species) with a percentage of 40.3 per cent.; while in West Africa this percentage is only 21.4; in East Africa 25, and in Madagascar 13.3. Next come the *Nymphalidae* (65) with 18 per cent.; the *Pieridae* (48) with 13.3, the *Acraeidae* (36) with 10 per cent., and the *Satyridae* (34) with 9.4.

Aurivilius has also divided this South African sub-region into four parts, in which the following number of species and genera have been recorded :—

German South-West Africa ..	37	genera	104	species.
Cape Colony and Transkei ..	52	,,	192	,,
Natal, Delagoa and Transvaal ..	67	,,	273	,,
Bechuanaland and Matabeleland	47	,,	135	,,

Subsequent records have not modified materially this distribution.

There is no doubt whatever that except in the immediate vicinity of the forest belt extending along the coast from Knysna eastwards, butterflies in the Cape Colony are scarce both in species and individuals. In the south-western parts, in the Karroo, the monotony and paucity of insect life is relieved by the appearance of a few *Danais chrysippus* flitting lazily round the sparsely-scattered wild cotton plants (*Gomphocarpus arborescens*); on the ground rest the low-flying *Phasis pierus*, *thyra*, *xeuxo*, while along the sea-board *Phasis pyrœis*, *thisbe* and *osbecki*, less soberly clad, flit gaily over the sand dunes; *Phasis thero* is found round the bushes of Rhus, and also in waste, sandy places. *Phasis argyraspis* and *P. sardonyx* are met with in the dry uplands from Griqualand West to Namaqualand, to which part also *Phasis barklyi* seems to be restricted; on bare rocks and in secluded mountain nooks *Durbania saga* basks in the sun. The splendid *Capys alphæus* frequents hill-ridges and mountain sides, where the *Proteas* grow. *Pieris hellica*, the ubiquitous painted lady *Pyrameis cardui*, *Colias electra* are found everywhere; in the meadows or on the veld are seen the weak flyers of the Satyrinid genus *Pseudonympha*, while the superb *Meneris tulbaghia* flits or soars over mountains or dales, and even condescends to be admired in the precincts of Cape Town city.

But the *Rhopalocera* increase in number and beauty as we progress eastward along the forest belt which fringes the coast, and also extends partly inland, until Durban, this South African paradise of the Lepidopterist, is reached, and even further north, as far as Delagoa Bay, where the East African sub-region infringes so remarkably on the Western. Abundant are the Nymphalids *Amauris echeria*, *ochlea*, *dominicanus*, naturally-protected species, the colouring of which other species imitate; from the copses surge suddenly from among the underwood *Melanitis leda*, *libya*, *diversa*, the underside of wings of which is painted so wonderfully like dry or brown leaves; numerous everywhere in species as in individuals are the slow, lazy fliers belonging to the genus *Acræa*, said to be nauseous to the taste, and thus made unpalatable to would-be devourers of the bird or lizard tribes; there one meets also the gaily or conspicuously-coloured Nymphalid *Eurema schaeneia*, *Atalanta phalantha*, *Junonia clelia*, *cebrene*, *boopis*, the last three spread all over Africa and the Mascarene Islands, the numerous species of *Precis*, *P. octavia*, with its varieties, *natalensis* and *sesamus* which not only differ in colouring of wings but also in habits, and yet prove to be seasonal varieties of one species, *P. tugela*, which when at rest mimics a dry leaf as accurately as any of the eastern *Callima* butterflies; the gorgeous *P. artaxia* roams northward from Manica to the Cunene, and one must see *Salamis anacardii* gliding with extended wings to realise what a beautiful object this " mother of pearl " butterfly is; *Euralia wahlbergi* and *mima*, *Diadema misippus*, etc., which are palatable to birds or other enemies go about under the colour disguise of *Danais* and *Amauris*, said to be distasteful to birds and animals; *Pseudacræa*, as its name implies, does the same; *Godartia wakefieldi*, *Euphaedra neophron* add a touch of beauty to the landscape, while high, near the top of trees, hover these beautiful objects *Charaxes varanes*, *candiope*, *jahlusa*, *saturnus*, *castor*, *brutus*, etc. Among the numerous species of the genus *Lycaena* is to be found probably the smallest of all butterflies, *Lycaena barberae*, very nearly equalled in size by *L. stellata*; *Iolaus silas* and *Myrina ficedula* hide the splendour of the under side of their wings when at rest by clinging to the bark of the wild fig trees. Few species are more beautiful than *Aphnæus hutchinsoni*, few more delicate-looking than *Pontia alasta*, while the *Pierinae* with their white and creamy livery relieved by black dots or patches, red or violet tips, enliven the landscape; *Papilio cenea* with its protean female is far from uncommon, and the black and grey *Papilio lyaeus*, as well as *P. demodocus* (*P. demoleus*, olim), prove unfortunately too numerous a pest for the citrus orchardist.

The *Heterocera* or moths, including the *Hesperidae* or skippers, are far from being as well known as the *Rhopalocera*. But good, although necessarily slow, progress is being made in the Descriptive Catalogue of *Lepidoptera phalenae*. The *Hesperidae* are not well represented in the African region, but they are more numerous in the Western African sub-region than in the southern, where in turn they number more species than in the eastern. Trimen grouped the South African ones (South of the tropic of Capricorn) into sixty-four species included in nine genera, two of which were restricted to that part of Africa, but Mabille in his Genera of the *Hesperidae* (1903) records in what corresponds to Aurivilius' South African region, seventy-three species comprised in twenty-five genera, seven of which are endemic. For the most part these species are not brightly coloured, but the pattern of *Caprona canopus* is a most delicate one, and *Abantis paradisea* and *A. zambesina* are very gaily tinted. The number of South African *Syntomidae, Arctiadae* and *Agaristidae* recorded or described by Hampson is 131 included in forty genera, and that of *Noctuidae* 574 sp. comprised into 134 genera. Rotschild and Jordan in their Monograph of the *Sphingidae* (1903) say that contrary to that of the diurnal Lepidoptera, the separation of the African continent into western, southern and eastern sub-regions is not very distinct in the case of Hawk Moths. This is easily explained by the fact that these insects are very powerful flyers, and are thus able to roam over great distances. According to these two authors the number of African species is 179 included in fifty-two genera : of this number fifty-nine species and twenty-four genera are represented in the South African sub-region, but only two genera are endemic, and these two occur in Southern Rhodesia, on the northern limit of this sub-region ; it is therefore most likely that they will eventually be found in the adjoining eastern sub-region ; as for the species, the author opines that no more than six will prove to be absolutely endemic. But although not restricted to South Africa, *Cephonodes* (*Sesia*) *hylas*, *Macroglossum trochilus*, *Basiothia medea*, *Euchloron megaera*, *Lophostethus demolini*, *Poliana natalensis*, could be hardly surpassed in beauty of form, and they enliven the stillness of our short twilight by their light humming noise ; *Acherontia atropos*, the death-head, robs here, as elsewhere, the bees of their honey , while *Cœlonia solani*, *Deilephila nerii*, *Hippotion celerio*, these denizens of the Palæarctic region, have also found here a home. The *Bombycidae* have huge representatives ; paramount are the long-tailed *Argema mimosae*, the pretty *Ludia delegorguei*, the numerous species of *Nudaurelia*, *Belina*, *Angelica*, *Melanocera ;* in the south-western part of the Cape Colony are found the extremely rare *Henucha grimmia* and *H. dewitzi*, and in Namaqualand the gorgeous *Euchroa trimeni*. Few are the described species of *Psychidae*, but the cases which they use as their homes assume most fantastic shapes, resembling thorns of acacia, faggots, pellets, seeds, aborted inflorescences; and no wonder that sheep farmers, seeing occasionally these objects deambulating, look upon them with awe, and attribute to them the loss of their stock. The South African representatives of the other families of *Heterocera* are not sufficiently known to be dilated upon, and probably not one twentieth of their number has, as yet, been described.

Diptera.

This order has been more neglected than any other, and although a considerable number of South African species have been described, it may be asserted with safety that the species unknown are hundred-fold those described, but as the diptera of the other sub-regions of the Ethiopean fauna are less known still, a comparison with the South African sub-region is impossible at present. In the *Nemocera,* very few *Cecidomydae* are known to the author, in the *Culicidae* several species of the dreaded *Anopheles*, these carriers of fever, have been described. Of the *Tipulidae* nine species only are recorded; the *Tabanidae* are numerous and much varied, and *Pangonia angulata, chrysaor, tricolor, Mycteromia rostrata,* the female of which has a proboscis one inch long, are great helpers in the cross-fertilisation of flowers, while the numerous species of *Tabanus* are suckers of blood, and the ten local species of *Haematopota* make their presence felt. *Chrysops* has a few fine representatives; but numerous here are the *Nemestridae,* with very long proboscis; their diet consists of nectar, and of great importance indeed must be the influence in the cross-fertilisation of flowers having a long or deep perianth, of flies such as *Megistorrhynchus longirostris* which has an extended proboscis reaching sometimes to a length of four inches, and of others with a shorter, but still considerably extended, similar organ.

The *Bombylidae*, with their humped thorax covered as they are with a rigid pile of yellow or white hairs, are especially beautiful objects as they hover on these spots where they will eventually deposit their eggs, and our local *Bombylius stylicornis, mixtus, argentifer, servillei*, are among the prettiest and most delicate looking of their congeners; *Bombylius analis* and *B. fulvonotatus* seem to range all over South Africa; *Anthracidae* are especially numerous in kind and individuals; this is perhaps due to the abundance of locusts, because the larvæ of some species are known to feed on the contents of the egg-cases of certain *Acridii*. We have a few representatives of the *Mydasidae*, but very abundant are the "Robber-Flies" *Asilidae*, and much varied are their forms; butterflies or wasps on the wings are mastered with incredible facility by these insect-devourers, of which ninety-eight South African species included in thirty-five genera have been described; but this is only a small proportion of the actual number. *Pipunculidae, Conopidae* and *Syrphidae* are well represented; the syrphidous larvæ of the genus *Microdon* live also here in an ant's nest. In *Diopsis apicalis* the eyes are inserted at the extremity of a long stalk; one species of the extremely curious *Celyphus*, in which the scutellum covers the upper part of the abdomen has been lately discovered; one of the *Anthomyiidae, Bengueyella depressa* deposits its eggs on or under the skin of man, and, it is said, also of dogs; it is at times very common in Natal and Mozambique, and it has been met with in Pretoria, in the Transvaal. Among the *Tachinidae, Cynomia pictifacies* proves most destructive to the migratory locusts on the body of which the eggs have been laid by the mother fly; and so do several other representatives of the *Sarcophagidae*; one of the *Muscidae, Glossina morsitans*, the dreaded "Tsetse." is the cause of the "Nagana disease, in the same manner as its congener *G. palpalis* found in Eastern and Western Africa causes in Uganda the "sleeping-sickness"; *Æstridae, Hippoboscidae, Nycteribiæ* are fairly well represented. But, as already stated, the Ethiopean Diptera have been too little worked as yet to treat here of the analogies of the genera and species, or of their distribution in the three African sub-regions.

HEMIPTERA-HOMOPTERA.

Want of space precludes the author from enlarging on the representatives of this order, which are characterised by their very wide range in South Africa or beyond this limit. Thus the brightly-coloured *Odontopus sexpunctatus* occurs in Abyssinia, Senegal, Mozambique, and punctures in German South-West Africa that extraordinary plant *Welwischia mirabilis*. Too numerous indeed in kinds and individuals are, from the agriculturist's point of view, the species of *Aspongopus* and other *Pentatomidae*, as well as *Holopterna alata* with its pungent smell, easily discernible from a distance; *Petascelis remipes*, the largest of South African Bugs, except the huge water one *Belostoma nilotica*, is abundant everywhere but in the Cape Colony; *Pephricus capensis, Craspedum phyllomorphum* are as beautiful imitations of a partly-eaten dry leaf as any occurring among the order *Orthoptera*, and *Physorrhynchus principalis* or *Platymeris rhadamanthus* are amongst the largest of the blood-thirsty *Reduviidae*. The quaintly-shaped local representatives of the *Tingidae* will prove to be numerous.

In summer one's attention cannot fail to be attracted by the shrill, piercing noise made by the Homopterous Cicads of the genus *Platypleura* and *Pæcilopsaltria*, and *P. stridula* in the south-western part of the Colony is as noisy as *P. divisa* and *P. semiclara* in the eastern, or in Natal, *Pæcilopsaltria trimeni* in Namaqualand, or *Pæcilopsaltria leopardina* in Southern Rhodesia; the male of *Tympanistria* utters a clicking noise as it flies jerkily. Among the *Cercopidae, Ptyelus grossus* and *Endara euchroma* cling to the bark of trees and are surrounded by a white waxy material, the better perhaps to escape detection, and the exudation of the peculiar fluid emitted by some of these species drip like water from the branches to which the insects are adhering. On the whole the species are fairly numerous, and as the number of individuals naturally follows the increase in vegetation they are more numerous in the east than in the west.

In concluding this very short sketch the author would like to point out that it is to the climatic and not to the physical conditions obtaining in the South African Sub-Region that the great diversity in the entomological fauna is mainly due, and that nowhere else is to be found an area of equal size presenting such a diversity of climatic conditions.

3. NOTES ON SOUTH AFRICAN LAND AND FRESH-WATER INVERTEBRATES, EXCLUSIVE OF MOLLUSCS AND INSECTS.

By W. F. Purcell, B.A., Ph.D., C.M.Z.S., First Assistant, South African Museum.

Land and Freshwater Crustaceans.

A large brachyurous land-crab (*Thelphusa perlata*) is common in all streams and ponds throughout South Africa, and many species of *Oniscidae* are common under stones, etc.

Amongst the purely aquatic forms a very large ostracod (*Megalocypris princeps*), some large copepods (*Broteas falcifer*), and a number of large species of *Branchipodidae* (*Streptocephalus*, *Branchipodopsis*) and *Estheriidae* (*Leptestheria*, *Estheria*) are very common everywhere. Several very large species of *Apus* occur in the Karroo and along the South-east Coast districts. All these aquatic forms have been very fully described and figured by Professor G. O. Sars. They are easily transported alive by simply collecting some of the dried mud of an old pool and adding some water to the mud some months later, when the crustacea will soon develop.

Land and Freshwater Earthworms, Planarians and Leeches.

The South African earthworms are comparatively little known, and there is no doubt that the majority of the species still remain undescribed. They fall principally into three groups, namely, (*a*) the imported species of *Lumbricus* and *Allolobophora*, which are very common everywhere, not only in the immediate vicinity of dwellings and cultivated lands, but also in the native woods on the slopes of Table Mountain, etc. *L. rubellus* is a common large species. (*b*) The giant earthworms of the genus *Microchaeta*, which occur more especially in the eastern districts, and attain a length of 5 feet. (*c*) Numerous smaller forms of the family *Acanthodrilidae*, into which the bulk of the native earthworms fall. These latter may be obtained, together with imported *Lumbricidae*, under stones or in rotten wood in the ravines on the slopes of mountains and hills, in the native forests of the Knysna and eastern districts, and on the sandy flats under the hottentot fig (*Mesembryanthemum edule*) and particularly in the wet sand on the edges of the numerous small ponds which form during the winter months.

A few species of land planarians have been described from South Africa. They are not very uncommonly met with under stones and in rotten wood in the Peninsula, etc., during the winter months. The widely distributed *Bipalium kewense* is common in gardens in Cape Town. A few freshwater planarians are plentiful in the streams on the summit of Table Mountain, but they do not appear to have been described.

Leeches are rare, but one rather large species was discovered in fresh water on the Cape Flats by the naturalists of the "Novara."

ARACHNIDA.

The most striking feature of this class in South Africa is the abundance of scorpions, *Solifugae* and trap-door spiders. Except as regards the scorpions, however, our knowledge is still very incomplete, for although a large number of *Solifugae* and tetrapneumonous spiders have been described, the majority of the dipneumonous spiders, *Acari*, *Opiliones* and pseudoscorpions still remain undescribed, as the collections in the South African Museum show.*

SCORPIONS.

About eighty-five South African species of scorpions may be distinguished (being more than one-fifth of the total number known), and of these two-thirds occur within Cape Colony alone. Of the six scorpion families only the *Buthidae* and *Scorpionidae* are represented in South Africa, and each again by two subfamilies, as follows :—

1. The *Buthinae* contain all the native species of *Buthidae*, and are represented principally by the genera *Parabuthus* and *Uroplectes*, although a few species of *Buthus* and *Lychas* occur here and there. *Parabuthus* includes all the larger South African forms with very thick tails and slender hands or chelae (about twelve species in all), and is distributed all over South Africa, with the exception perhaps of Natal. Some of the species have an evil reputation among country folk, and I am acquainted with an apparently well-authenticated case of the death of a man due to the sting of *P. granulatus*. This genus also occurs in Central and North Africa and in Arabia, where it exists side by side with the large and closely allied genus *Buthus*. In South Africa, however, it practically entirely displaces the genus *Buthus*, of which only two or three South African specimens have as yet been recorded. *Uroplectes* includes the smaller South African forms with small nippers (about twenty-one in number), and may be distinguished from *Parabuthus* by the black marks and stripes on the back and tail. This genus is evenly distributed throughout South Africa, to which

* The Scorpions, *Pedipalpi* & *Solifugae* are diagnosed by Kraepelin in Das Tierreich : Scorp. & Pedip., 1899 ; & Palpigradi & Solif., 1901. The genera of *Araneæ* may be ascertained from E. Simon's Hist. Nat. Araignées, 2 Edit. 1892-1903. Since these publications, however, many other species and genera have been described.

it is almost entirely confined, only about three of the species occurring outside of the South African limit. The sting is comparatively harmless. *Lychas* (*Archisometrus*), which is mainly Asiatic, is represented in South Africa by a single species, which is, however, rarely met with.

2. The *Centrurinae* are represented by the cosmopolitan species *Isometrus maculatus*, which is occasionally found at seaports, and has no doubt been introduced by ships.

3. The *Scorpioninae* are represented by the single genus *Opisthophthalmus*, which replaces the large scorpions of North Africa and Asia belonging to the genera *Pandinus* and *Heterometrus*. *Opisthophthalmus* is the largest as well as the most characteristic South African genus of scorpions, for of its thirty species only one (from Mossamedes) has not been recorded from within the South African limit, and it is quite possible that even this species may occur south of the Cunene. One or two of the species extend from Cape Colony northwards beyond the Zambesi. Many, however, have a very limited distribution area, and this is particularly the case in the western part of Cape Colony, where the genus finds its greatest development. The genus is distributed over the whole of South Africa, and most of the species may be easily recognised by the position of the median pair of eyes, which are generally placed behind the centre of the cephalothorax. All stridulate by rubbing the mandibles (chelicerae) against the lower side of the anterior edge of the cephalothorax, by which means a hissing sound is produced. Most of the species construct deep burrows in the ground, while other South African scorpions usually live under stones or bark. The sting does not appear to be fatal.

4. The *Ischnurinae* are blackish or dark green forms with broad strong nippers like those of an *Opisthophthalmus*, but with the eyes in the centre of the cephalothorax. They differ from the latter too in habit, being always found, so far as I have observed, clinging to the underside of the stone or other object under which they take refuge, or else in cracks in rocks or under bark. None of the genera are distributed over the whole of South Africa, and nothing is known regarding their sting. The genus *Hadogenes* is remarkable for the length of the slender tail of the adult male, which in some cases exceeds 11 cm. There are about eleven South African species, as well as some tropical African and Madagascar ones. *Opisthacanthus* is found principally in the eastern parts and along the South Coast districts. There are about six South African forms as well as several tropical African and Madagascar forms, and one Mexican one. *Cheloctonus* with three species is peculiar to South Africa.

Solifugae.

Africa is the home of the *Solifugae*, two-thirds of the known genera being found in this continent, and nearly half the known genera also occur in South Africa. Of the three families into which the order is divided, the *Galeodidae* are entirely absent from South

Africa, which is rather remarkable, as they are numerous in North Africa.

The *Solpugidae*, which include the bulk of the species, are widely distributed, and most of the South African genera, which number eleven in all, are distributed over the continent. Only four genera of this family have hitherto been obtained from South Africa alone, while *Solpuga, Zeriassa, Daesia, Blossia, Gluviopsis, Ceroma*, and doubtless also *Hemiblossia* occur north of the Zambesi as well. The large nocturnal yellow and black species of *Solpuga*, measuring sometimes over 6½ cm. in length from the tip of the jaws, occur throughout the country, and are well known to frequenters of the country districts. They come into houses at night and present a most alarming appearance, although they are in reality quite harmless. They are variously known locally by the name of *Romans, Jagd-spinnekoppen* (Hunting Spiders) or *Haarscheerders* (Hair-cutters), and there is a current belief that they cut off the hair of a sleeping person at night. Most *Solpugidae* attain maturity in summer (say from November to February), except the *Karschiinae*, which are met with in the winter months only. The brightly-coloured species of *Solpugidae* are generally diurnal in habit, running about with extraordinary rapidity during the hottest part of the day.

The curious *Hexisopodidae*, so rare in collections, are confined exclusively to the dry regions of South Africa. Unlike the rest of the order, they are slow runners, with very short and stout hind legs, and with the three posterior thoracic and the abdominal segments greatly distended dorsally to form a single large thoraco-abdomen overhanging the hind part of the cephalothorax. There are two genera, *Hexisopus* and *Chelipus*.

ARANEAE.

Of recent years many species of South African spiders have been described by Simon, Pocock and O. P. Cambridge, and some also by myself, but no comprehensive account of them exists. Moreover, only a few of the groups have been at all extensively investigated, such as the *Tetrapneumones*, the *Cribellatae*, the *Ecribellatae haplogynae* and the *Lycosidae*; while several of the larger families, such as the *Drassidae*, have hardly been touched at all, Of the thirty-eight families into which Simon divides the *Araneae*. no less than twenty-seven have representatives in South Africa, but of these only one, the *Ammoxenidae*, is exclusively South African.

Tetrapneumones.—Most interesting are the numerous tetrapneumonous or four-lunged forms, which in South Africa belong to the five subfamilies (or families) *Aviculariinae, Barychelinae, Ctenizinae, Miginae* and *Diplurinae*. The first includes the large so-called "bird-catching" spiders, all the South African forms of which fall into the group *Harpactireae*, a group distributed over South and East Africa only. The members of the principal genus, *Harpactira*, are locally known as "Baviaan Spinnekoppen"

(Baboon spiders), either because baboons are supposed to be fond of them or on account of the resemblance of the velvet-padded feet to the fingers of a monkey. Some species attain a length of over 5 cm. They live in deep burrows with or without a turret of sticks, etc., at the entrance, and one species of *Pterinochilus* constructs a perfect trap-door. The *Barychelinae* are smaller, but resemble the foregoing and build similar nests. The commonest genus is *Harpactirella*. The *Ctenizinae* include many species, whose burrows have either trap-doors or are open like those of *Harpactira*. They are extremely local. The principal genera are *Spiroctenus*, *Hermacha* and *Stasimopus*, and the large nests of the latter with their strong and beautifully constructed lids, sometimes an inch across, are met with in many places. The *Miginae* are a small group of spiders which construct sack-like nests, with one or two trap-doors, on trees, etc.; a few species, however, build ordinary trap-door burrows in the ground. The principal South African genus is *Moggridgea*.

Dipneumones.—Amongst the cribellate spiders of special interest are the social spiders (*Stegodyphus*), which have the unusual habit of living together, often in hundreds, in a huge nest of leaves spun together and suspended by strong cables on or between low bushes. When an insect strikes the web the little spiders sally forth in numbers, lay hold of the insect and kill it, and afterwards carry it off and devour it. Social spiders are found all over South Africa, and also in the Indian region, but most of the species of the genus live singly. Another genus, *Seothyra*, of the same family (*Eresidae*) constructs a most remarkable nest in the sand of the Karoo and Kalahari, the narrow burrow being closed above by a large four-lobed flexible carpet-like lid from beneath which the spider creeps at will.

The *Zodariidae* are a small group of ecribellate spiders, and are interesting on account of the habits of some of the species. Some forms of *Caesetius* live under loose sand without constructing regular burrows, the sand closing in behind them as they move along, while a species of *Cydrela* on Lion's Hill builds regular trap-door-burrows.

Some of the *Theridiidae* of the genus *Latrodectus* have here, as elsewhere, an evil reputation amongst the country people, who, in certain districts, believe them to be very dangerous and sometimes fatal.

Amongst the *Argiopidae* (Orb-spinners) the large yellow and silvery or yellow and black females of *Argiope* and *Nephila* form very conspicuous objects, when sitting in the centres of their large spiral webs. The males, on the other hand, are quite tiny, being many times smaller than their mates, and may be found hiding in some corner of the same web. The silk of *Nephila* is so strong that attempts have been made in several countries to weave fabric of it. The large forms of *Caerostris*, which are grey, brown or greenish, and have curious protuberances on the abdomen, are equally conspicuous in their webs, but when crouching against the bark of a branch with their legs tucked up would hardly be taken for a live spider. The species of *Nemoscolus* are small but remarkable for constructing tubular nests in the form of trumpets, horns or snail-shells, composed of sticks or stones and suspended in bushes. Some of the hard-shelled species are very striking, such as the spiny *Gasteracantha* and the curious *Paraplectana*, which closely resembles a common coccinellid beetle in shape and colour.

Very large species of *Clubionidae* belonging to the genus *Palystes* are frequently met with on the walls in houses and present a somewhat terrifying appearance. They are brown or grey above with black and pale bands on the legs below and rush sideways or backwards at will. Some of the hard-skinned genera of Rhodesia mimic *Mutilla* wasps in form and colour in a remarkable manner.

Among the *Agelenidae* the marine spider *Desis*, which lives on the shores of False Bay between tide-marks, may be mentioned.

Numerous *Lycosidae* are conspicuous everywhere, rushing over open ground in summer with their egg-sacks attached to their bodies. Some (*L. darlingi*, etc.) construct open burrows with turrets of sticks at the entrance, like those of a *Harpactira*, while a few (*L. domicola*, etc.) construct neat round lids for closing the burrow. Some Karroo forms (*Evippa*) are remarkably swift runners.

The *Attidae* or jumping spiders are very numerous, and many have recently been described by M. Simon and Mr. and Mrs. Peckham.

Onychophora.

The species of *Peripatus* found in the Cape Peninsula have an interesting history. The first specimen was found by M. Goudot on Table Mountain, and was described by De Blainville as long ago as 1837 under the name of *P. brevis*. The next specimens recorded were obtained by the naturalists of the "Novara" Expedition, and included two species which were confused together by Grube, who named them *P. capensis* in 1868. During the visit of the "Challenger" Expedition in 1872 Moseley obtained and dissected specimens of the same two forms and discovered the tracheae. In 1882 Balfour investigated the embryology of some specimens sent by Lloyd Morgan, but his researches were interrupted by his death. In 1883 Sedgwick came to the Cape and commenced his well-known investigations on the embryology. He first separated the smaller Cape species, *P. balfouri*, from the larger form, retaining Grube's name, *capensis*, for the latter. Quite recently Bouvier ascertained that De Blainville's *P. brevis* is evidently identical with *P. capensis* (Grube) Sedgw., and from the evidence he adduces I do not doubt but that this is the case. Finally in 1895 Mr. R. M. Lightfoot pointed out to me the existence of a *Peripatus* on Signal Hill (Lion's Hill) on the immediate outskirts of Cape Town, and on investigation this proved to be a new species which had apparently not been observed by previous collectors—a circumstance perhaps accounted for by the fact that this species appears to occur only on Signal Hill, where neither of the two other species have as yet been found. *P. balfouri* has also afforded material for a valuable paper on the spermatogenesis by Montgomery in 1900 (Zool. Jahb. Anat. v. 14).

R. I. Pocock in subdividing the old genus *Peripatus* created the genus *Peripatopsis* for the Cape forms, and I have subsequently added another genus, *Opisthopatus*, for a recently discovered South African form. While the genus *Peripatopsis* is confined to South Africa, where six species are now known to occur, the genus *Opisthopatus* has, according to Bouvier, a second species on the west coast of South America, namely, *O. blainvillei* (Gerv.) from Chili.

Owing to the remarkable combination of annelid and tracheate arthropod characters in *Peripatus*, the latter has long been an object of the greatest interest to zoologists, and it is often looked upon as a kind of phylogenetic connecting link between the worms and the myriapods and insects.

Peripatus is an animal which perishes within a few hours if exposed continuously to dry air, and this must be borne in mind in searching for specimens. In the Cape Peninsula they may be found under stones or leaves or in rotten wood alongside any mountain stream, in the woods on the southern slopes of Table Mountain, and in the valleys on the southern side of Signal Hill. They are naturally most abundant in such places as afford a safe retreat from the dry heat of summer, such as dense forests or open hill slopes where a thick layer of loosely-packed stones lies beneath the surface. *Peripatus* makes its first appearance after the first rains in March and remains out for about six months until the end of the rainy season.

4. THE SOUTH AFRICAN MARINE FAUNA AND ITS ENVIRONMENT.

By J. D. F. Gilchrist, M.A., D.Sc., Ph.D., C.M.Z.S., F.L.S.
Government Biologist, Cape Colony.

Historical.

From the time when Bartholomew Diaz ended his long and venturous voyage by rounding the "Cape of Storms," the South African seas have continued to attract the attention and interest of the civilised world if only as an important point in the voyage to the regions beyond. It was in this way that a closer scrutiny into the forms of marine life to be met with began, for the intelligent voyagers of those early days were constantly on the look out for some marvel or wonderful fact to be recounted to their fellow countrymen at home. Thus we find that one of the first notices of the marine fauna of the Cape is contained incidentally in an account of the "Old and New East Indies," by Valentyn, where, amongst other notes and weird illustrations there is some mention of the Cape marine fauna. Somewhat later appeared a book, Kolben's "Present State of Good Hope," containing a more detailed account.

Subsequently to this, material for more careful and reliable examination and description gradually found its way to Europe through the early Dutch merchants, and at a later date this was augmented by travellers and by exploring expeditions such as the "Novara," "Gazelle," and "Challenger," which called at the Cape.

It was not, however, until recently that a systematic study of this subject was possible, when a few years ago the Cape Government, realising the need for a more accurate knowledge of the marine fauna of its coasts, both from a scientific and a practical point of view, began a systematic investigation which is still in progress.

Certain general characteristics are beginning to appear more clearly from the facts now ascertained, but it is still premature to state them in any definite or limited manner.

One of the main objects of this paper is to indicate the necessity for further investigation, not only as a means of adding new and interesting genera and species to the known lists, but in order to throw light upon the relationships of the Cape marine fauna to the fauna of the seas in general, for it may at once be said that the feature of greatest interest and importance is not to be found in any characteristic peculiar to the South African marine fauna but in the general geographical distribution of its constituents.

This being so, it is obvious that the study of the marine fauna of the Cape is closely bound up with that of the physical conditions and geographical situation of the Cape Seas, though this has received even less detailed attention than the study of its fauna.

A general outline, however, of what is known in regard to this subject is a necessary preliminary, and we may briefly review the outstanding facts in connection therewith before proceeding to zoological detail.

2. General Physical and Geographical Features of Environment.

The chief feature of oceanic circulation is that due to prevailing winds which give rise to a surface movement of the waters over which they pass, so that there is a general movement from the Poles in corresponding directions towards the Equator where they meet and flow in a westward direction parallel to each other, forming the great Equatorial currents of the Northern and Southern Hemispheres. There are, however, two great continuous land barriers interposed in the course of these currents, Europe, Asia and Africa forming one, North and South America forming the other. In addition there is another barrier (with gaps however) viz., that formed by discontinuous land masses in the meridian of Australia, the East Indies and China. This third barrier is mentioned separately for a reason which shall appear later.

The result of the interpolation of these land masses is that the bodies of water, which are thus set in motion and which must find an outlet somewhere in order to maintain the general oceanic equilibrium, are directed towards the Poles again. This is,of course, most clearly marked in the parts of the Indian, Pacific and the Atlantic Oceans situated in the Southern Hemisphere, for there the movements of the waters are less interrupted by land masses, and, inasmuch as the Pacific is comparatively shallow, and the movement of its water is much influenced by islands and coral reefs, it is in the Indian and South Atlantic oceans that this phenomenon is best illustrated.

There is one striking difference in the course of the two currents in these regions. In the Indian Ocean there is no outlet towards the north, and the whole mass of water is turned down the South African coast, where it is known successively as the Mozambique, the Natal and the Agulhas current. The South Atlantic current, on the other hand, is met in its course by the projecting portion of South America, and is split up into a branch which flows to the south along the coast of Brazil, and another which is directed northwards into the Carribean Sea and the Gulf of Mexico, the origin of that great current of the North Atlantic—the Gulf Stream. A possible connection is thus established between the waters of the temperate regions of the Southern and the Northern Hemispheres.

These are the outstanding features of circulation of the surface waters of the ocean. There is yet another to be considered before we can be in a position to realise the peculiar features of the seas round South Africa. It is found that there is a constant drift of the waters of the Southern Hemisphere from the Pole in an easterly and northerly direction, forming a South Polar drift current or the west wind drift current, and this mighty current moves between the Antarctic Circle and the parallel of 45° S., round the open waters of the southern seas unimpeded, except by the tongues of land projecting into those regions, viz., the continent of South America, that of Africa, and, to a less marked degree, that of Australia. The continent of South America projects far south beyond the parallel of 50 °, consequently a great portion of the current is caught and deflected northwards along its western coast, while the whole of its southern portion is laved by the cold water. In the case of South Africa, however, which is situated in a much lower latitude, a smaller portion of the current is caught and deflected northwards along its western side, and it is not strong enough to completely force back the warm Equatorial current which is coming south along its eastern side, though strong enough, however, at times to bring icebergs from the Antarctic to within a short distance of the South African coast. The main portion of the warm current is turned back into the Indian Ocean and is partly carried on with the Antarctic current in its circum-Polar course (c.f. page 194).

It will thus readily be seen that the sea round the South African coast exhibits an almost unique character and one of fundamental importance, not only in oceanic circulation but in the distribution of marine life. On the one hand it is connected by currents with the seas to the eastwards, directly to the Indian Ocean and more indirectly to the Pacific, while on the other it is directly connected to the South Atlantic by the deflected northwards-going branch of the Antartic drift, and more indirectly to the North Atlantic, as this branch in its course northwards becomes mingled with the return current of the South Atlantic equatorial to form the Benguela Stream which is ultimately carried over, perhaps partly as a cold undercurrent, to the coast of South America, part passing through the Carribean Sea into the North Atlantic.

If, then, marine pelagic fauna is determined by its environment like other faunas, and if, like other environments, there are great factors within it determining the geographical distribution of the contained forms of life, it will be readily understood that the key to the character of the marine fauna of the Cape is to be ultimately found in the peculiar features of its sea, which have just been enumerated. Before, however, passing on to this it will be necessary to consider some of these features in more detail.

Some years ago, in view mainly of the great importance of the currents and changing character of the sea for a determination of the laws which regulate the occurrence, migration and habits of fish and other forms of sea-life, a series of temperature observations was begun at about twelve different stations round the coast ;

and it has been observed that while there is a gradual cooling of the Agulhas current as it proceeds southwards and westwards there is a very abrupt difference between the stations in False Bay and

MEAN MONTHLY TEMPERATURE
AT
SIMON'S BAY AND TABLE BAY,
FOR THE PERIOD 1898—1900.

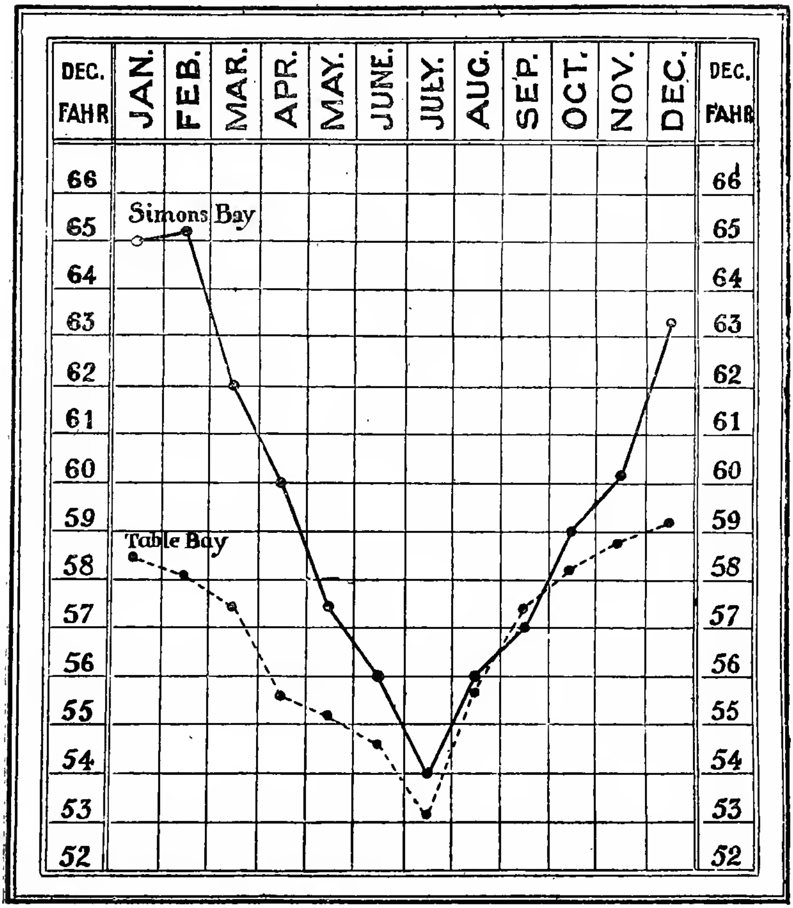
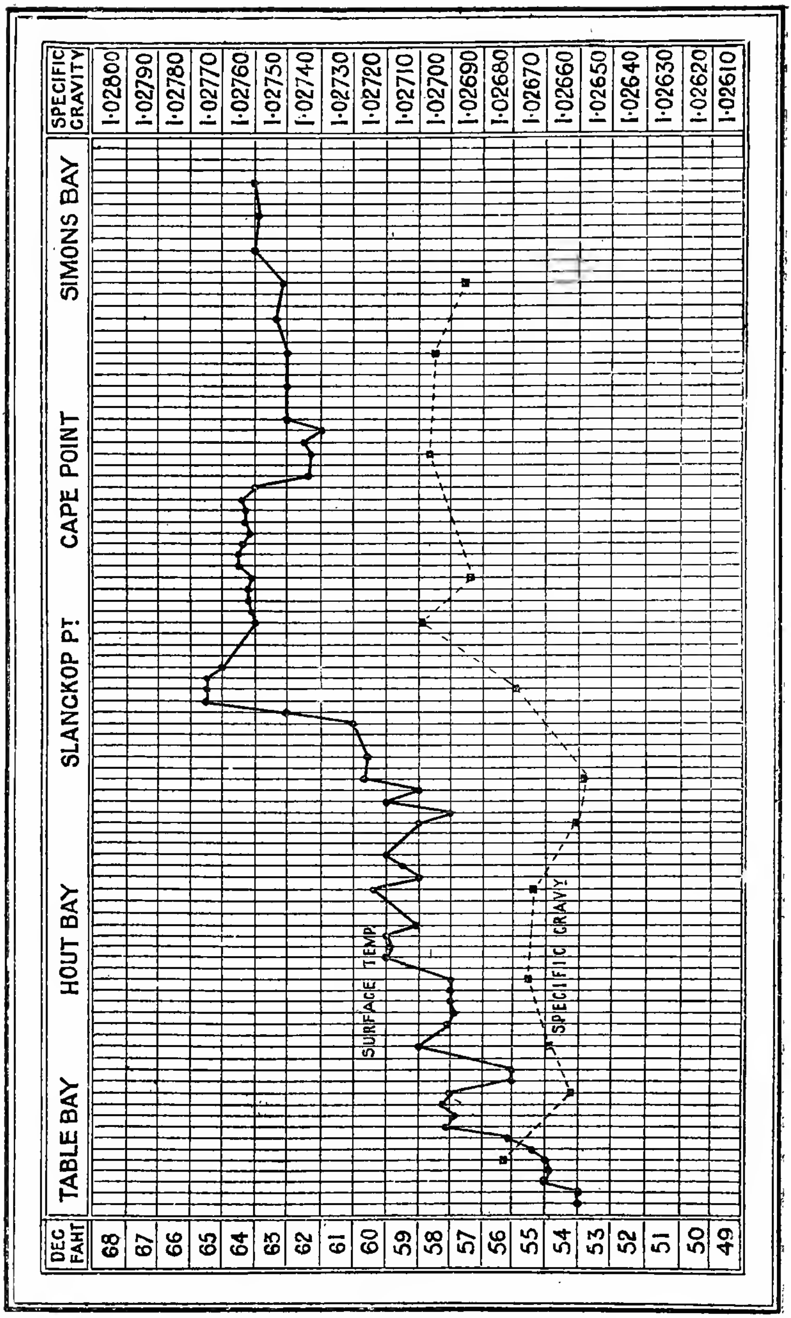


Table Bay, showing that this is the meeting place of two great bodies of water of different origin.

The details of the transition at this point are of special interest and can be shown by the result of a series of observations of sea temperatures taken for a number of years at the Roman Rock Lighthouse in Simon's Bay and at Robben Island in Table Bay. The above diagram constructed from these data shows the mean


DEG FAHT
68
67
66
65
64
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62
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59
58
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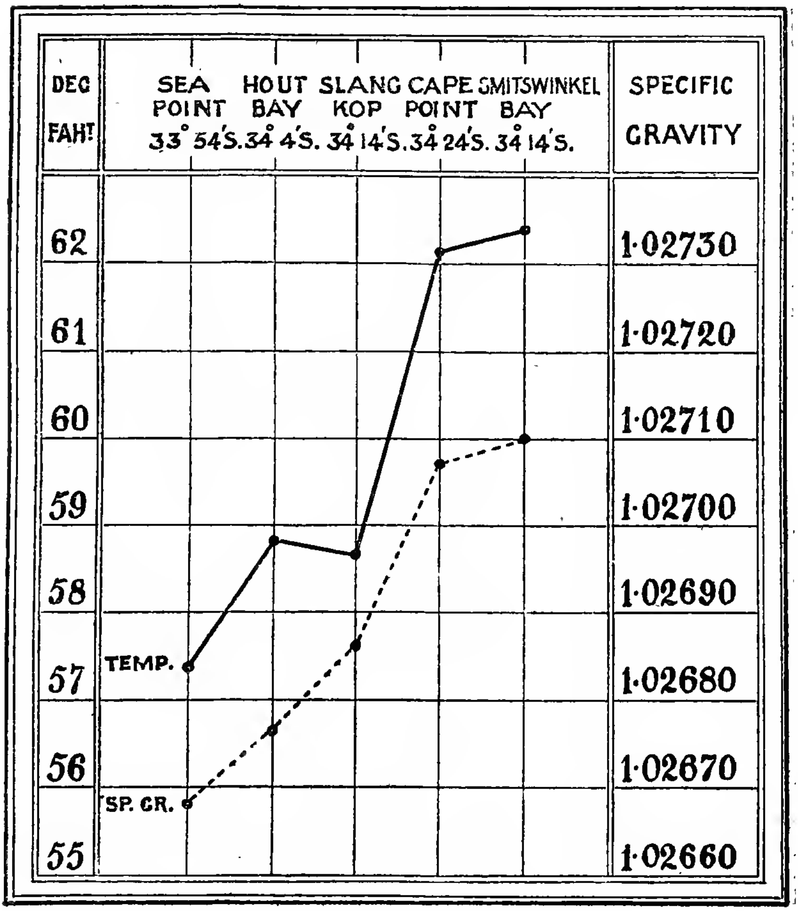
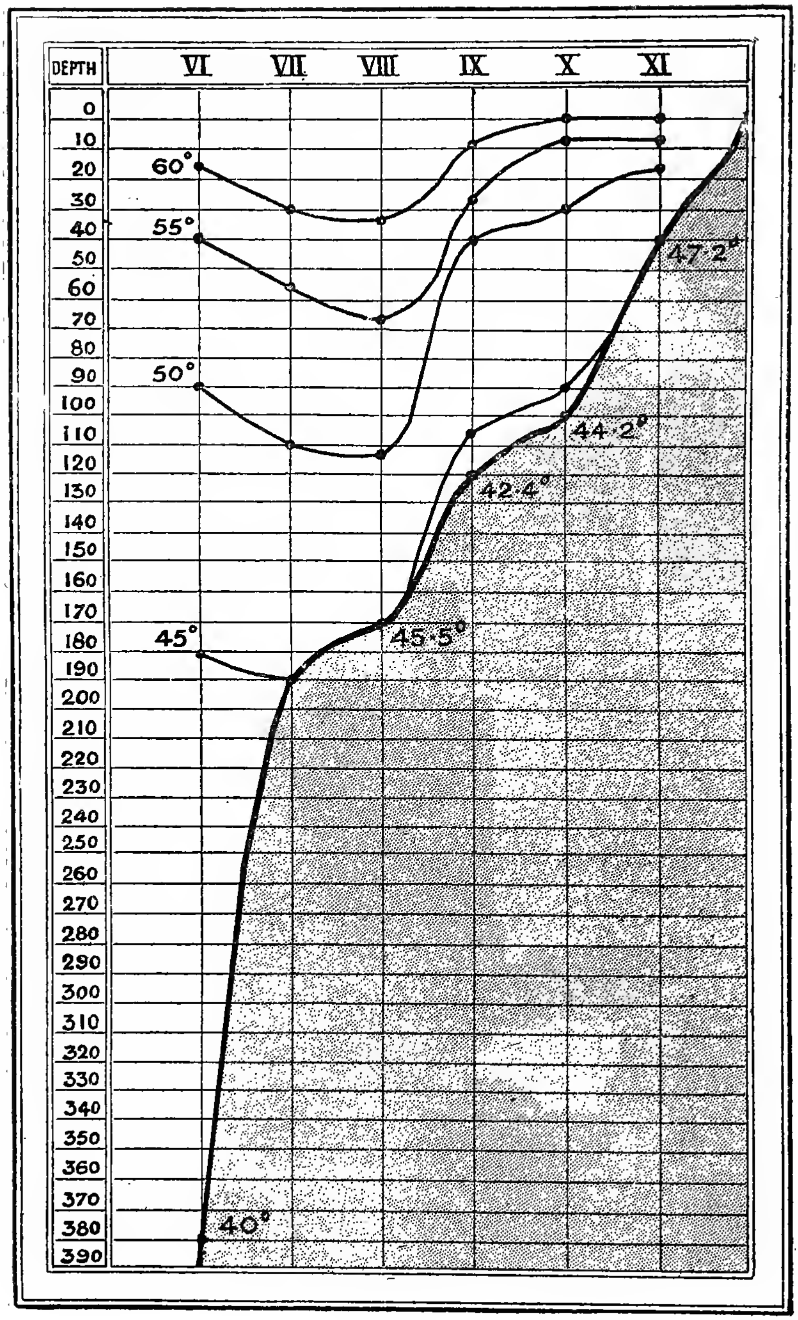
56
55
54
53
52
51
50
49
TABLE BAY
HOUT BAY
SLANCKOP PT.
CAPE POINT
SIMONS BAY
SURFACE TEMP.
SPECIFIC GRAVY.
SPECIFIC GRAVITY
1·02800
1·02790
1·02780
1·02770
1·02760
1·02750
1·02740
1·02730
1·02720
1·02710
1·02700
1·02690
1·02680
1·02670
1·02660
1·02650
1·02640
1·02630
1·02620
1·02610

monthly temperature of the respective places for a period of three years. It will be observed that in summer there is a difference of about 6°, while in winter there is a close approximation of the curves of temperature. The diagram on the opposite page (p. 186) shows the details of the variation of temperature at points between these two stations at practically the same time. It is drawn up from observations taken every ten minutes on board the *Pieter Faure* when on passage from Table Bay to False Bay. In conjunction with the temperature curve is shown one indicating the variation in salinity of the sea-water.

MEAN TEMPERATURE AND SPECIFIC GRAVITY OF SEA WATER

BETWEEN TABLE BAY AND FALSE BAY.




DEPTH
VI
VII
VIII
IX
X
XI
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40
50
60
70
80
90
100
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150
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170
180
190
200
210
220
230
240
250
260
270
280
290
300
310
320
330
340
350
360
370
380
390
60°
55°
50°
45°
40°
45·5°
42·4°
44·2°
47·2°

Another diagram (p. 187), drawn up from a series of observations made by the mail steamer, between Cape Town and Cape Hangklip, illustrates the same phenomenon.

This variation in temperature, conjoined with a corresponding variation in salinity, is of interest as indicating that the cold waters of the west coast of the Cape are not merely the welling up of the deeper waters when the warmer upper layers are driven away from the shore by winds ; no doubt much of the variation in temperature can be brought about by such an agency, but this very marked difference of temperature and salinity combined with current observations can most satisfactorily be explained by the close proximity of the southern drift current.

As might be expected there is, however, no hard and fast line of demarcation between the two bodies of water. Recent investigations on this point by means of drift bottles have shown that part at least of the warm current may escape past the Cape Peninsula to the west coast. That the courses of the drift bottles were not influenced merely by local winds was indicated by the fact that in several instances the wind at the time was in an opposite direction. This was further confirmed by a series of temperature observations made at different stations (VI.–XI.) off the western side of the Cape Peninsula. The section of the sea in this region (p. 188) is drawn up from these observations and indicates an interesting problem for further investigation. The column on the left indicates depth in fathoms ; the Roman numerals indicate stations, about ten miles apart.

3. Local Features : Configuration of Coast, Deposits, etc.

The foregoing are the main physical features of South African waters as they are modified by the great ocean currents which meet in this region ; the more local peculiarities are also important features in the moulding of the character of South African marine fauna, but not to the same extent as in many other regions, for a feature of the South African coast is its want of bays, natural harbours or inlets, and of islands or large fresh-water inlets, all of which in other countries give rise to peculiar modifications of sea-life. Although, however, there is not a single large river which does not admit the sea for several miles inland, all are capable of swelling into floods of great volume, bringing down with them, to be deposited on the sea bottom, much mud and *debris* of all sorts. Thus it has been found that there are extensive areas of mud in St. Helena Bay into which the Berg River opens, at Sebastian Bay near the mouth of the Breede River, at Mossel Bay near the mouth of the Gouritz River, and at Bird Island near the Sundays River.

Another feature of the sea bottom is a deposit of a totally different character and origin. It has been found on the west coast from St. Helena Bay to Cape Point, and over the western side of the Agulhas Bank, but not beyond on the eastern side of the bank nor on the eastern side of South Africa. This is a kind of green mud or sand, apparently of organic origin, to which attention will be directed further on.

The remainder of the area of the sea bottom consists, on the east and west coasts, of sand and sand and shells interspersed with rock within a short distance from the shore, where there is an abrupt shelving off into deeper water. The extensive Agulhas Bank off the south coast has, besides mud and green sand, large areas with often very abrupt transitions from coarse and fine sand to rock.

4. Diversity of Faunas of East, South-East and West Coasts.*

As has been already indicated it is from a distributional rather than a systematic point of view that the Cape marine fauna is most profitably studied, and it is chiefly this aspect that is therefore considered here.

In the first place it has become evident from recent investigations that there is well-marked difference in the character of the fauna at different localities on the South African coast, so that it can even with convenience be divided roughly into a number of characteristic regions. This can most readily be illustrated by the distribution of the flat fishes which have been found at different points on the coast during the trawling operations of the Government steamer, the *Pieter Faure*. The great economic importance of these fishes called for special attention, so that their distribution is now fairly well known as well as the number of species (twenty-five in all, of which fifteen have proved new species).

Trawling operations were first commenced on the west coast, and it was found that in a stretch of ground between Dassen Island and Saldanha Bay a species of sole (*Synaptura microlepis*) occurred. On proceeding further north the same sole was found, some of the specimens being of a remarkably large size, several of them weighing about 9 lbs. In neither of these places, however, did it occur in great abundance. Another species of flat fish was found near Dassen Island (*Cynoglossus capensis*), but only occasionally. On extending operations to False Bay it was found that the first-mentioned was not to be found, while the second was in fair abundance. Further to the east another species (*Synaptura pectoralis*) was found in great abundance—in such abundance that it now forms the chief item in the catch of three large trawlers which shortly afterwards commenced operations in this area. The same sole was found in abundance on a large area of mud near Bird Islands and at a spot several miles beyond East London. The attention of the Natal Government was attracted by these results (a Natal trawler was the first on the new ground after its discovery), and at their request the Cape Government surveyed their coast for trawling

* For a detailed account of the S. African Marine Fauna see "Marine Investigations" published by the Cape Government.

ground. Here, however, an entirely different state of things prevailed. Suitable ground, with a deposit of fine mud, was indeed found off the Tugela River, and several species of flat fish were discovered, but all of a small size. There was no trace whatever of the sole so abundant on the east and south coasts of Cape Colony.

Another example from the group of the fishes illustrates just as forcibly the effect of the different conditions to be found on the east and west coasts of South Africa. This is the "snoek" (*Thyrsites atun*), which, being of great commercial importance, is better known than most of the other fishes with respect to its places of occurrence and relative abundance. It is a migratory fish, and during the season appears in immense shoals* on the west coast. It is known to occur as far north as Sandwich Harbour, which was formerly open to fishing boats, though now inaccessible through accumulation of sand. Here a fishing station was at one time established for the special purpose of snoek fishing, so that it must have been found in fair abundance. It is found further south in the neighbourhood of St. Helena and Saldanha Bays, where also a fishery has been carried on for many years, and a large export trade to Mauritius and other places carried on. In Table Bay it is not so abundant, though at one time it was found in almost incredible numbers. In False Bay on the other hand it is less seldom seen, though in good fishing seasons it occurs very abundantly. Further to the east the supply falls off rapidly. It has, however, occasionally been known to visit Mossel Bay. There is no record of its having ever been seen at Algoa Bay, and it is quite unknown on the east coast. Its distribution is, therefore, intimately associated with the colder waters of the west coast. It is indeed probable that some light might be thrown on its relative abundance or scarcity at different periods by a more intimate knowledge of the temperature conditions prevailing in different years.

An example, from the group of the Crustacea, illustrates, perhaps even more forcibly than the last two, the effect of the changing environment we meet in passing round the South African coast: this is the large crawfish (*Jasus lalandii*). This crustacean occurs in such quantities in Table Bay that the supply was sufficient to keep a large canning factory at work, and it seems practically inexhaustible. It is found in the same abundance northwards to beyond Angra Pequena. It occurs also in quantity in Hout Bay, but only now and again in False Bay, and it falls off rapidly towards the east, both in number and size.

Though in both the above-named instances of distribution—that of flat fish and crustacean—the species become more numerous and the individuals of a smaller size toward the region of the warmer waters (the east coast), another instance may be mentioned to show that this is not valid for all forms. The pearl oyster (*Avicula*) has not been found on the west coast, nor on the south coast westwards of Cape Agulhas. It is met with, however, in fair abundance just

* Though of recent years somewhat scarcer, there is evidence of late that it is again reappearing in the same abundance in some places.

beyond (eastwards) of this point; indeed at one time it was thought a valuable industry might be developed there owing to the finding of the beds of this bivalve, and a few valuable pearls. It is known to occur at several localities to the eastward of this, and is found on the east coast as far as the Mozambique Channel where it is larger and more abundant, so much so that a profitable trade can be carried on there.

A final instance from the group of the Ascidians is also striking, and may be classed with the preceding. One of the features of the rocky parts of the coast line *from Cape Point eastwards* is the clusters of "rooias" or "red bait" (a large Ascidian) which cover the rocks. It is not now to be seen in abundance except at low tides as it has been used extensively by the fishermen for bait, but on favourable opportunities masses of rock thickly carpeted with it may be observed.

We see, therefore, that the different physical conditions on the east and west coast are reflected in the character of the fauna, the general rule seeming to be that in the colder waters the species in certain groups are fewer, and the individuals more numerous, while the warm waters are characterised by greater variety of species and fewer individuals of any one species; in other groups the reverse is the case. In some of the cases cited the cold-water forms grow to a much larger size, in others the warm-water forms. It is a significant fact that the latter—to which may be added the sponges—are more directly dependent on the floating minute forms of the plankton which has been found to be richer in the warmer waters. This, however, raises a question which cannot be dealt with here beyond these general statements.

5. Relation of South African to other Marine Faunas.

The character of the water does not, however, account for the variety of species; for light on this point we must go elsewhere. A key to a fuller explanation is found when we consider the general distribution of this marine fauna, and the affinities of its component elements to the general marine fauna of the globe. For this purpose we must turn attention more to the distribution of the strictly pelagic or oceanic forms. One of the most obvious instances is found in the general distribution of the snoek (*Thrysites atun*), which we have already taken to illustrate another point. It is found in abundance on the Chilian coast of South America, at Tristan de Cunha, on the west coast of South Africa, and on the west coast of Australia—that is, on those coasts on which the Antarctic drift current impinges. It is therefore a form which is characteristic of the west wind current. There are other forms of the South African fish fauna such as the genera *Bdellostoma*, *Agriopus*, *Callorhynchus*, *Clinus*, which link it on to the regions traversed by the Antarctic current; and those genera in South African waters, like the snoek, seem to be most characteristic of the west and south coast.* On the other hand, there are a number of forms, growing more numerous towards the west, which show a great affinity with the warmer waters of the Indian Ocean. Thus the well-known Blaasop (*Tetrodon honckenii*) is a representative of the tropical Gymnodontes. It is found in abundance in False Bay, but seldom in Table Bay, though it is found in Hout Bay. One or two other members of the group are occasionally found in False Bay, and they become much more abundant towards the east coast. There also such forms as *Pterois*, *Apistus*, etc., have been found, while the Squamipinnes increase in numbers and species. The same fact is illustrated in the flat fishes.

The affinity with tropical Indian Ocean forms is, like the previous case, readily understood by the intimate connection with that region brought about by the warm current of the east coast, and we are not surprised to find that regions of the same latitude on the west coast are entirely devoid of these forms. When, however, we find in the Cape seas such forms as *Zeus japonicus*, *Monocentris japonicus*, and even a flat fish, identical with Japanese species, it is more difficult to realise that the distribution can be accounted for by currents connecting the two regions, though it is to be remembered that there are no insuperable land barriers between the northern Pacific coast and that of South Africa.

There is, however, another element in the South African marine fauna much more difficult to account for, and one which from evidence now accumulating, seems to be a characteristic feature. This is the presence of forms specifically identical with some that occur in European waters. Such anomalies of distribution are not rare. For instance, Günther has drawn attention to the fact that several of the genera, and even species, in Japanese waters are identical with Mediterranean forms, and similarly Alcock has shown that the same phenomenon occurs in the Indian seas. To account for the first case Günther has advanced the hypothesis that at some time in the geological history of continents there was a direct sea communication between Japan and the Mediterranean, and Alcock has had recourse to the same convenient and not improbable explanation. The familiar Stock-fish (*Merlucius vulgaris*) and the Maasbanker (*Caranx trachurus*) are examples from the group of the fishes illustrating identity of Cape and European forms, and several other species recently found in South African waters have proved to be identical. Even in the group of marine annelids and other invertebrates the same agreement has been observed. In the fishes the affinity to the Mediterranean forms has been specially noted. In drawing attention to the similarity of the Japanese and Mediterranean forms Günther has given a list of Japanese shore fishes, of which fifty-four genera are identical in both places; of these, thirty-five have now been found at the Cape, where also three

* The shore forms might be taken as additional evidence of the former existence of an Antarctic continent. An explanation, however, postulating the existence or removal of continents is to be regarded as a last resource.

genera, described in the list as peculiar to Japanese waters, have been found. How is the presence of Mediterranean forms in South Africa to be accounted for? Unfortunately we cannot have recourse to an explanation that would postulate a former direct communication in past geological times, elastic as such explanations are, and we are compelled to look about for further information with regard to the existing means of distribution. I have said "unfortunately"; perhaps, however, the necessity of a further enquiry into the facts will, in the long run, lead to a truer solution. As has been indicated, the direction in which the solution may be looked for is in a more intimate knowledge of the connection between the waters of the North and South Atlantic, and perhaps between the Northern Pacific and Indian Oceans, and it is in this direction also we may first look for a solution of the much greater but cognate problem of bipolarity, or the identity of Arctic and Antarctic forms, and that only after looking nearer home into the specific diagnosis of authors.

Before leaving this subject two suggestive cases may be mentioned. A certain Gasteropod occurs in comparatively shallow water in Iceland. It has also been found in deep waters near the Equator, and recently has been found in comparatively shallow waters in South Africa.* Still more instructive in this respect are the results of a recent examination of the different species of Copepoda found in South African waters. It has been shown that of the species found south and west of Cape Colony a considerable number occur also in the Northern Hemisphere. Professor Cleve, who made this discovery,* from an examination of material supplied by the Cape Government, finds in it a confirmation of his hypothesis that the waters of the temperate Atlantic in the Northern Hemisphere originate not in the Gulf Stream but in the Benguela current, which is supposed to pass as an under-current below the waters of the tropical Atlantic. He further finds evidence in the plankton that some of the forms found on the east coast of Africa may be carried in the mingled waters of the Agulhas and Antarctic currents to the west coast of America. Along with these examples is to be noted also the presence in South African waters of the ubiquitous *Teredo navalis* and *Limnoria lignorum*.

6. Deep-Sea Fauna of South Africa.

Within a few miles of Cape Point is to be found a fauna totally different from the forms we have been considering, but which must be glanced at even in this short review. At the locality in question is to be found deep water from 100 to 1,000 fathoms. Recent investigation has shown that this region contains forms which, on the whole, are characteristic of deep waters throughout the world. Considering the fishes alone we find, in contrast to the shallow-water forms of the South African seas, which are distinguished by a preponderance of the family of the Sparidae, or fishes provided with

* Vide Marine Investigations, S. Africa.

cutting and grinding teeth, that in deeper water there is a preponderance of forms belonging to the cod tribe, of which only three or four representatives are found in the shore forms—a fact which seems to suggest that in the more strenuous existence on the South African coast the process of specialisation and the driving off of older forms into deep waters has been carried a step further than in other regions. The deep-water fish fauna is not, however, without some special feature. It is a noteworthy and yet unexplained fact that the family of the Cyttidae are here well represented. To this somewhat restricted group three new genera have been added from this region as the result of a few hauls of the net. The other groups, with perhaps the exception of that represented by a new genus (*Tripterophycis*) in the Gadidae, present no outstanding feature. Depth of water forms an even more effective barrier than difference of temperature, and these two factors being well illustrated in this region, we have the interesting phenomenon of three different marine faunas occurring within thirty miles of one point—the Cape of Good Hope.

7 Early Stages of some South African Fishes.

Next to a knowledge of the kinds, numbers and localities of the different marine forms is that of their individual growth or stages of development—both from a strictly scientific as well as a practical point of view. The necessity of a knowledge of the spawning habits and early stages of Cape fishes has been forced upon the attention of the Cape Government on several occasions in the most unmistakable way. About twenty years ago an enterprising American schooner was practically driven away by the Colonial Government on the representation of the native fishermen that damage was being done to the spawn and young of fish. On the advent of trawling these representations were vigorously renewed, and about the same time petitions were presented praying for the abolition of netting in rivers and lagoons on the ground of damage done to eggs and spawn.

As a result of this certain facilities were afforded by the Government for making the necessary investigations into the subject, and some reliable information has now been procured which, to a certain extent, meets the practical difficulties. These we can only briefly note here.

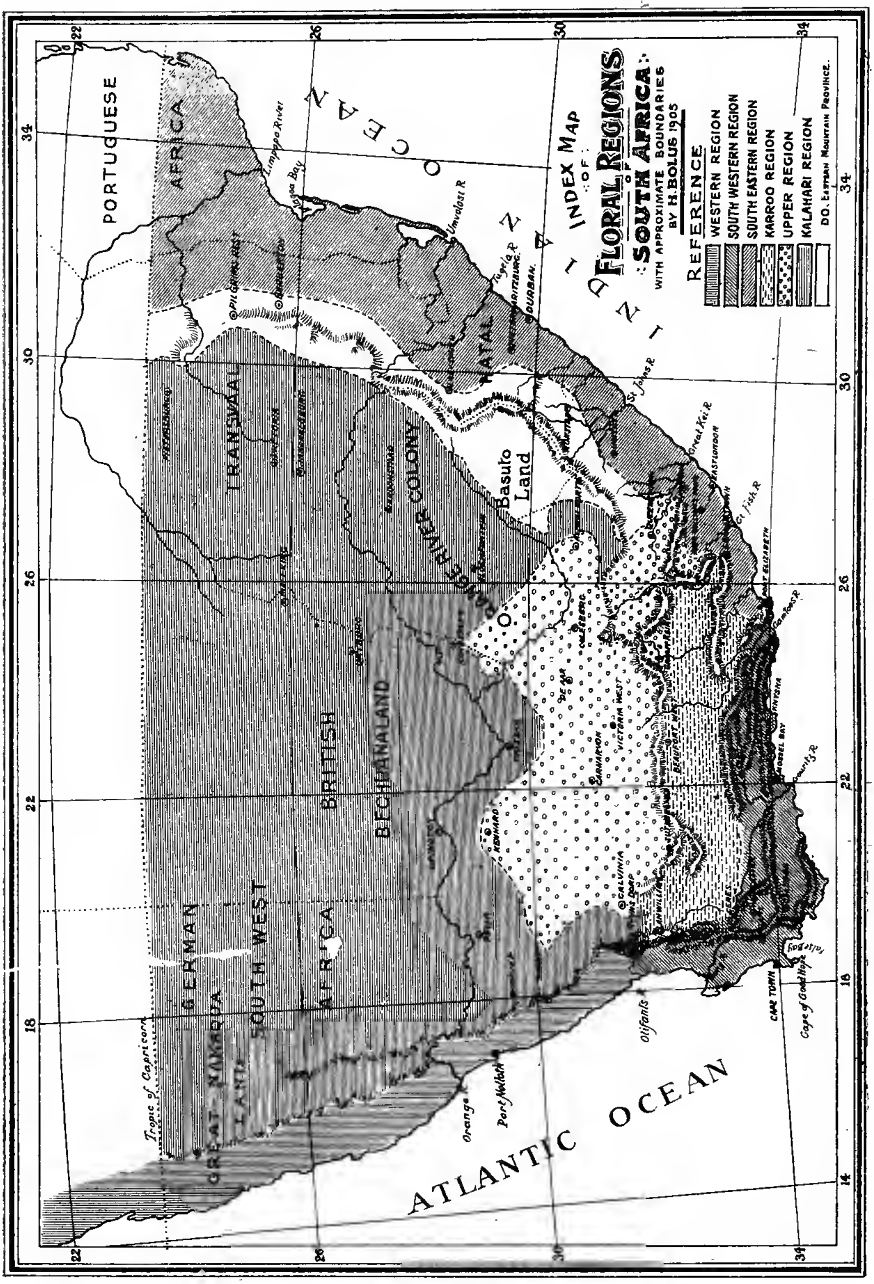
It has been found that, as in the Northern Hemisphere, most of the edible fishes have floating eggs. Two or three species of fish have eggs which are deposited on stones, shells, etc. Only one of these first have as yet been determined with certainty, and it is a small fish of no direct economic importance. Concerning the nature of the eggs and young of some fish, such as the Cape salmon of the east coast, on which a great deal of dispute has taken place, no definite information has yet been obtained. A number of species of the genus *Clinus* are viviparous, and the male of the Barger (*Galeichthys feliceps*) has the curious habit of carrying the eggs and young in its mouth. The eggs of some species of *Macrurus* have been procured from ripe specimens and also in fine nets at about 100 fathoms. One deep-sea fish (*Cataetyx*) has been found to be viviparous, and shows evidence that the embryos live at the expense of each other during the ovarian period of their development.

8. Character and Significance of Green Mud and Sand Deposit.

We now return to a subject which may prove on further investigation to indicate a characteristic feature of marine life here, and which I just touched upon previously, viz., the occurrence of a peculiar deposit, commonly known as green sand or mud, which, as recent soundings have shown, is to be found very extensively over the bed of the sea off the south and west coast of the Cape. The green colour has been found to be due to phosphate of lime ; it coats the coarse grains of sand inshore, and, where these terrigenous deposits are absent in deep water, it is found encrusting and filling up the shells of foraminifera and other characteristic deep-sea deposits. It is often also found as nodules formed round a central nucleus. It is therefore a formation of comparatively recent date, and can hardly be derived from the common mineralogical forms—apatite—which are found in volcanic rocks ; it might be thought to be derived from submarine mineral springs, but its great extent is against such a supposition. Finally it might be derived from the phosphates found in sea-water, but the small quantity thus found and the mode of its occurrence are against this. The distinguished oceanographer, Sir John Murray, has devoted particular attention to this problem, and he suggested that it is derived from the phosphate of lime stored up in the living organisms (especially in their bony tissue) which inhabit the sea. He has observed that these deposits of green mud or sand are characteristic of the regions where currents of different character meet, and suggests that it is there that a great mortailty amongst sea animals may occur. It is of course difficult to procure direct and reliable evidence on such a point, but some recent occurrences in South African waters and others of an earlier date appear to confirm this supposition in a remarkable manner ; for instance, some months ago the captain of the trawler which started fishing operations recently on the Agulhas Bank was startled to find one day that instead of fresh fish he hauled on board a net full of dead fish in an advanced stage of decomposition, and an observer at Knysna near this same region states that it is a not unusual occurrence to find dead and dying fish on the shore. There are also traditions of extensive mortality among the fish in the neighbourhood of Table Bay and on the west and south coasts. If the interpretation, then, of these facts be correct the deposit of green mud is to be regarded as a great ocean graveyard, and constitutes another striking feature of the sea and sea life on the South African coast. The question is one worthy of further investigation and careful observation both from a scientific and practical point of view.

The foregoing is a slight short of the main features of the South African marine fauna. It will have become apparent that for an adequate solution of the scientific and practical problems connected therewith due consideration must be given to the peculiar environment by which it is linked on to the two great oceans of the world, the Indo-Pacific and the Atlantic, as well as to the Antarctic. The most outstanding problems are those connected with the distribution of its diverse forms of life, and these are as yet but vaguely defined and understood.

As the Cape of Good Hope has been, and always will be, the main natural highway between the east and west, and is consequently characterised by the possession of a cosmopolitan population, the result of incursions from the most diverse races, so the sea surrounding its coasts for the same reason, viz., its geographical position, is characterized by forms of life from the most remote regions—from the North Atlantic, the Antarctic and the Indian Ocean, and even an element from the far East.


INDEX MAP OF FLORAL REGIONS OF SOUTH AFRICA
WITH APPROXIMATE BOUNDARIES
BY H. BOLUS 1905
REFERENCE
WESTERN REGION
SOUTH WESTERN REGION
SOUTH EASTERN REGION
KARROO REGION
UPPER REGION
KALAHARI REGION
DO. EASTERN MOUNTAIN PROVINCE.
PORTUGUESE
AFRICA
TRANSVAAL
ORANGE RIVER COLONY
Basuto Land
NATAL
BRITISH
BECHUANALAND
GERMAN
SOUTH WEST
AFRICA
GREAT NAMAQUA LAND
INDIAN OCEAN
ATLANTIC OCEAN
Tropic of Capricorn
Limpopo River
Delagoa Bay
Umvolosi R
Tugela R
DURBAN
St Johns R
Great Kei R
EAST LONDON
Gt Fish R
PORT ELIZABETH
Gamtoos R
KNYSNA
MOSSEL BAY
Gouritz R
False Bay
CAPE TOWN
Cape of Good Hope
Olifants
Port Nolloth
Orange
CALVINIA
KENHARDT
CARNARVON
VICTORIA WEST
BEAUFORT W.
DE AAR
COLESBERG

SECTION IV —BOTANICAL.

1. SKETCH OF THE FLORAL REGIONS OF SOUTH AFRICA.

BY HARRY BOLUS, D.SC., F.L.S.

That branch of botany which is termed plant-geography may be said to be divided into two subordinate parts—(1) the investigation of the distribution of plants, *i.e.*, as to what plants grow in the different countries of the world; and, therefrom, the division of the earth's surface into floristic regions or geographical groups of similar or related plants. This is termed *Geographical Botany.* (2) *Oecological Botany*, or the enquiry into the environment, or the factors of the life-history of plants (in respect of water, heat, light, winds, soils, etc.); and the investigation of their influence, absolutely and comparatively, upon plants in different parts of the world. The latter part can be scarcely touched upon here, except indirectly or in general terms; because it is only in recent years that it has been much worked, its pursuit requiring much time and skill, and many workers; and very little has hitherto been done in South Africa. The recent publication of Schimper's* great work, which will constitute an epoch in this branch of science, will no doubt stimulate research and progress here and everywhere in this respect.

The Flora of South Africa cannot be treated or regarded as a whole. The diversified character of the surface of the country and the difference in the distribution and in the amount of the rainfall are so considerable as to have caused corresponding important differences both in the aspect of the vegetable landscape and in its systematic constituents.

METHODS OF INVESTIGATION.

What is ultimately desired is to present a view of regions, districts or other groups, convenient in size and sufficiently homogeneous in character to facilitate comparison, and to enable the student who cannot visit them all to gather the chief characteristics of each, to pursue further the problems of the local vegetable world, and to investigate its relations to its chief factors. The first step is the taking of a proper botanical census, not, of course, of individual plants, but of the occurrence and stations of those more or less definite forms which we call families or orders, genera and

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* Bibl. App. 47. This and all similar references are to the numbers cited in the Bibliographical Appendix at the end of this paper.

species. Such a census being merely a means to an end may be made upon arbitrary divisions—the smaller the better, compatible with practical possibilities. Fiscal divisions might serve, as counties have been adopted in England, but for the objection that in a new country these are so frequently sub-divided or re-arranged; while to ideal divisions, such as those into squares of one or more degrees of latitude and longitude, there is opposed the difficulty that it would be almost impossible so to demarcate them that the ordinary observer should recognise them. A second requisite is available maps, contoured, if possible, or, at least, of sufficient accuracy and topographical detail. Both censuses and such maps have been or are still imperfect or nearly wanting in South Africa.

There remains another method, viz., to mark out certain areas which, on a rough survey, appear to form or contain natural groups, and to use them, hypothetically, as census-areas. This was the course adopted by Meyer* and Drège.† It is open to the obvious objection which lies in the danger of the tendency to make the facts fit the hypothesis. But it has some countervailing advantages: the larger areas it adopts are better suited to the state of our knowledge, and lend themselves more easily to census-making than smaller divisions; besides that they will probably in the end necessitate fewer or less important changes, though changes must be inevitable in our schemes of plant-distribution in South Africa. Partial censuses of such areas have been made and are still being carried on, but the workers are few. An ideal system of investigation would be the adoption by the schools of the country throughout its whole extent of a series of plant-collections of each fiscal division. These being sent to a central bureau would be tabulated, and would in the course of years, by the stimulus of the love of knowledge and the zeal begotten of a wholesome rivalry, soon yield the richest results. There is no investigator in natural history like the resident. Much as science is indebted to travellers, it is often because they were first in the field and, *ceteris paribus*, it must be evident that the resident in a given district throughout a number of years must have great advantages over the traveller who passes through it once or twice only during a few days or weeks in the year.

Beyond and outside of the difficulties mentioned above is one which is inherent in the subject, viz., that of drawing a line between two adjacent regions which overlap, and where no hard and fast boundary line exists. Thus, to give an example: it seems probable that there are very few regions upon the face of the globe which are adjacent to each other and which yet differ more fundamentally in their constituent elements than do the Floras of the South-western and South-eastern regions of this country. Yet wherever we draw the line between them Nature overleaps it. Let the line be taken at the Van Stadensbergen, we still find south-western types such as Erica, Protea, Leucadendron and others occur, though sparingly, up to and even beyond Kaffraria; on the other hand, many south-

* Bibl. App. 6 and 7. † Bibl. App. 7.

eastern forms, such as *Euphorbia grandidens*, *Encephalartos caffer*, *Strelitziae*, *Angraecum*, *Habenaria*, etc., pass beyond the Van Stadens westward. The search can only be for a line which will give greatest differences on each side of it.

Progress of Investigation.

But in spite of these drawbacks attempts have been made, and must necessarily continue, to form a general estimate of the Flora from the observations of botanical explorers and travellers. We may pass over the fragmentary passages in the writings of Thunberg and Lichtenstein. Burchell* was one of the scientific travellers in this country best equipped by his numerous gifts for careful research. But his results, except plant descriptions, were never worked up, and a valuable "Catalogus Geographicus Plantarum" recording during his extensive journeys the stations and dates of about 8,700 plants, remains to this day in fourteen small volumes of neat manuscript in the Kew Library.

The first to undertake a systematic investigation of the country in this respect was J. F. Drège,† who travelled throughout the Colony from 1826 to 1834, and carefully recorded the stations of a large number of collected plants. These were named and tabulated by Professor Ernst Meyer,‡ and published together with Drège's arrangement of the Colony into regions, with sub-divisions and a map; the whole preceded by a most valuable introductory essay by Meyer. Drège did not travel beyond the limits of the old Cape Colony; his groups require to be extended, and his sub-divisions, although excellent, are too numerous to be treated of in a brief and general survey such as the present. But his work was more systematic than that of any previous or subsequent explorer; it is characterised by clearness of view, thoroughness and honest exactitude, and will probably remain as the foundation of all future investigation.

Other valuable, though less extensive, contributors to our knowledge of the South African Flora were the travellers and collectors Ecklon and Zeyher§ (1826-1836), Krauss|| (1844) and Bunbury** (1838-1840).

Grisebach†† regarded the Colony proper as far eastward as the Kei River as forming one region, which he treated as one, under the name of the "Kap Flora." Eastward of this he brought down the vast "Soudan Region," including the whole of tropical Africa; north of the Orange River he constituted his "Kalahari Region." It is impossible, in my opinion, for reasons which will appear further on, to accept this arrangement as a natural one, more especially as regards his first division.

A. Rehmann,‡‡ an Austrian traveller and botanical collector in South Africa during the years 1875-1880, proposed a division of

* Bibl. App. 1.
† Bibl. App. 6 and 7.
‡ Bibl. App. 6 and 7.
§ Bibl. App. 5.
|| Bibl. App. 8.
** Bibl. App. 11.
†† Bibl. App. 13.
‡‡ Bibl. App. 24.

South Africa which consisted chiefly in the redintegration of Drège's regions, and in the erection of the country about the Knysna and Zitzikamma into a separate "Forest Region." This is by no means an unnatural arrangement; but the tract thus treated is relatively a very small one; other isolated forests occur along the coast eastward; and the author himself appears to admit that, from a systematic point of view, this forest region is more closely allied to the South-western than to the South-eastern (termed by him the "Monsoon") region. Rehmann's collections which were chiefly from Natal and the Transvaal, have been in part worked up and published by Szyszylowicz.*

In 1886† appeared my first attempt to treat the South African Flora as a whole.

In 1894 J. Medley Wood‡ and T. R. Sim § greatly increased our knowledge of the Flora of the South-eastern region by their almost simultaneous publication of catalogues of Natal and Kaffrarian plants, both indispensable to the student of this branch of botany. Drège indeed, and after him Krauss, travelled as far as Natal; but the recorded collections of Wood and Sim are far larger, and show the superiority of the observations of resident collectors over those of travellers.

R. Schlechter,|| made very extensive explorations and large collections throughout South Africa from 1892-1898, from near the mouth of the Orange River on the west to Delagoa Bay on the east, and inland almost to the Limpopo River. He has published descriptions of large numbers of new species, and these are interspersed with much information on the subject of their stations and distribution.

Justus Thode¶ has well investigated the Flora of Kaffraria, Natal and the neighbouring high mountain region of the Drakensbergen, penetrating some of the more difficult country previously untrodden by European botanists, of which he has given a very graphic account. He published the results of his explorations in 1891, 1893, 1901, and gives valuable general views on the natural floral divisions of that region. He divides it into three districts, according to longitude, and each of these into three vertical zones, based on three successive steps of elevation from the coast to the highest plateaux of the last mountain range (the Drakensbergen). He includes these plateaux in the South-eastern Region, of which they are actually on the very boundary. But his observations on the great predominance of the Compositae (27 per cent. of the whole Flora) lead to a doubt whether these mountain-summits should not be more properly included either in our Upper Region, which is referred to subsequently, and of which this predominance forms one of the most marked characteristics; or in the Kalahari Region.

* Bibl. App. 23.
† Bibl. App. 18.
‡ Bibl. App. 38.
§ Bibl. App. 37.
|| Bibl. App. 39, 41, 42.
¶ Bibl. App. 32, 36, 52.

Engler,* in 1902, made a short visit to South Africa and the next year published his views on the distribution of the Flora. He proposed five divisions, of which, however, neither the boundaries nor the relative rank are clearly defined. These are—(1) the South-Western Coast; (2) the South and South-eastern Coast; (3) the Karroo and Roggeveld; (4) the South African Highlands, Orange, Transvaal and Kalahari; (5) the Western Namaqua and Hereroland.

This approaches very nearly to the groups adopted for the arrangement of stations in the later volumes of the Flora Capensis, under the editorship of Sir W. T. Dyer.†

Dr. Siegfried Passarge‡ made, in 1896-1898, extensive journeys in the middle Kalahari. Though the official object of his travel was of an economic-geological character, he made a large series of strictly scientific investigations which have been published in two portly volumes of text and numerous maps. These are chiefly geological; but there is added a considerable chapter on the plant-geography of that region, which is replete with observations, and bears witness to the remarkable energy and industry of the author under circumstances of great difficulty and hardship. In this he treats of the distribution-areas of the whole of Southern Africa, following Engler substantially in his divisions (though under a modified nomenclature). The chief difference is that he unites Engler's sub-province of the "Karroo and Roggeveld" with the vast Kalahari Region—the latter being again sub-divided.

O. Stapf‖ has proposed (1904) as a result of his masterly study of South African grasses,§ the division of the country into five provinces. The arrangement of these is in several respects very different from any previously put forward. The author, however, expressly states that the grouping is made "so far as regards the grasses," and that each province "possesses, on the whole, a characteristic Grass-flora." The investigation, therefore, although a contribution to the knowledge of our Flora of the greatest value, must be regarded as supplying the data for one element only out of many necessary for the consideration of the Flora as a whole; and must be correlated with other facts—the relative importance of which is as yet unknown.

During 1884–1886 Dr. H. Schinz¶ travelled in German West Africa, and even extended beyond it eastward as far as Lake Ngami. He has since published a series of numerous papers upon the general features of that country, and descriptions and lists of a large number of plants collected therein. These, of which the publication dates extend from 1887–1904, form the most important contribution to our knowledge of the western part of the Kalahari Region.

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* Bibl. App. 53.
† Bibl. App. 37.
‡ Bibl. App. 59.
‖ Bibl. App. 56.
§ Bibl. App. 48.
¶ Bibl. App. 17, 21, 22, 25, 30, 44.

Divisions Proposed.

I propose to arrange the South African Floral Regions as follows :

I. The Western Coast Region.
II. The South-Western Coast Region.
III. The South-Eastern Coast Region.
IV. The Karroo Region.
V. The Upper Region.
VI. The Kalahari Region.

I. The Western Coast Region.

This consists of a littoral strip along the west coast beginning at the Olifant's River, and with a width of probably from 40 to 60 miles, northward as far as the tropic, or beyond our limits. Its width is to be determined by the distance of the higher mountains from the coast, which varies. In Little Namaland the coast rises gradually from Port Nolloth to Annenous, a distance of some 45 miles, and then ascends the mountains somewhat steeply to Klipfontein, which is about 3,000 feet above the sea. Here we have a different Flora, and these mountains form there the eastern boundary of the region. This is given as an instance, within my own knowledge, of what is probably the case, in a general sense, throughout the whole tract ; for we know that there, as elsewhere, throughout South Africa, the country rises from the coast towards a range, or successive ranges, of mountains, which are not, however, always continuous, nor always equidistant from the coast.

The intervening country, in the part I have mentioned, is composed of low rolling hills, sandy near the sea coast and more clayey or of reddish sand nearer the mountains. According to the geological maps these are of the Schistose rocks of the "Pre-Cape Series" (Rogers), with gneiss.

Very little is known of the climate of the region except in the Colonial part between the Olifant's and Orange rivers. We have rain returns from three stations (Buchan*).

Rain-Fall, Western Region.

	Altitude above Sea.		Mean Annual Fall for 10 years.		Mean Annual Fall during 6 winter months.		Mean Annual Fall during 6 summer months.	
	metres	feet	milli-metres	inches	milli-metres	inches	milli-metres	inches
Port Nolloth ..	12	(40)	62	(2.45)	48	(1.91)	13	(0.54)
Van Rhyn's Dorp ..	123	(400)	158	(6.24)	129	(5.11)	28	(1.13)
Ebenezer	30	(100)	117	(4.64)	97	(3.84)	20	(0.80)

* Bibl. App. 46.

These show the rainy period, poor as it is, to be chiefly in the winter. But the whole coast in this part is subject to frequent fogs, which probably would not condense into a raingauge, but would collect upon the vegetation. When I visited Port Nolloth in August, and again in September, 1883, I found the atmosphere very humid, although there was no rain.

Temperature.

Our data for this are few :—

	Altitude.	Number of years.	Absolute Maximum.		Absolute Minimum.	
	metres.		C.	(Fahr.)	C.	(Fahr.)
Port Nolloth ..	12	9	40.0	(104.0)	0.0	(32.0)
Van Rhyn's Dorp ..	123	3	42.4	(108.4)	1.6	(34.9)

The aspect of the country between Port Nolloth and the mountains is, in most years, extremely desert-like, and very similar to that of the drier parts of the Karroo Region. Nevertheless there are occasional good seasons, with rain considerably above the average, every seven or ten years. In such years (as when I was there) the spring flowers, and especially annuals, are numerous ; the small shrubs, mostly from 4 to 6 feet high, flower also ; but the stunted growth and many dead branches of the latter bear evidence of the severity of many years of drought.

The plant-forms of the Region do not seem to be very numerous. But there is one which is of special interest, viz., the celebrated *Welwitschia mirabilis Hook. f.* (of the Order Gnetaceæ), of which little need be said, since so many writers have dwelt upon its remarkable characters.* Trees are extremely few, so far as we know, certainly there were none near Port Nolloth ; *Tamarix usneoides* is said only to begin to appear near the Orange River ; while *Acacia albida* and *A. giraffae, Combretum primigenium* and *Euclea pseudebenum*, are reported as occurring in the waterless-bed of the Kuisib River, near Walwich Bay (Engler†).

Systematic Constituents of the Flora.

Our records of the systematic elements of the Flora of the Region are almost too scanty for publication. This is partly owing to the insufficient localisation of their plants by collectors ; partly to the smallness of the area really explored, and partly to our own defective records. Such as they are they are presented here, until better material shall become available :—

* Christ (Bibl. App. 43) wrltes of it as the " oldest imaginable Phanerogam " ; but, by other authorities, it is regarded as younger than the Cycads or even, perhaps, than the Conifers.

† Bibl. App. 53 (p. 57).

	Orders.	Genera.	Species.
Native Phanerogamia :			
Dicotyledons	55	193	541
Gymnosperms	1	1	1
Monocotyledons	7	45	114
Total ..	63	239	656

Proportion of Monocotyledons to Dicotyledons, 1 : 4.7.
Proportion of genera to species, 1 : 2.7.

Predominating Orders—Western Region.

	Number of Species.	Per cent. of the whole.
1. Compositae	150	22.9
2. Scrophulariaceæ	76	11.6
3. Gramineæ	44	6.7
4. Ficoideæ	34	5.2
5. Leguminosae	30	4.9
6. Liliaceæ	29	4.4
7. Geraniaceæ	23	3.6
8. Iridaceæ	23	3.6
9. Acanthaceæ	18	2.7
10. Selaginaceæ	18	2.7
11. Euphorbiaceæ	17	2.6
12. Labiatæ	14	2.1
13. Crassulaceæ	12	1.8
14. Campanulaceæ	12	1.8
15. Cyperaceæ	11	1.7
16. Zygophyllaceæ	11	1.7
17. Boraginaceæ	10	1.5
18. Amarantaceæ	10	1.5
19. Sterculiaceæ	9	1.4
20. Asclepiadaceæ	9	1.4
21. Chenopodiaceæ	8	1.2
22. Cruciferæ	7	1.1

The following are the remaining Orders arranged according to the number of species of each :—Loranthaceæ (6 species) ; Solanaceæ, Thymelæaceæ, Amaryllidaceæ (5 each) ; Anacardiaceæ, Ebenaceæ (4 each) ; Sapindaceæ, Rosaceæ, Umbelliferæ, Santalaceæ, Verbenaceæ, Rubiaceæ (3 each) ; Hydrophyllaceæ, Lentibulariaceæ, Cucurbitaceæ, Polygonaceæ, Capparidaceæ (2 each) ; Menispermaceæ, Papaveraceæ, Frankeniaceæ, Caryophyllaceæ, Tamaricaceæ, Elatinaceæ, Malvaceæ, Burseraceæ, Saxifragaceæ, Onagraceæ, Loasaceæ, Geraniaceæ, Celastraceæ, Combretaceæ, Plumbaginaceæ, Gentianaceæ, Bignoniaceæ, Pedalinaceæ, Plantaginaceæ, Cytinaceæ, Urticaceæ, Gnetaceæ, Haemodoraceæ, Juncaceæ (1 each).

The following is a list of the larger genera arranged in numerical order :—Senecio (16) ; Othonna, Sutera (15 each) ; Manulea, Euphorbia (13 each) ; Pelargonium, Crassula, Mesembrianthemum, Nemesia (11 each) ; Oxalis (10) ; Hermannia, Selago, Ornithogalum (9 each) ; Zygophyllum, Lotononis, Helichrysum, Eriocephalus, Aristida, Eragrostis (8 each).

II. The South-Western Coast Region.

The South-western Region comprises the oldest part of the Colony, and has been more explored, botanically, than any other. A glance at the index map will show that it is an angular littoral strip of about 500 miles in length, by an average width of about 50 miles, beginning at the Olifant's River on the north-west and terminating at the Van Staden's Mountains on the extreme east. Inland from the coast the whole area rises by successive steps marked by mountain ranges. Each range by its effect upon the rainfall, in the sense of a diminution, causes a successive change in the vegetation. The higher mountain ranges, called successively (beginning at the north and proceeding southward and then eastward) the Giftberg, Nardouw, Cederbergen, Cold Bokkeveld, Hex River-bergen, Zwartbergen, Baviaan's Kloof-bergen, Elandsbergen and Van Stadensbergen form the inland boundary which divides this Region from the Karroo.

Drège carried its eastern boundary as far as the Sundays River, about 35 miles further eastward than the Van Staden's range. The difference is not a very important one, but I have preferred on this point to follow the views of Ecklon,* Krauss† and Bunbury,‡ who all dwell upon the striking change in the floristic character of the vegetation in the country in that neighbourhood, which I can confirm from personal observations and collections in the field.§

Climate.

In this region, as elsewhere throughout South Africa, the predominant factor of the vegetation is water, *i.e.*, the rainfall, both in regard to its quantity and its periodicity. The following table, compiled from the reports of the Meteorological Commission, includes stations of some of the chief towns of the Region. Their order begins from the north and proceeds towards the south and east. The record is for a period of ten years, showing the total mean fall; and also the mean fall during the six summer months (October—March, inclusive) and during the six winter months. The altitude of each station is appended :—

* Bibl. App. 5. † Bibl. App. 8. ‡ Bibl. App. 11.

§ Amongst the Regions adopted for the purpose of grouping the stations of plants in the 6th vol. of Dyer's "Flora Capensis" (1896-1897) is the "Coast Region," which answers to our South-western Region, except that it extends very much further eastward, viz., to the Kei River. It is true that the grouping there adopted makes no pretension to be a natural one, and has apparently been chosen as affording the convenience of a well-marked river course. But its import may, and probably will, be misunderstood and lead to erroneous ideas; and, in any case, it is to be regretted as uniting under one name two such completely distinct Floras as that of the western extremity of the Colony, and that of King William's Town and Komgha, which approach closely to that of Natal.

RAINFALL—SOUTH-WESTERN REGION.

	Altitude above Sea.		Mean Annual Fall for 10 years.		Mean Annual Fall during 6 winter months.		Mean Annual Fall during 6 summer months.	
	metres	feet	milli-metres	inches	milli-metres	inches	milli-metres	inches
Clanwilliam ..	75	(245)	239	(9.41)	188	(7.43)	50	(1.98)
Piquetberg ..	215	(700)	567	(22.36)	445	(17.55)	122	(4.81)
Ceres	459	(1,493)	1,057	(41.65)	851	(33.54)	205	(8.11)
Worcester ..	240	(780)	296	(11.69)	214	(8.44)	82	(3.25)
Paarl	153	(500)	887	(34.95)	724	(28.54)	162	(6.41)
Cape Peninsula :								
Town House ..	27	(88)	605	(23.84)	474	(18.70)	130	(5.14)
Platteklip ..	169	(550)	1,184	(46.65)	926	(36.48)	258	(10.17)
Table Mountain	953	(3,100)	1,574	(61.97)	1,168	(46.00)	405	(15.97)
R. Observatory	12	(40)	709	(27.95)	562	(22.14)	147	(5.81)
Rondebosch ..	30	(100)	1,126	(44.34)	909	(35.79)	217	(8.55)
Wynberg ..	76	(250)	1.077	(42.43)	893	(35.16)	184	(7.27)
Caledon	233	(760)	296	(20.44)	348	(13.73)	170	(6.71)
Swellendam ..	153	(500)	519	(35.09)	437	(17.32)	451	(17.77)
Ladismith ..	569	(1,850)	393	(15.48)	191	(7.52)	202	(7.96)
Riversdale ..	129	(420)	494	(19.47)	254	(10.01)	240	(9.46)
Oudtshoorn ..	335	(1,090)	264	(10.42)	145	(5.71)	119	(4.71)
George	246	(800)	899	(35.43)	413	(16.29)	486	(19.14)
Knysna	9	(30)	713	(28.09)	342	(13.47)	371	(14.62)
Humansdorp ..	110	(360)	691	(27.21)	347	(13.69)	343	(13.52)
Van Staden's River	304	(988)	830	(32.70)	405	(15.96)	425	(16.74)

The foregoing table exhibits clearly, first, the gradual change in the periodicity of the rainfall as we proceed from the west towards the east. Whereas in the west the winter fall largely predominates, in the east the fall of the two seasons is nearly equal.* Secondly, it will be noted by consulting the map annexed, that every station northward, or further inland, shows a much reduced rainfall as compared with that of the Cape Peninsula, and the southern coast generally.

Temperature.—The following table shows in a condensed form the most important facts under this head. The altitude of each each station above the sea has, of course, an important influence ; but in this Region, the distance from the coast has probably a still

* In the map accompanying Stapf's paper already cited,† the author has applied to the tract of country lying between Mossel Bay and Humansdorp the term "Vorwiegend Sommerregen" (preponderating summer rains). To a certain extent this is literally true. But in how small a degree will be seen in the following list of stations throughout that tract, showing the proportion of the summer rainfall to the winter fall, expressed in millimeters : George, 486 to 413 ; Knysna, 371 to 342 ; Humansdorp, 343 to 347 ; Van Staden's River, 425 to 405 ; and at Port Elizabeth, 25 miles further eastward, the summer rains again decrease, being as 242 to 283 (based upon Buchan's ten-year period).

† Bibl. App. 56.

greater. The absolute maximum and minimum, as is observed by Schimper, are of greater moment to the life of plants than the mean annual temperature, which is usually cited.

TEMPERATURE—SOUTH-WESTERN REGION.

	Altitude.	Number of years.	Absolute Maximum.		Absolute Minimum.	
	metres.		C.	(Fahr.)	C.	(Fahr.)
Clanwilliam	75	12	44.4	(112.0)	−1.9	(28.5)
Ceres	459	12	40.5	(105.0)	−3.3	(26.0)
Worcester	240	12	40.8	(105.5)	−1.1	(30.0)
Hopefield	42	6	43.3	(110.0)	−1.1	(30.0)
Cape Town	34	11	40.0	(104.0)	1.3	(34.5)
Royal Observatory	12	18	39.7	(103.5)	−.55	(31.0)
Wynberg	76	6	42.2	(108.0)	2.7	(37.0)
Caledon	233	4	39.4	(103.0)	.05	(32.1)
Oudtshoorn ..	335	1	42.7	(109.0)	−2.7	(27.0)
Knysna	9	1	36.3	(97.5)	3.8	(39.0)
Van Staden's River	304	5	40.8	(105.5)	0.0	(32.0)

Edaphic Influences upon Vegetation.

The influence of the nature of the soil upon the vegetation in South Africa has, as yet, been very little investigated. That individual plants, or even species, are, in certain respects, so affected, is undoubted. But I speak of it here in a wider sense, viz., as to its influence upon the distribution of the larger groups such as genera and natural Orders. The Proteaceæ, for instance, seem chiefly to prefer the geological formation known as the Table Mountain Sandstone. This formation traverses, more or less interruptedly, the whole Colony, from the Bokkeveld Mountains to the Cape Peninsula and thence to Port Elizabeth. Throughout its entire length the Proteaceæ appear at short intervals, and often accompanied by other plants (Rutaceæ, Ericaceæ, Restionaceæ) which are characteristic of the Cape Peninsular Flora or of that of the South-western Region. At Port Elizabeth, however, the formation enters the sea, and with a wide curve re-appears at the mouth of the St. John's River (Rogers*), and thence extends eastward through Pondoland towards Natal. Upon this Rogers† observes :—" The change in the character of the vegetation on passing from the Table Mountain Series to another formation is usually very sharply defined. From the Bokkeveld Mountains right round the great sandstone mountains of the folded belt, the same or similar shrubs and flowers are found. A most striking contrast to anyone who is even slightly acquainted with the vegetation of the western mountains is seen on passing from the Karroo‡ formation in Pondoland

* Bibl. App. 60 (p. 106).
† Bibl. App. 60 (p. 118).
‡ This refers to the Karroo in a geological, not in a botanical, sense.—H.B.

to the strip of country near the coast formed by the Table Mountain Sandstone; leaving the monotonous grass-veld of the interior of Pondoland one meets with the same flowers and small shrubs that are abundantly found on the western mountains. It is difficult to understand how such an outlier can be clothed with the same vegetation as the main area by a process of colonisation and selection by the soil; probably the plants of the Pondoland coastal plateau arrived there when the sandstone was still connected with the western ranges by the more or less rectangular strip, corresponding to the bent ranges round the Warm Bokkeveld, that may still exist off the south-east coast between the Gualana and St. John's rivers." The author's supposition of the origin of the Flora of that tract is probably correct. But the question remains, do the Proteaceæ and other associates not grow indifferently upon some other geological formation? Marloth has found them upon the Witteberg Series near Matjesfontein in the Karroo; and they extend to the Drakensbergen in Natal, but on what geological formation or soil is not stated. Respecting the former, Rogers* remarks:—"The resemblance between the Witteberg quartzites and the Table Mountain Beds was the cause of much confusion in the early days of Cape geology, but it is more apparent than real."

Other instances have been seen by the writer, of identical species growing on the same geological formation, separated by intervals of 100-200 miles, as Gazania sp., and *Aristida brevifolia, Steud.* (the Twa-Grass),† which occur in Bushmanland and near Prince Albert, in both cases on the Ecca Beds. Again, *Hyobanche atropurpurea mihi*, a rare species, has only been collected in three specimens in three distant stations—Table Mountain, Winterhoeksberg, and on the Zwartberg range near Prince Albert, all on the Table Mountain Sandstone. But though it may be possible, or even probable, that these plants are confined to the geological areas mentioned, yet it is far from certain.

The whole subject needs far more thorough investigation, and even experimental observation by cultivation.

Plant Formations.

The chief formation of the Region is what is termed by Schimper, woodland of the "shrub-wood" or "bush-wood" type, in some parts the two are intermingled. Here and there occur tracts of grass-lands, but of no great extent. The height and size of the bush increases generally towards the eastern extremity. The true small forest tract is reached near the Knysna and the Zitzikamma.

* Bibl. App. 60 (p. 138).

† Of this grass, Drège drolly observes that it is a "grass affording pleasant nutriment equally to cattle and sheep, termites and Bushmen. There is no grass on which the first-named fatten more quickly; while the ants collect the grain, of which they are robbed by the Bushmen."

Thousands of square miles are covered by more or less detached clumps of dwarf shrubs or small bushes, ranging in height from 2 to 8 feet. For the most part the foliage of these is of the sclerophyllous type, is of a mournful dark green or greyish hue, and is characterised by " a smaller surface but proportionately thicker, more leathery, fleshy, or rudimentary and caducous " (Schimper,* who also speaks of the strong resemblance in this respect of our coast Flora to that of the sclerophyllous Wood-land of the Mediterranean coast). The majority of these shrubs have leaves of the *pinoid* or of the *ericoid* type, often with revolute margins, as is so frequent in the Ericaceæ ; but there are also some with broader leaves, in that case usually either leathery or clothed with so dense a pubescence on one or both surfaces that transpiration is greatly hindered or retarded (*e.g. Leucadendron argenteum, Helichrysum* and *Helipterum*, many species). The leaves also, when broader, are often not " placed with their flat surfaces perpendicular to the strongest light, but usually avoid it by assuming an oblique or parallel position " (Schimper)†. This is strikingly illustrated in many of our Proteaceæ, as in *Protea grandiflora* and others ; the " set " of the leaves is almost exactly as in the Australian Eucalypti and Acaciae so commonly planted in the Colony, and which inhabit a similar climate.

The shrubs of this Formation are of numerous and very diverse Orders and genera, of which only a few can be mentioned, as *Polygalaceæ* (Polygala, Muraltia) ; *Rutaceæ* (Macrostylis, Diosma, Coleonema, Agathosma, many) ; *Rhamnaceæ* (Phylica, many) ; *Leguminosæ* (Cyclopia, Borbonia, Amphithalea, Lebeckia, Aspalathus, many, Indigofera) ; *Rosaceæ* (Cliffortia) ; *Bruniaceæ* (Berzelia, Brunia, Staavia) ; *Ficoideæ* (Acrosanthes, Pharnaceum, Coelanthium, Adenogramma, Mesembrianthemum) ; *Rubiaceæ* (Anthospermum, Nenax, Carpacoce) ; *Compositae* (many genera and species ; the most abundant are Pteronia, Aster, Felicia, Helichrysum, Metalasia, Eriocephalus, Athanasia) ; *Ericaceæ* (Erica, large numbers of species and individuals ; also Grisebachia, Simochilus, Sympieza, Scyphogyne, Salaxis) ; *Selaginaceæ* (Selago, etc) ; *Proteaceæ* (several species of seven genera) ; *Thymelaeaceæ* (Passerina, Chymococca, Cryptadenia, Lachnaea, Struthiola, Gnidia) ; *Santalaceæ* (Thesium, many species) ; *Euphorbiaceæ* (a few species).

Intermingled with these shrubs is a great variety of other plant-forms : annuals, herbaceous perennials, succulents, monocotyledons with conspicuous or small petaloid flowers, glumaceous plants, etc.

Inland, and especially in the long valleys which lie between the parallel ranges of mountains grows in great abundance, sometimes subsocially, the notorious *Elytropappus rhinocerotis Less* (Vern. " Rhenosterbosch "), a plant which no animal seems to touch, covering vast stretches of country, hated by the farmers, yet characterised by Drége‡ as " that index of a more fertile and

* Bibl. App. 47 (pp. 507-527). † Bibl. App. 47 (p. 510).
‡ Bibl. App. 6 (pp. xxi., xxvi.).

fundamentally moist soil," and, again, as "by its greater luxuriance presaging future harvests to the Colonists." Still further inland, the country becomes gradually drier, approaching the Karroo in appearance, with an increasing number of succulent plant-forms; until ascending the higher mountain ranges forming the boundary lines of the Region (the Zwartbergen and others) we again meet, often in abundance, as on the Zwartberg Pass, with the last of the Ericae, Proteaceæ, Restiaceæ and other typical south-western plants; and, descending northward, finally leave them and enter the true Karroo.

In certain parts of the Region, about or between Caledon and Swellendam, there are considerable grassy tracts with thinner bush, yet hardly Grass-land proper; and possibly due, in part at least, to edaphic influences.

A feature of some importance is the number of clumps of tall Restionaceæ (Restio, Thamnochortus, etc.) which occur at intervals, chiefly however more prominent towards the west. *Cannamois cephalotes, Beauv*, and *Elegia verticillaris, Kunth*, attain a height of 8 to 12 feet or more in mountain ravines, and the former, growing subsocially, forms thickets sometimes difficult of penetration.

Annuals are less abundant in individuals than in European countries, not being everywhere prominent. This seems to be chiefly due in many cases to their small size, as well as to their smaller numbers; nevertheless there are exceptions, and nowhere are they entirely absent. Schimper,* on the authority of Scott-Elliot,† says that "Annuals appear to be wanting." But this is a grave error. I have compiled a list of annuals growing on the Cape Peninsula only, all undoubtedly indigenous. It reaches 197 species, out of a total of 2,117 species of flowering plants on the Peninsula; and, of course, would be much larger for the whole South-western region. It includes eighty genera of twenty different Orders. Amongst the genera with more than six species are:—Heliophila (16); Crassula and Sebaea (each 12); Senecio and Nemesia (each 9); Lobelia, Harveya and Scirpus (each 7). The more abundant and prominent species are *Heliophila pusilla* and *dissecta, Grammanthes gentianoides, Mesembrianthemum criniflorum* and *pyropaeum, Charieis heterophylla, Felicia tenella, Cotula turbinata, Senecio arenarius, Gymnodiscus capillaris, Venidium hirsutum, Dimorphotheca pluvialis, Sebæa aurea* and *S. albens, Belmontia cordata, Hemimeris montana, Nemesia barbata, Manulea Cheiranthus.*

Further eastward in this Region are many more, but considerations of space forbid detail.

Forests occur only in the extreme eastern portion of the Region, viz., in the districts of Knysna and Humansdorp (Zitzikamma).

* Bibl. App. 47, p. 526.

† Bibl. App. 27 (p. 243), Scott-Elliot's words are even more emphatic. He says:—"There is apparently not a single undoubtedly indigenous annual in the South-western Flora."

The trees forming them are chiefly of the genera Scolopia, Doryalis, Kiggelaria, Vepris, Ekebergia, Apodytes, Ilex, Gymnosporia, Cassine, Pterocelastrus, Elaeodendron, Scutia, Ptaeroxylon, Rhus, Virgilia, Cunonia, Olinia, Cussonia, Curtisia, Canthium, Burchellia, Rapanea, Sideroxylon, Olea, Nuxia, Chilianthus, Ocotea, Celtis, Podocarpus (the most abundant). Small forests are found in most of the deep mountain ravines facing the sea, along the whole Region, but these are, for the most part, of small extent and little economic importance. In the extreme north-west on the Cederbergen, Clanwilliam, are still found a few trees of *Callitris juniperoides L*, the sole remains of a thin, but once extensive, forest. It had been nearly exterminated, but has since been largely replanted by the Government. Another species (*C. Schwarzii Marloth*) has lately been discovered in the Uniondale district on the Kouga Mountains, where it is said to attain a height of 40–50 feet.

Aquatic plants are not numerous, since surface water throughout the whole area is deficient, as compared with many other countries. The following species may be mentioned, somewhat in the order of their frequency :—*Prionium palmita*, E. Mey. ; *Aponogeton distachyon*, Linn. f., and *A. angustifolium*, Ait. ; *Cyperus fastigiatus*, Rottb., and *C. textilis*, Thunb. ; *Crassula natans*, Thunb. ; *Typha capensis*, Rohrb., and *T. australis*, Schum. ; *Oxalis natans*, L.f. ; *Dipidax triquetra*, Baker ; *Hypoxis aquatica*, L.f. ; *Scirpus fluitans*, Linn., and *S. capillifolius*, Parl. ; *Wachendorffia thyrsiflora*, Linn. ; *Nymphaea stellata*, Willd. ; *Limnanthemum Ecklonianum*, Griseb. ; and a few others.

Sociable Plants.

These, in a strict sense—*i.e.*, growing to the exclusion of all others—are, so far as is known to me, absent from South Africa. A few of those, which, from their numbers and contiguity, may be called sub-social may be named as *Podalyria calyptrata, Elytropappus rhinocerotis, Erica hirtiflora, Protea incomta, Leucadendron argenteum, Bobartia filiformis, Watsonia rosea*, and *W. augusta, Aponogeton distachyon, Elegia parviflora.*

Plant Forms.

The numerous plant-forms of the Region cannot all be enumerated here. It must suffice to intimate that the Olive-, Protea-, Myrtle-, and Heath-forms are the most prevalent forms of shrubs and bushes ; that succulents, in various forms, abound ; the Agave-form in numerous aloes ; the Aroid-form in the wide-spread *Zantedeschia aethiopica*, Spreng. (Richardia) only ; the Thorn-bush-form is not abundant, but occurs occasionally. The Bulb-form is ubiquitous—in water and on land, on mountains, valleys and plains, isolated or occasionally (as in Bobartia and Watsonia) in dense masses ; they chiefly belong to the Orders Iridaceæ, Amaryllidaceæ and Liliaceæ. The Reed-Grass-form is abundant in the larger Restiaceæ, Phragmites, Typha, etc. ; the Bromelia-form in the Prionium ; the

Dwarf-Palm-form in the Cycad Encephalartos, which just makes its appearance on the eastern edge of this Region, near Jagersbosch.

Lianes are few, chiefly of the Orders Ampelidaceæ and Asclepiadaceæ (Secamone).

Epiphytes, confined to Orchidaceæ, only occur in the forest country from Swellendam eastward. They consist of but one Polystachya and three small species of Angraecum.

Parasites.—Amongst these are three species of Cuscuta, five species of Viscum, widely distributed, and one Loranthus.

Root-parasites.—These are numerous both in species and individuals. They occur chiefly in the Scrophulariaceæ: Melasma, 4 species; Striga, 1 species; Harveya, 13 species, of which some, as *H. stenosiphon* (abundant on the Langebergen near Swellendam) and *H. Bodkinii* (on the Skurfdebergen) are of striking beauty and brilliancy; Hyobanche, 4 species. In Rafflesiaceæ: *Cytinus dioicus*, Juss.

Alpine Plant-Forms—Perennial Rosette-Plants*.—This is Schimper's† term for a well-marked and familiar form which, in South Africa also, occurs on many of the higher mountains. Marloth‡ has drawn attention to these in an interesting paper. He mentions several species and figures two (*Psammotropha frigida*, Schltr., and *Felicia bellidioides*, Schltr.). A more widely-distributed one is *Mairea crenata*, Nees; another, recently found, is *Leyssera*, n.sp., on Matroosberg at 6,500 feet.

Alpine Plant-Forms.—Cushion Plants.—Marloth § enumerates several, of which the most singular is *Bryomorphe Zeyheri*, Harv., which is by no means restricted to Matroosberg. Few plants are more striking than the large cushions of *Pelargonium violareum*, Jacq., which are from 1–2 feet or more, in diameter, and covered with scores of the most brilliant flowers.

Pollination of Plants.

The great majority of the plants of this Region are without doubt anemophilous; next in order are the entomophilous. The subject is only mentioned here to record some interesting recent observations on ornithophily. Darwin suggested the fertilisation of *Strelitzia reginae* by birds. Scott-Elliott|| has given a list of twenty-five plants visited by various species of sun-birds. Evans** has observed it in two species of Loranthus in Natal; and Marloth†† in several other species in this Region.

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* The general reader is cautioned against the supposition that the term "Alpine" is here used to indicate any systematic relationship with the Flora of the European Alps. It is used simply to identify a common plant-form produced upon many mountains in different parts of the globe, resulting from similar or identical climatic factors. Speaking broadly, the absence of European species and the rarity even of European genera is one of the most striking characteristics of the mountain Flora of South Africa.

† Bibl. App. 47, pp. 705–7.

‡ Bibl. App. 50.

§ Bibl. App. 50.

|| Bibl. App. 28, 29.

** Bibl. App. 34.

†† Bibl. App. 51.

Introduced Plants.

There is no adequate record of the number of these throughout the Region. Most of those which occur are European weeds of cultivation. On the Cape Peninsula alone (where the greatest concentration of all species of the Region appears to exist), 179 species of introduced plants, including all which are in any degree doubtful, have been recorded,* out of a total of 2,296 flowering plants. This proportion is probably much larger than that of the whole Region. The number of those which, by their multiplication or noxious character, have become harmful is comparatively small.

Systematic Constituents of the Flora.

For the discussion of any Flora, either absolutely or for the purpose of comparison with other Regions, it is necessary to present statistics. The following lists of the plants of this and of the other Regions to be treated have been in preparation during many years. They are not and, of course, cannot be complete, but they are doubtless more comprehensive than any yet published. They are here necessarily restricted to summaries of Orders, of the largest genera, and of totals of recorded species :—

Native Phanerogamia :	Orders.	Genera.	Species.
Dicotyledons	92	548	4,279
Gymnosperms	1	2	5
Monocotyledons	17	155	1,301
Total ..	110	705	5,585

Proportion of Monocotyledons to Dicotyledons 1 : 3.29.
Proportion of genera to species .. .. 1 : 7.9.

Predominant Orders—South-Western Region

	Number of species.	Per cent. of the whole.
1. Compositæ	821	14.7
2. Ericaceæ	489	8.8
3. Leguminosae	468	8.4
4. Iridaceæ	282	5.0
5. Proteaceæ	254	4.5
6. Restionaceæ	210	3.8
7. Liliaceæ	209	3.7
8. Ficoideæ	194	3.5
9. Gramineæ	193	3.5
10. Geraniaceæ	188	3.4
11. Scrophulariaceæ	179	3.2
12. Cyperaceæ	179	3.2
13. Orchidaceæ	175	3.1
14. Rutaceæ	160	2.9
15. Campanulaceæ	139	2.5
16. Crassulaceæ	104	1.9
17. Selaginaceæ	95	1.7
18. Thymelaeaceæ	83	1.5
19. Cruciferæ	82	1.5
20. Polygalaceæ	81	1.5
21. Umbelliferæ	69	1.2
22. Rhamnaceæ	69	1.2
23. Rosaceæ	60	1.0

* Bibl. App. 5..

The following are the remaining Orders arranged according to number of species of each :—Amaryllidaceæ (56 species); Boraginaceæ (54); Santalaceæ (53); Bruniaceæ, Asclepiadaceæ (51 each); Sterculiaceæ (43); Euphorbiaceæ (42); Labiatæ (41); Gentianaceæ (38); Anacardiaceæ, Rubiaceæ (33 each); Celastraceæ (27); Solanaceæ (24); Juncaceæ (22); Ebenaceæ, Malvaceæ, Acanthaceæ (20 each); Zygophyllaceæ, Caryophyllaceæ (19 each); Naiadaceæ (17); Verbenaceæ (16); Penaeaceæ (15); Plumbaginaceæ, Convolvulaceæ (14 each); Haemodoraceæ (11); Polygonaceæ, Ranunculaceæ (10 each); Droseraceæ (9); Chenopodiaceæ, Oleaceæ (8 each); Dipsaceæ, Loranthaceæ, Sapindaceæ, Urticaceæ, Myricaceæ (6 each); Papaveraceæ, Bixaceæ, Apocynacceæ, Plantaginaceæ, Coniferæ (5 each); Lauraceæ, Onagraceæ, Cucurbitaceæ (4 each); Capparidaceæ, Violaceæ, Linaceæ, Saxifragaceæ, Halorrhagidaceæ, Lentibulariaceæ, Dioscoreaceæ, Commelinaceæ (3 each); Menispermaceæ, Frankeniaceæ, Tiliaceæ, Ampelidaceæ, Hamamelidaceæ, Valerianaceæ, Myrsinaceæ, Amarantaceæ, Cytinaceæ, Balanophoraceæ, Scitamineæ (2 each); Nymphæaceæ, Resedaceæ, Pittosporaceæ, Elatinaceæ, Hypericinaceæ, Meliaceæ, Combretaceæ, Myrtaceæ, Lythraceæ, Araliaceæ, Cornaceæ, Primulaceæ, Hydrophyllaceæ, Orobanchaceæ, Gesneriaceæ, Bignoniaceæ, Myoporaceæ, Nyctaginaceæ, Illecebraceæ, Piperaceæ, Salicaceæ, Hydrocharidaceæ, Xyridaceæ, Typhaceæ, Araceæ, Cycadaceæ (1 each).

It will be at once noticed that the facts which distinguish this list; and the Flora of this Region are, first, the prominent position of the Orders Ericaceæ, Proteaceæ, Restionaceæ, Geraniaceæ, Rutaceæ, Ficoideæ; secondly, the comparatively low position of Gramineæ and Cyperaceæ; thirdly, the great scarcity of Rubiaceæ, Myrtaceæ, Asclepiadaceæ and Acanthaceæ, as compared with the neighbouring Regions.

It is to be noted that there are many species of South African plants which have been published without any adduced locality beyond "South Africa" or "Cap Bonae Spei." In the majority of cases it has been impossible to place these in any Region. They are most numerous in Liliaceæ, and though the species in this Order appear to have been unduly multiplied, yet its rank in the foregoing list, if all localities were known, would probably be raised to the fifth or sixth place.

The considerable number of large genera is noteworthy. The following are arranged in numerical order :—Erica (405 species); Aspalathus (154); Mesembrianthemum (128); Senecio (98); Oxalis (96); Restio (91); Pelargonium (84); Crassula (81); Agathosma (78); Helichrysum (76); Disa (72); Phylica (67); Heliophila (61); Protea (60); Muraltia (58); Ficinia (57); Serruria (54).

Comparisons with other Regions.

The affinities of the Flora of this Region with that of Australia, especially of South-Western Australia, are very striking, and have already been pointed out by Sir. J. D. Hooker.* The reader must be referred to his work for further details, and I may perhaps be permitted also to refer to some notes of my own on the subject in previous essays.† Bentham also points out the remarkable affinities in the Compositæ in his well-known revision of that Order (*Journ. Linnean Soc.*, vol. 13, pp. 552 ff.). The hypothesis of Hooker of a common origin of the Australian and South-West African Floras, derived from ancestors inhabiting a vast antarctic continent of which the greater part has been submerged ; and that during the ages which have succeeded the severance of the continents the two Floras have become differentiated as we now know them, does not appear to have attracted the attention it deserves, even from those botanists who have perceived the close relationship of these two Floras. Yet some additional evidence has been accumulated in its favour since it was put forward. In reading the remarks of Rogers cited above (p. 209) on the occurrence of South-western Cape plants in Pondoland at a distance from their centre, one is involuntarily struck by the partial analogy between the facts there stated and the case of Australia. If the South-western Region were further removed or entirely separated by sea, and time allowed for the effects of changes of climate, we should see a Flora in Pondoland strikingly different from that of the neighbouring country, but recalling in its peculiar natural Orders that of a more distant region.

The affinity with the Karroo Region consists chiefly in the presence of considerable numbers of succulents, especially in Ficoideæ and Crassulæ. These abound in some of the drier, inland semi-Karroid valleys, as, *e.g.*, near Montagu, but they are not confined to them. They penetrate to the coast, and on the Cape Peninsula alone there are sixty-two species of Mesembrianthemum, twenty-nine species of Crassula, and even the very Karroid *Cotyledon fasciculata* has established itself in a dry, rocky nook close to the sea. It is like the Karroo, too, in its deficiency in Rubiaceæ and Acanthaceæ. But the differences are far more striking, and seem to point to a quite different origin of the two Floras. Almost the same may be said of the South-eastern Region, as may be seen by a comparison of the predominant Orders of each, as well as by noting the deficiency or total absence of certain Orders in the one which are well represented in the other.

III. The South-Eastern Coast Region.

This Region is bounded on the south-east by the Van Staden's Mountains, thence by an uncertain line it passes north-eastward towards the Zuurberg Range, the lower slopes of the Boschberg, Kagaberg, Katberg, Amatola, thence across to the Stormbergen, and following the great range of the Drakensbergen, Quathlamba,

* Bibl. App. 12.

† Bibl. App. 18 and 55.

etc., to the northern boundary of the Transvaal. No more accurate definition is as yet possible; for the line should keep to a contour of about 3.500 feet of altitude, above which the vegetation begins to assume the character of the steppes of the Kalahari Region, but no such contour-line is marked on any map. The country thus includes Kaffraria, Tembuland, Griqualand East, Pondoland, Natal and Zululand, finally continuing up to the tropic, where it may be said to join the great Tropical African Region. Its width may vary from 80 to 160 kilom. (50–100 miles).

The Region is probably, in its origin, a southern and maritime extension of the Tropical Region just named, modified by two factors, viz., the increasing cold of a higher latitude, and the closer approach of lofty mountain ranges towards the coast. Its surface, like that of the whole South African coast-line, is highly diversified, being much eroded into valleys by the steeply-descending streams from the mountains. For the most part it consists of intermingled Wood-land, Grass-land and Savannah formations. As already stated, the country has been divided by Thode* into three zones of successive altitude. His descriptions of these and of the Flora generally are very valuable, and form the most complete account that we possess of the Kaffrarian and Natal vegetation; and the reader is referred to his pages for more detailed information. It may be briefly stated that the vegetation generally is of a xerophilous type, like that of the South-western Region; but that the vegetative characters are usually of a more luxuriant growth.

Rainfall of the South-Eastern Region.

The following table exhibits the rainfall of eight stations throughout the Region :—

	Altitude above Sea.		Mean Annual Fall for † years.		Mean Annual Fall during 6 winter months.		Mean Annual Fall during 6 summer months.	
	metres	feet	milli-metres	inches	milli-metres	inches	milli-metres	inches
Port Elizabeth ..	55	(181)	524	(20.66)	283	(11.14)	242	(9.52)
Grahamstown ..	553	(1,800)	754	(29.72)	294	(11.60)	460	(18.12)
King William's Tn.	403	(1,314)	697	(27.47)	263	(10.38)	434	(17.09)
East London ..	10	(33)	648	(25.52)	266	(10.51)	381	(15.01)
Umtata	738	(2,400)	696	(27.41)	214	(8.46)	481	(18.95)
Maritzburg ..	1,070	(2,200)	743	(29.27)	115	(4.54)	628	(24.73)
Umzimkulu ..	769	(2,500)	721	(28.40)	163	(6.45)	557	(21.95)
Durban	80	(260)	1,078	(42.46)	347	(13.68)	731	(28.78)

* Bibl. App. 36.

† The period was 10 years' records (Buchan); except in the case of the three last stations which were for nine, nine and six years respectively.

Temperature—South-Eastern Region.

The following table shows the temperature at six stations in this Region, but we have no records beyond Durban. It will be seen that the inland stations are greatly affected by their altitude.

	Altitude.	Number of years.	Absolute Maximum.		Absolute Minimum.	
	metres.		C.	(Fahr.)	C.	(Fahr.)
Port Elizabeth ..	55	14	40.5	(105.0)	3.3	(38.0)
Grahamstown ..	553	12	42.7	(109.0)	−4.0	(24.7)
King William's Town	403	12	42.7	(109.0)	−3.0	(26.5)
East London ..	10	12	38.3	(101.0)	2.2	(36.0)
Umtata	738	12	43.3	(110.0)	−6.1	(21.0)
Durban	80	?	41.0	(105.8)	5.5	(41.9)

Plant Formations.

The chief differences between the plant-formations of this and the preceding Region consist in the gradual transition from the lower dull-green bushes of the former to more frequent and larger shrubs and trees, with more extensive grass-land of a livelier hue, between them. They are mostly in clumps, but here and there are more aggregated and have larger foliage of a less decidedly sclerophyllous character. Droughts are perhaps less prevalent, but when they do occur, as occasionally in the more western tracts, their effects are, temporarily at least, more disastrous than in the more bushy *veld* of the South-western Region. The grasses are rapidly withered, and when these are dead there is little sustenance for flocks and herds. The constituents of this "zuur-veld" (or sour-veld), as it is called by the colonists, are of a coarser character, and include large numbers of Iridaceæ, Amaryllidaceæ and Liliaceæ, which are of little use to live-stock; just as they, and also the rhenoster-bush (*Elytropappus rhinocerotis*) and the Restionaceæ, are the great drawbacks of the grazing grounds in the South-west Region. Sim* has well pointed out the differences between the "sweet-veld" of the tracts further removed from the coast and the "sour-veld" of this Region. He says :—"In the former the pasturage is mostly composed of small but very nutritious grasses, having abundant prostrate, wiry or somewhat bulbous stolons or creeping stems rooting at every joint, and capable of retaining life through months of most intense drought. The sour-veld, on the other hand, is composed of rank, strong-growing grasses, of tufted habit, without stolons, having in themselves low feeding qualities, but always well intermixed with strong-growing succulent composites." He omits, however, to mention the admixture of many coarse monocotyledonous plants of no use as pasture.

* Bibl. App. 37, p. 14.

Forests occur at intervals throughout the Region, but chiefly near the coast. Sim, who has more particularly made these his study, thinks that these were formerly more extensive, but that even now they cover about 300,000 acres (within the eastern part of the Cape Colony only), consisting "for the most part of slow-growing, hard-grained timber." Amongst the chief genera are Podocarpus (as in the Knysna forests, the most frequent), Vepris, Olea, Apodytes, Olinia, Scolopia, Mimusops, Sideroxylon, Ekebergia, Ocotea, etc.

In some of the larger river-valleys, as the Fish River, Kei River, etc., the rainfall is apparently deficient. There a sub-Karroid Flora makes its appearance on the dry ground; succulents, Euphorbias and Aloes abound, and the contrast with the vegetation of the more elevated tracts on either side is strongly marked.

Plant Forms.

The most frequent plant-forms are the same as those mentioned under the preceding Region, with the addition of the Cactus-form in the large tree Euphorbia (*E. grandidens*), besides smaller shrubby ones; of the dwarf Palm-form in *Phœnix reclinata* (which is said to attain a height in Zululand of 12–15 feet), *Hyphaene coriacea* and several species of Encephalartos, which sometimes form dense thickets.

Almost all those natural Orders, Rutaceæ, Bruniaceæ, Ericaceæ, Proteaceæ and Restiaceæ, which stamp by their abundance the character of the Flora of the South-western Region, diminish rapidly throughout this Region the further we go eastward. Eight species of Rutaceæ are recorded by Sim, in the more westerly portion; seven by Wood, in Natal (six of these being common to both), and two since described, being eleven species in all. Of Bruniaceæ there is one in Natal. Ericaceæ (excluding those found only at a greater altitude than 3,500 feet) are represented by about forty-two species.* Proteaceæ by six or seven species (besides three on the mountains of the bordering Kalahari Region). Of Penaeaceæ none, so far as known to me, have yet been recorded.

On the other hand the great tropical African and Indian Orders —Myrtaceæ, Rubiaceæ, Asclepiadaceæ, Apocynaceæ, Acanthaceæ— which are so small in number in the South-west Region, begin here to assume much more important or even prominent positions in the constituent elements of the Flora.

These form the chief differences between the two Regions. As before stated the transition from the one to the other is not abrupt, but gradual. Nevertheless if one compares the vegetation near Swellendam with that of Albany or King William's Town the contrast is striking.

Foreign plants which have more or less established themselves in this Region do not appear to be numerous. Sim has included

* Those of the higher mountains being included in the eastern mountain division of the Kalahari Region.

sixty-one species in his list of Kaffrarian plants; and Wood, in his Natal list, forty species. These are not to be added together, many being the same. But there are doubtless others. Most are European weeds of cultivation, and on the whole they form but an insignificant proportion of the Flora, either in species or in individuals.

Systematic Constituents of the Flora.

The following statistics are compiled chiefly from the publications of Wood, Sim and Thode, also from their collections and others less extensive, and from the records in various other botanical works. These show :—

Native Phanerogamia:	Orders.	Genera.	Species.
Dicotyledons	114	548	3,495
Gymnosperms	2	4	12
Monocotyledons	21	246	1,257
Total	137	798	4,764

Proportion of Monocotyledons to Dicotyledons 1 : 2.78
Proportion of genera to species 1 : 5.97

The following are the

Predominating Orders—South-Eastern Region.

	Number of species.	Per cent. of the whole.
1. Compositæ	633	13.3
2. Leguminosæ	400	8.4
3. Liliaceæ	363	7.6
4. Gramineæ	251	5.3
5. Asclepiadaceæ	195	4.0
6. Orchidaceæ	182	3.8
7. Scrophulariaceæ	163	3.4
8. Iridaceæ	140	2.9
9. Acanthaceæ	122	2.6
10. Rubiaceæ	114	2.4
11. Labiatæ	111	2.3
12. Amaryllidaceæ	106	2.2
13. Crassulaceæ	104	2.2
14. Euphorbiaceæ	91	1.9
15. Cyperaceæ	88	1.8
16. Ficoideæ	85	1.8
17. Geraniaceæ	76	1.6
18. Campanulaceæ	68	1.4
19. Selaginaceæ	61	1.3
20. Sterculiaceæ	56	1.2
21. Convolvulaceæ	55	1.2
22. Umbelliferæ	52	1.0
23. Anacardiaceæ	48	1.0

The following are the remaining Orders arranged according to number of species of each :—Polygalaceæ (47); Celastraceæ, Malvaceæ (46 each); Gentianaceæ (43); Ericaceæ (42); Cucurbitaceæ

(40); Thymelaeaceæ (38); Solanaceæ (36); Rutaceæ (27); Cruciferæ, Boraginaceæ, Verbenaceæ (26) each; Ebenaceæ, Sapindaceæ (23 each); Capparidaceæ (22); Bixaceæ, Ampelidaceæ, Rosaceæ, Naiadaceæ (21 each); Amarantaceæ, Santalaceæ (19 each); Apocynaceæ, Loganiaceæ, Restionaceæ (18 each); Ranunculaceæ (17); Caryophyllaceæ, Tiliaceæ, Gesneriaceæ, Juncaceæ (16 each); Rhamnaceæ, Loranthaceæ, Commelinaceæ (15 each); Polygonaceæ, Dioscoreaceæ (14 each); Combretaceæ, Oleaceæ (12 each); Chenopodiaceæ, Proteaceæ (11 each); Meliaceæ, Moraceæ (10 each); Myrtaceæ, Lythraceæ, Onagraceæ, Araliaceæ, Sapotaceæ, Lentibulariaceæ, Urticaceæ, Cycadaceæ (9 each); Menispermaceæ, Myrsinaceæ, Hæmodoraceæ, Araceæ (8 each); Begoniaceæ, Dipsaceæ, Primulaceæ, Eriocaulaceæ (7 each); Papaveraceæ, Linaceæ, Bruniaceæ, Melastomaceæ, Passifloraceæ, Ulmaceæ (6 each); Violaceæ, Portulacaceæ, Zygophyllaceæ, Burseraceæ, Olacaceæ, Hippocrataceæ, Rhizophoraceæ, Bignoniaceæ, Xyridaceæ (5 each); Anonaceæ, Hypericaceæ, Halorrhagidaceæ, Lauraceæ, Scitamineæ (4 each); Malphigiaceæ, Saxifragaceæ, Samydaceæ, Pedalinaceæ, Piperaceæ, Myricaceæ, Coniferæ, Zingiberaceæ, Typhaceæ (3 each); Frankeniaceæ, Elatinaceæ, Ochnaceæ, Droseraceæ, Hamamelidaceæ, Plumbaginaceæ, Plantaginaceæ, Phytolaccaceæ, Podostemaceæ, Salicaceæ, Palmæ, Lemnaceæ (2 each); Nymphæaceæ, Resedaceæ, Pittosporaceæ, Guttiferæ, Connaraceæ, Cactaceæ, Cornaceæ, Valerianaceæ, Goodeniaceæ, Salvadoraceæ, Nyctaginaceæ, Illecebraceæ, Cytinaceæ, Monimiaceæ, Balanophoraceæ, Ceratophyllaceæ, Flagellariaceæ (1 each).

The following are the largest genera:—Senecio (121 species); Helichrysum (93); Crassula (81); Indigofera (69); Mesembrianthemum (51); Hermannia (48); Asclepias (incl. Gomphocarpus) (48); Gladiolus (45); Schizoglossum (44); Pelargonium (42); Eulophia (40); Berkheya (40); Erica (42); Ornithogalum (38); Rhus (38); Asparagus (35); Cyperus (34); Aloe (34); Polygala (33); Lotononis (30); Ipomaea (28); Disa (26).

Comparison with other Regions.

The Flora of this Region may be regarded as derivative from the great Tropical African Flora with, of course, many modifications. This view appears to have been generally adopted, but it is impossible in so condensed a review as this to cite statistical evidence in support of it.

It has also affinities, though not very close, with the Indian and Madagascar Floras.

Such affinities as it shows with the South-western Region are probably due to the intermingling across the border on either side of it. For the further we proceed to the eastward in the Region the fewer do the typical plants of the South-western Region become; conversely, the further westward we travel the fewer are the more characteristic plants of this Region. Thus *Phœnix reclinata* gets down to the Albany district and then stops. Encephalartos, of which there are in this Region some eight or nine species, decrease so rapidly westward that only one (*E. caffer*) succeeds in just crossing the border, as far as Jagersbosch and Swanepoel's Poort. On the other hand, the typical western Leucadendron and Leucospermum reach in a single species each as far as Kaffraria, while in Natal not a single species is recorded.

IV. The Karroo Region.

This Region is bounded, if we begin from the west, at Karroo Poort (Ceres district), on the south, by the long mountain range described above as the northern limit of the South-west Region. About the Elandsbergen (Uitenhage) the line curves upward towards the Zuurbergen, and follows them nearly to Grahamstown. There it again curves northward along the Fish River Heights, ascends the Fish River Valley for some distance northward, then returns and passes westward, skirting the chain of mountains known as the Boschberg, Sneeuwbergen, Nieuwveld's-bergen, Roggeveldsbergen; then the boundary crosses by an uncertain line to the Cederbergen Range and along them southward towards Ceres.

The Region is, broadly speaking, a vast shallow basin, which appears to have formed, in earlier ages, the bed of a large lake, which at length broke through the various "poorts" of the southern mountain-range to the sea. Its altitude ranges from 1,800–2,500 feet above the sea. The mountains which surround it reach to a considerable height on the northern margin (4,000–8,000 feet), but are much lower, sometimes even a mere rim on the southern side. For the purposes of floristic computations only those parts below about 3,750 feet are considered as belonging to this Region, all above that altitude being regarded as in the Upper Region. It is traversed by numerous river-beds or torrents, mostly dry or nearly so, except when filled by the summer thunderstorms, when the channels suddenly fill, carry off a great quantity of muddy water for a few days, and soon again become dry. Water generally is scarce; springs are infrequent; cultivation is impossible without irrigation, and the Region as a whole is considered, if we except some parts of Little Namaland, as the poorest part of the Cape Colony. Nevertheless the soil is fertile, and after good rains, especially in the more eastern portions, there is in such seasons excellent grazing for sheep, and flocks rapidly increase. The vegetation is of an intensely xerophilous character; succulents and thorn-bushes, tubers and bulbs abound, while trees are deficient except along the river banks, where *Acacia horrida* and a very few other fringe the margins.

The exposed rocks are mostly the sandstones of the "Karroo System" (Rogers*), chiefly yielding a fertile and friable red soil,

* Bibl. App. 60.

but sometimes shaly and harder. These are traversed by numerous doleritic dykes. Only on the southern and western margins do the Ecca and Dwyka series make their appearance.

For a more detailed description of the aspects of the country (in which I spent some years) and of some of the more remarkable plants in it, I must be allowed to refer to my essay already cited.

RAINFALL—KARROO REGION.

	Altitude above Sea.		Mean annual Fall for 10 years.		Mean annual Fall during 6 winter months.		Mean annual fall during 6 summer months.	
	metres	feet	milli-metres	inches	milli-metres	inches	milli-metres	inches
Prince Albert ..	652	(2,120)	291	(11.49)	147	(5.79)	144	(5.70)
Willowmore ..	849	(2,760)	280	(11.04)	94	(3.73)	185	(7.31)
Steytlerville ..	..	..	219	(8.65)	71	(2.81)	148	(5.84)
Beaufort West ..	876	(2,850)	247	(9.74)	66	(2.63)	180	(7.11)
Aberdeen ..	738	(2,400)	359	(14.15)	100	(3.94)	259	(10.21)
Graaff-Reinet	769	(2,500)	476	(18.76)	155	(6.14)	320	(12.62)
Jansenville ..	..	..	331	(13.07)	98	(3.86)	233	(9.21)
Cookhouse (4 years)	584	(1.900)	381	(15.00)	114	(4.50)	266	(10.50)

The above are from Buchan's tables (Meteorological Commission) and all for ten years, except the last. It should be noted, however, in the case of Graaff-Reinet, that a record of twenty-three previous years gave a mean fall of 14.5 inches ; and I do not think it less accurate than the above, which I suspect, from grounds of personal knowledge of the subject, involves some error.

The table shows that with the exception of one station (Prince Albert) on the southern edge of the Region, and affected by its proximity to the lofty Zwartebergen, by far the greater part of the fall takes place in the summer months. It is also well known that the rains are usually accompanied by thunderstorms which invariably travel from west to east. Occasionally, in the eastern portions, a strong south-east monsoon-wind brings up a general rain ; but this is rare, the clouds being usually discharged on the intervening mountain ranges between them and the South-east Coast Region.

TEMPERATURE—KARROO REGION.

	Altitude.	Number of years.	Absolute Maximum.		Absolute Minimum.	
	metres.		C.	(Fahr.)	C.	(Fahr.)
Prince Albert ..	652	8	42.7	(109.0)	−2.2	(28.0)
Graaff-Reinet ..	769	13	43.3	(110.0)	−6.6	(20.0)

These are the only records we have been able to obtain ; they probably present a fair average of the Region.

Systematic Constituents.

The following is a summary of the records compiled by me :—

Native Phanerogamia :	Orders.	Genera.	Species.
Dicotyledons	71	281	1,013
Gymnosperms	1	1	1
Monocotyledons	12	107	330
Total	84	389	1,344

Proportion of Monocotyledons to Dicotyledons 1 : 3.07
Proportion of genera to species 1 : 3.45

Predominating Orders—Karroo Region.

	Number of species.	Per cent. of the whole.
1. Compositæ	205	15.2
2. Leguminosæ	112	8.3
3. Ficoideæ	111	8.3
4. Liliaceæ	99	7.4
5. Gramineæ	90	6.7
6. Geraniaceæ	77	5.7
7. Crassulaceæ	73	5.4
8. Iridaceæ	59	4.4
9. Scrophulariaceæ	34	2.5
10. Sterculiaceæ	33	2.5
11. Asclepiadaceæ	29	2.2
12. Cruciferæ	28	2.0
13. Cyperaceæ	26	1.9
14. Amaryllidaceæ	24	1.8
15. Zygophyllaceæ	21	1.6
16. Euphorbiaceæ	17	1.3
17. Anacardiaceæ	16	1.2
18. Umbelliferæ	16	1.2
19. Boraginaceæ	15	1.1

The following are the remaining Orders, arranged according to the number of species of each :—Polygalaceæ (14) ; Malvaceæ (13) ; Rubiaceæ, Labiatæ (12 each) ; Convolvulaceæ, Solanaceæ, Restionaceæ (11 each) ; Portulacaceæ, Acanthaceæ (10 each) ; Cucurbitaceæ, Juncaceæ (9 each) ; Rutaceæ, Ericaceæ, Loranthaceæ (8 each) ; Caryophyllaceæ, Celastraceæ, Campanulaceæ, Chenopodiaceæ (7 each) ; Rosaceæ (6) ; Capparidaceæ, Rhamnaceæ, Thymelaeaceæ, Hæmodoraceæ (5 each) ; Selaginaceæ (4) ; Ranunculaceæ, Papaveraceæ, Olacaceæ, Santalaceæ, Commelinaceæ (3 each) ; Menispermaceæ, Frankeniaceæ, Tiliaceæ, Onagraceæ, Plumbaginaceæ, Moraceæ, Naiadaceæ (2 each) ; Resedaceæ, Bixaceæ, Pittosporaceæ, Tamaricaceæ, Elatinaceæ, Linaceæ, Burseraceæ, Ampelidaceæ, Sapindaceæ, Saxifragaceæ, Hamamelidaceæ, Halorrhagidaceæ, Lythraceæ, Loasaceæ, Valerianaceæ, Dipsaceæ, Primulaceæ, Ebenaceæ, Salvadoraceæ, Apocynaceæ, Lentibulariaceæ, Amarantaceæ, Cytinaceæ, Lauraceæ, Urticaceæ, Salicaceæ, Cycadaceæ, Dioscoreaceæ, Typhaceæ (1 each).

The following is the list of the largest genera :—Mesembrianthemum (70 species) ; Crassula (54) ; Pelargonium (39) ; Pteronia (32) ; Oxalis (30) ; Senecio (23) ; Indigofera (20) ; Cotyledon (18) ; Heliophila (17) ; Helichrysum (16) ; Othonna (14) ; Euphorbia (14).

The affinities of this Region appear to be strongest with those of the Upper, and next with those of the Kalahari Region. Its great characteristic is the predominance of succulents and other extreme xerophilous types. The strength of the Flora to maintain itself under the difficult conditions of a desert-like environment is shown by its ability to push outward in every dry valley of the neighbouring Regions.

The only marked exception to its general strength to resist foreign invaders is also a tribute to its age-long adaptation to the severity of its environment. For the one plant which has successfully invaded this Region, and has spread to such an extent as to become its greatest pest, is a species of Opuntia (perhaps *O. tuna*, Mill.), from the drier desert parts of Mexico and Central America.

The connection with the South-western Region is but a slight one. For while many typical Karroo plants have apparently invaded the latter, there are but few of the peculiar South-western types to be found here. The few Rutaceæ, Ericaceæ and Restionaceæ which appear are mere stragglers on the nearer mountains ; while Bruniaceæ, Proteaceæ and Penæaceæ are, so far as we know, entirely absent.

V. The Upper Region.

This Region forms the next ascending step northward from the Karroo Region, and on the south its boundary is conterminous with it, taking in all the mountains above 3,500 to 3,750 feet. On the south-east it takes in the loftier tracts lying northward of the Fish River Heights, and the Winterberg and Amatola Mountains, including Queenstown ; thence round the loftier mountains which form the commencement of the Stormberg Range, avoiding them, and going northward towards Aliwal North. From this point the line is an uncertain one, there being apparently no natural boundary, but the vegetation passes over by a wide transition towards the Kalahari. For convenience sake, and provisionally, a line has been drawn running north-westward until, south of Kimberley, it reaches the curve of the Dwyka conglomerate and the Ecca beds which here come up from the south-westward and stretch north-eastward right across the Orange River Colony and the Transvaal (Rogers). These formations (which are probably synonymous with the "red-sand" and "pan-veld" of the Hope Town district) appear to exercise a marked edaphic influence on the character of the Flora, which was first pointed out to me by the late Dr. E. B. Muskett, of Hope Town. They pass by curves south of the Orange River near Hope Town and thence near to Prieska and Kenhardt, then still further westward, through the tract known as Bushmanland, next by a wide curve southward to the high mountains west of Calvinia,where it oins the northern boundary of the Karroo Region.

This Region is thus an elevated, rather flat tract of from 3,500 feet to 4,000 feet in altitude, of which the waters, with the exception of some depressed valleys of the Great Fish River and the Kei River, are drained by the Orange River.

By far the greater part of the surface consists of the Beaufort series of the Karroo System (Rogers), and, like that, is generally of a reddish hue and fertile when watered.

The climate is more severe than that of the Karroo, the extremes of heat and cold showing a greater difference. Severe frosts are common, with occasional snow in winter (or frequent on the higher mountains) and hailstorms in summer. The rains are almost entirely during the summer months, and usually accompanied by thunderstorms.

RAINFALL—UPPER REGION*.

	Altitude above Sea.		Mean annual Fall for 10 years.		Mean annual Fall during 6 winter months.		Mean annual Fall during 6 summer months.	
	metres	feet	millimetres	inches	millimetres	inches	millimetres	inches
Kenhardt ..	830	(2,700)	171	(6.74)	49	(1.96)	121	(4.78)
Carnarvon ..	1,249	(4,060)	251	(9.90)	72	(2.86)	178	(7.04)
Fraserburg ..	1,292	(4,200)	209	(8.24)	82	(3.26)	126	(4.98)
Victoria West ..	1,261	(4,100)	306	(12.06)	117	(4.61)	189	(7.45)
Richmond ..	1,444	(4,700)	357	(14.06)	101	(4.00)	255	(10.06)
Hanover ..	1,384	(4,500)	423	(16.66)	125	(4.96)	297	(11.70)
De Aar ..	1,476	(4,800)	414	(16.33)	110	(4.35)	304	(11.98)
Colesberg ..	1,375	(4,470)	462	(18.21)	130	(5.14)	331	(13.07)
Middelburg ..	1,230	(4,000)	448	(17.67)	111	(4.39)	337	(13.28)
Cradock ..	878	(2,856)	437	(17.21)	116	(4.58)	320	(12.63)
Tarkastad ..	1,323	(4,300)	580	(22.86)	160	(6.31)	420	(16.55)
Queenstown ..	1,080	(3,544)	699	(27.53)	181	(7.14)	517	(20.39)
Aliwal North ..	1,332	(4,330)	671	(26.44)	198	(7.83)	472	(18.61)

From the above there are deducible two general curves though by no means regular, viz., 1, showing the increase in the total rainfall from west to east; and 2, showing the increasing predominance, from west to east, of the summer rainfall over that of the winter months.

TEMPERATURE—UPPER REGION.

	Altitude.	Number of years.	Absolute Maximum.		Absolute Minimum.	
	metres.		C.	(Fahr.)	C.	(Fahr.)
Kenhardt	830	6	44.4	(112.0)	-6.6	(20.0)
Victoria West ..	1,261	4	43.0	(109.5)	-8.0	(17.5)
Aliwal North ..	1,332	15	36.3	(97.5)	-9.7	(14.5)
Queenstown ..	1,080	12	40.0	(104.0)	-7.2	(19)

* Buchan's Tables (Meteorolog. Commission).

The general aspect of the country in the central portion is that of a vast, tree-less, monotonous plain, interspersed at considerable distances by a few isolated and flat-topped mountains, or short ranges ; or lower, and then very rugged, rocky hills. On these hills, or in the few ravines of the mountain sides, may be seen a few stunted bushes. In moister and more fertile shallow valleys ("vleis") grassy patches, with more luxuriant bushes 6 to 8 feet high, may be seen ; but trees never, except such few as have been planted by the hand of man, or except the few (chiefly *Salix capensis* and Rhus spp.) which fringe the banks of the Orange River where, for a certain distance, it flows through this Region. The usual appearance of the plains is that of a heathy or dry, elevated moorland, covered with small shrublets of a dull green hue (chiefly Compositæ), the few intervening plants of different growth which occur being too small or too few to alter or modify the general appearance above described.

The Flora, like that of the Karroo, is of a decidedly xerophilous type ; more extreme and desert-like in the west, and becoming gradually less so towards the east.

For some further details of the more remarkable plants of this Region I must refer to my previous essay above-cited, and proceed to an account of the systematic elements of the Flora, so far as we know it.

Systematic Elements of the Flora.

Native Phanerogamia :	Orders.	Genera.	Species.
Dicotyledons	77	365	1,426
Gymnosperms	..	..	..
Monocotyledons	15	140	420
Total	92	505	1,846

Proportion of Monocotyledons to Dicotyledons 1 : 3.4
Proportion of genera to species 1 : 3.66

Predominant Orders—Upper Region.

	Number of species.	Per cent. of the whole.
1. Compositæ	525	28.4
2. Liliaceæ	152	8.2
3. Scrophulariaceæ	139	7.5
4. Gramineæ	93	5.0
5. Asclepiadaceæ	71	3.8
6. Crassulaceæ	56	3.0
7. Leguminosæ	55	2.9
8. Ficoideæ	51	2.8
9. Cyperaceæ	46	2.5
10. Campanulaceæ	45	2.4

Predominant Orders—Upper Region—(continued.)

	Number of species.	Per cent. of the whole.
11. Iridaceæ	44	2.4
12. Selaginaceæ	33	1.8
13. Amaryllidaceæ	32	1.7
14. Boraginaceæ	30	1.6
15. Orchidaceæ	29	1.6
16. Acanthaceæ	26	1.4
17. Geraniaceæ	24	1.3
18. Sterculiaceæ	22	1.2
19. Solanaceæ	20	1.0
20. Labiatæ	20	1.0
21. Umbelliferæ	19	1.0

The following are the remaining Orders, arranged according to number of species of each :—Rubiaceæ (18) ; Cruciferae (17) ; Euphorbiaceæ (15) ; Ericaceæ (14) ; Convolvulaceæ (13) ; Cucurbitaceæ, Anacardiaceæ, Thymelæaceæ (11 each) ; Santalaceæ (10) ; Chenopodiaceæ, Polygalaceæ, Malvaceæ (9 each) ; Ebenaceæ, Rosaceæ, Proteaceæ (8 each) ; Verbenaceæ, Juncaceae (7 each) ; Restionaceæ, Gentianaceæ (6 each) ; Urticaceæ, Loganiaceæ, Plantaginaceæ, Zygophyllaceæ, Rutaceæ (5 each) ; Amarantaceæ, Polygonaceæ (4 each) ; Ranunculaceæ, Portulacaceæ, Ampelidaceæ, Sapindaceæ, Araliaceæ, Dipsaceæ, Plumbaginaceæ, Apocynaceæ, Lentibulariaceæ, Loranthaceæ, Commelinaceæ (3 each) ; Papaveraceæ, Resedaceæ, Caryophyllaceæ, Hypericaceæ, Celastraceæ, Rhamnaceæ, Onagraceæ, Passifloraceæ, Primulaceæ, Bignoniaceæ, Pedalinaceæ, Piperaceæ, Haemodoraceæ, Naiadaceæ (2 each) ; Capparidaceæ, Bixaceæ, Tiliaceæ, Linaceæ, Saxifragaceæ, Halorrhagidaceæ, Valerianaceæ, Myrsinaceæ, Oleaceæ, Gesneriaceæ, Myoporaceæ, Nyctaginaceæ, Phytolaccaceæ, Cytinaceæ, Lauraceæ, Dioscoreaceæ, Xyridaceæ, Aroideæ, Eriocaulaceæ (1 each).

The following are the largest genera :—Senecio (86 species) ; Helichrysum (71) ; Crassula (40) ; Sutera (31) ; Pelargonium (25) ; Pteronia (24) ; Mesembrianthemum (23) ; Wahlenbergia (23) ; Othonna (23) ; Berkheya (21) ; Ornithogalum (19) ; Diascia (19) ; Asparagus (19) ; Felicia (17) ; Indigofera (17) ; Cotyledon (15).

This Region is of an intermediate character between that of the Karroo and the Kalahari. Yet it is stamped by two features peculiarly its own—the marked predominance of Compositæ, and the deficiency, in individuals at least, of succulents, as compared with the Karroo. It may hereafter be annexed to the eastern mountain-province of the Kalahari, when this province comes to be more fully explored.

VI. The Kalahari Region.

It must at once be stated that this vast Region is as yet so imperfectly explored as to its physical divisions, its aspect, its climate, and the systematic constituents of its vegetation, that it is impossible at present to do more than offer a very general view of a country which will need many years of study and which will hereafter almost certainly require to be divided into several Regions, or, at least, to be sub-divided into provinces.

As now treated it is bounded on the west by the still less explored Western Region, on the south by the Upper Region, on the south-east and east by the mountains of the South-eastern Coast Region, on the north by the great Tropical Region, which is beyond the scope of our inquiry.

It thus includes :—

1. The higher eastern mountain country, forming parts of Cape Colony, Natal and Basutoland, with an altitude higher than 3,500 or 4,000 feet. (This, in our view, will probably hereafter require separation as a Region or Province.)

2. Almost the whole of the Orange River Colony, of the Transvaal and Bechuanaland.

Generally speaking, it is a wide inland basin, drained by the Orange River and its tributaries ; with some exceptions towards the east and south-east, where numerous rivers from the high mountains empty themselves into the Indian Ocean.

The aspect of the country is very varied. The high mountain tract has bare grassy summits, rising from 6,000–10,500 feet above the sea ; on the south and east of these there are forests in the lower ravines. The "high-veld," which succeeds the mountains to the west, is virtually a grass-steppe, yet with numerous interspersed small shrublets. Further to the west and north we reach the so-called "bush-veld," a Savannah, which extends over a considerable area. Westward of this a gradual transition is effected to the great desert-tract of the Kalahari, concerning which, botanically, our knowledge is comparatively small, only a few explorers—(Burchell, Schinz, Marloth and Passarge)—having collected or published accounts of their journeys. But Damaraland is excluded from our calculations by its inter-tropical position. The largest collectors in the eastern Kalahari have been Rehmann, Galpin, Wilms, Schlechter and Burtt-Davy. My own experience and collections have been chiefly between Delagoa Bay, Barberton and Pretoria ; and, more recently, about Pietersburg and Houtbosch. Hence our knowledge of the Flora of the eastern Kalahari is far greater than that of the western part.

The vegetation, as in that of all the other Regions, is of the xerophilous type. Nevertheless there are certain tracts in the eastern mountains where the climate during the summer months almost approaches that of the "rain-forest." But in the centre, and in the extreme west, the country is of a desert or semi-desert character ; and to such an extent is this the case that even its exploration is rendered extremely difficult. Yet in the present state of our knowledge no precise line can be drawn between the two regions of such widely differing character.

The data available respecting the climate are few. The following table exhibits the

RAIN-FALL—KALAHARI REGION.

	Altitude above Sea.		Mean Annual Fall for 10 years.		Mean Annual Fall during 6 winter months.		Mean Annual Fall during 6 summer months.	
	metres	feet	milli-metres	inches	milli-metres	inches	milli-metres	inches
Pella	553	(1,800)	96	(3.79)	26	(1.03)	70	(2.76)
Calvinia ..	953	(3,100)	220	(8.69)	145	(5.72)	75	(2.97)
Upington ..	861	(2,800)	220	(8.67)	56	(2.24)	163	(6.43)
Prieska ..	1,015	(3,300)	289	(11.41)	77	(3.07)	211	(8.34)
Kimberley ..	1,243	(4,042)	519	(20.44)	117	(4.62)	401	(15.82)
Vryburg ..	1,323	(4,300)	647	(25.50)	97	(3.85)	549	(21.65)
Mafeking ..	1,290	(4,194)	685	(26.98)	90	(3.57)	594	(23.41)
Pretoria ..	1,375	(4,471)	677	(26.66)	..	..	..	..
Johannesburg..	1,764	(5,735)	768	(30.26)	115	(4.56)	652	(25.70)
Kroonstad ..	1,384	(4,500)	690	(27.17)	140	(5.53)	549	(21.64)
Bloemfontein	1,387	(4,510)	644	(25.39)	166	(6.57)	478	(18.82)
Kokstad ..	1,318	(4,284)	755	(29.76)	159	(6.28)	596	(23.48)
Pilgrim's Rest..	1,200	(3,900)	1,043	(41.10)	150	(5.91)	893	(35.19)
Barberton ..	898	(2,920)	702	(27.65)	..	..	..	..

The rainfall in the west is shown to be very small, increasing greatly as we proceed eastward. The summer fall largely predominates, the only exception being Calvinia which is on the very margin of our boundary, and which may hereafter be rather regarded as an outlier of the South-western Region. The rains are most usually accompanied by thunderstorms, and these are sometimes of great severity.

TEMPERATURE—KALAHARI REGION.

	Altitude.	Number of years.	Absolute Maximum.		Absolute Minimum.	
	metres.		C.	(Fahr.)	C.	(Fahr.)
Kenhardt	830	6	44.4	(112.0)	-6.6	(20.0)
Prieska	1,015	1	41.0	(105.8)	-3.8	(25.0)
Kimberley	1,243	12	41.7	(107.2)	-5.8	(21.5)
Johannesburg ..	1,764	5	35.5	(96.0)	-6.1	(21.0)
Kroonstad	1,384	1	41.0	(105.8)	-3.8	(25.0)
Bloemfontein ..	1,387	12	42.7	(109.0)	-8.8	(16.0)
Kokstad	1,318	3	33.3	(92.0)	-6.1	(21.0)

It will be seen from the above that the temperature is by no means extreme nor the range excessively large. On the whole it probably does not differ greatly from that of our Upper Region, of which, however, the data are even fewer than the above. It is to be remembered that there are no records from what we have termed the Eastern Mountain Province, which would certainly be subject to much greater extremes of cold.

Systematic Constituents of the Flora.

Native Phanerogamia:	Orders.	Genera.	Species.
Dicotyledons	106	578	2,111
Gymnosperms	1	1	2
Monocotyledons	19	204	923
Total	126	783	3,036

Proportion of Monocotyledons to Dicotyledons 1 : 2.88
Proportion of genera to species . 1 : 3.9

Predominating Orders—Kalahari Region.

	Number of species.	Per cent. of the whole.
1. Compositæ	302	9.9
2. Gramineæ	251	8.3
3. Leguminosæ	247	8.1
4. Liliaceæ	202	6.7
5. Scrophulariaceæ	152	5.0
6. Asclepiadaceæ	148	4.9
7. Orchidaceæ	140	4.6
8. Cyperaceæ	121	3.9
9. Acanthaceæ	115	3.8
10. Iridaceæ	89	2.9
11. Labiatæ	74	2.4
12. Amaryllidaceæ	61	2.0
13. Convolvulaceæ	55	1.8
14. Sterculiaceæ	55	1.8
15. Rubiaceæ	52	1.7
16. Selaginaceæ	41	1.4
17. Campanulaceæ	38	1.3
18. Euphorbiaceæ	37	1.2
19. Verbenaceæ	35	1.2
20. Anacardiaceæ	35	1.2
21. Crassulaceæ	33	1.0
22. Gentianaceæ	32	1.0
23. Ficoideæ	31	1.0

The following are the remaining Orders, arranged according to number of species of each :—Capparidaceæ, Malvaceæ, Geraniaceæ (28 each); Cucurbitaceæ, Boraginaceæ, Amarantaceæ (26 each); Tiliaceæ (24); Santalaceæ, Ebenaceæ, Cruciferæ (17 each); Thymelæaceæ, Umbelliferæ, Polygalaceæ (16 each); Combretaceæ, Solanaceæ (15 each); Naiadaceæ (14); Ericaceæ, Loganiaceæ (13 each); Celastraceæ, Commelinaceæ, Caryophyllaceæ, Gesneriaceæ, Loranthaceæ (12 each); Ranunculaceæ, Rosaceæ, Polygonaceæ (11 each); Lentibulariaceæ, Chenopodiaceæ (10 each); Proteaceæ

(9); Lythraceæ, Zygophyllaceæ, Pedalinaceæ, Juncaceæ (8 each); Sapindaceæ, Oleaceæ, Nyctaginaceæ (7 each); Passifloraceæ, Ampelidaceæ (6 each); Apocynaceæ, Menispermaceæ, Malpighiaceæ, Rhamnaceæ, Sapotaceæ, Dioscoreaceæ (5 each); Eriocaulaceæ, Urticaceæ, Meliaceæ, Resedaceæ, Bixaceæ, Portulacaceæ. Olaceæ, Myrsinaceæ, Bignoniaceæ, Xyridaceæ (4 each); Papaveraceæ, Hypericinaceæ, Rutaceæ, Ochnaceæ, Burseraceæ, Myrtaceæ, Turneraceæ, Dipsaceæ, Plumbaginaceæ, Moraceæ, Salicaceæ, Araceæ (3 each); Linaceæ, Hippocrataceæ, Saxifragaceæ, Droseraceæ, Halorrhagidaceæ, Melastomaceæ, Ulmaceæ, Coniferæ, Hæmodoraceæ, (2 each); Anonaceæ, Nymphæaceæ, Pittosporaceæ, Elatinaceæ, Guttiferæ, Chailletiaceæ, Hamamelidaceæ, Onagraceæ, Samydaceæ, Loasaceæ, Begoniaceæ, Araliaceæ, Cornaceæ, Valerianaceæ, Vacciniaceæ, Primulaceæ, Hydrophyllaceæ, Plantaginaceæ, Illecebraceæ, Phytolaccaceæ, Cytinaceæ, Piperaceæ, Balanophoraceæ, Hydrocharidaceæ, Zingiberaceæ, Pontederiaceæ, Typhaceæ, Lemnaceæ (1 each).

The following are the largest genera :—Helichrysum (61 species); Asclepias (incl. Gomphocarpus) (47); Sutera (38); Hermannia (36); Eragrostis (36); Ipomaea (33); Eulophia (32); Indigofera (32); Senecio (32); Gladiolus (31); Rhus (29); Cyperus (26) Habenaria (26); Aristida (25); Schizoglossum (25); Selago (22); Scilla (21); Andropogon (21); Acacia (19); Lotononis (18).

Affinities of the Flora.

The Region is far too little explored botanically to warrant any opinion as to its affinity with other Floras. So far as known it seems more nearly allied to the great Tropical African Flora than to any other. But it will certainly require sub-division. For in the central portion it is practically a sandy desert, with very little surface-water, though it is probable that underground water exists in many parts, and that, hereafter, means may be devised for raising this for pastoral, or even for agricultural, purposes; whereas in the eastern portion the climate is of a warm, temperate character, the soil fertile and water moderately plentiful. The eastern portion of the Orange River Colony is probably as fertile and as capable of supporting a large population as any in the world. The eastern slopes and spurs of the Drakensbergen, above 3,000 feet, are also extremely rich in a floristic sense. Basutoland, which lies mostly at an elevation of from 4,500 to 10,000 feet, is also very little explored botanically; though cold in winter, it yields fine crops in the valleys and the lower-lying country.

SYNOPTICAL TABLE OF REGIONS.

Native Phanerogamia.	Westn. Region.			S.-Westn. Region.			S.-Eastn. Region.			Karroo Region.			Upper Region.			Kalahari Region.		
	Ords.	Gen.	Spec.	Ords.	Gen.	Spec.	Ords.	Gen.	Spec.	Ords.	Gen.	Spec.	Ords.	Gen.	Spec.	Ords.	Gen.	Spec.
Dicotyledons	55	193	541	92	548	4,279	114	548	3,495	71	281	1,013	77	365	1,426	106	578	2,111
Gymnosperms	1	1	1	1	2	5	2	4	12	1	1	1	..	..	..	1	1	2
Monocotyledons ..	7	45	114	17	155	1,301	21	246	1,257	12	107	330	15	140	420	19	204	923
Total	63	239	656	110	705	5,585	137	798	4,764	84	389	1,344	92	505	1,846	126	783	3,036
Proportion :																		
Monocots. to Dicots,	1 : 4·7			1 : 3·29			1 : 2·78			1 . 3·07			1 : 3·4			1 : 2·88		
Genera to Species ..	1 : 2·7			1 : 7·9			1 5·97			1 : 3·45			1 : 3·66			1 : 3·9		

Enumeration of the Flora of the whole of South Africa.

Orders	149
Genera	1,357
Species	12,714

(including about 300 not native).

THE MIGRATION OF THE FLORAS.

A recent writer, who has apparently overlooked or does not accept Hooker's hypothesis as to the origin of the South-western Flora referred to above, speaks of this origin as "an enigma."* But much more enigmatical and even more tantalising, because the problem meets us daily, is the question of the drift, or present movement, of the two Floras—the South-western and the South-eastern. For as with animal so with plant life, the struggle for existence is incessant. Some observers in the Colony, and also some European botanists, have thought that the Western Flora is encroaching upon the Eastern (*e.g.*, *Elytropappus rhinocerotis*, D.C., *Chrysocoma tenuifolia*, Berg, etc.), and support their arguments by the fact of the wider spread of certain other westerly forms along the mountain ranges of the east coast, northward, as *e.g.*, Ericaceæ, appearing on the Milanji Highlands, on Kilimandjaro Mountain, and (as *E. arborea*) even to the Mediterranean Region; also an Ericinella; *Myrsine africana*, common in Abyssinia; *Psoralea pinnata*, reaching from the Cape right across the continent, also, to Abyssinia; *Oxalis cernua*, to the Mediterranean, where it is now widely spread; and on Mount Sinai, *Lasiospermum brachyglossum*, D.C. (which I have myself gathered in Nama'land) has been found (Christ*), and many others. It is true that there does not seem to be any compensatory movement of any considerable extent in the opposite direction. Nothing is more remarkable than the absence or rarity of European types on the higher mountains of Southern Africa. It might have been expected that if African types could travel northward along the great mountain ranges of the east, so European types might have been enabled to penetrate south by the same path. But this is so rarely the case that the exceptions are striking. There are certainly some representative European genera, with Cape species, such as Astragalus, Rubus, Potentilla, Geum, Alchemilla, Vaccinium, etc., but the only identical species I can recall as being found on the eastern mountains is *Agrimonia Eupatoria*. This, however, does not affect the possibility of a movement southward and westward of African types from the Natal country towards the Cape. Nor is there any inherent necessity for the movement being only in one direction. It may be, reciprocally, in both directions. Yet, if we may step for a moment from the firm ground of facts to the airy region of imagination, it may be said that few botanists who, like the present writer, have spent many years in South Africa, and especially in the south-western districts, have not been penetrated by a gloomy impression that the South-western Flora is dying out, and is doomed to extinction. The idea is not quite baseless. Many species collected by Thunberg, Masson and Burchell have never, or but very rarely, been seen since. Some of the finest Ericæ have disappeared, often doubtless destroyed by bush-fires; and, in general,

* Bibl. App. 43 (p. 14).

species of the Bruniaceæ, Proteaceæ and Penæaceæ, so peculiar to this Region, seem to have become much more rare. No weight can be attached to this, for it is wanting in adequate evidence. *Absit omen!*

SUMMARY.

1. The South African Flora, broadly speaking, consists of two chief types: one, the smaller, South-western, older in its main features, and presenting striking marks of a similar origin to that of Australia. The other, an African type, covering all the remainder of the sub-continent, and presenting no affinities or very slight (as outliers) marks of affinity with the Australian region.

2. The whole of the Regions are of a well-marked xerophilous character, and the coast districts especially strongly resemble in appearance the Flora of the Mediterranean, in many parts markedly that of Sicily and Greece.

3. The two larger coast Regions (the South-western and South-eastern) are distinguished by their highly-differentiated character or by the narrow distribution-area of many species.

4. There is in general a marked deficiency of trees;

5. Also a want of luxuriance of growth, chiefly, however, in the western portions;

6. Also a paucity of sociable plants.

7. That there appears to be a strong inherent power to resist the aggression of foreign invaders.

8. That the prevalence of bush-fires is exercising a marked influence upon the Flora, in a manner not yet fully understood, but probably has, as one of its effects, the diminution in the number of species.

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SECTION V.—GEOLOGICAL.

1. GEOLOGY OF CAPE COLONY.

By A. W. Rogers, M.A., F.G.S., Director of the Geological Survey, Cape Colony.

In structure the Colony is comparable to a shallow basin, which is filled with deposits belonging to the Karroo formation ; the basin is breached on the south-eastern side, between the Gualana and St. John's rivers, by the Indian Ocean. On the north-east, between Kimberley and Pondoland, the Colony is bounded by an irregular line that passes across the basin, which extends through Basutoland, the Orange River Colony, Natal, and the eastern portion of the Transvaal. The beds of the Karroo formation along the southern and south-western edges of the basin dip at high angles towards its interior, but from the Tanqua Karroo northwards to Bushmanland, and thence eastwards to Hopetown, and again north-east to the Orange River Colony border they are very gently inclined towards the interior, and similar conditions obtain in Pondoland, though near St. John's the lower divisions of the Karroo formation are faulted down against a block (horst) of Table Mountain sandstone, a feature which has no counterpart in the west of the Colony. The Great Karroo, Upper Karroo, and the grass-covered plateaux of the east, as well as the Stormberg and Drakensberg, are all composed of nearly horizontal strata belonging to the Karroo system.

The area occupied by the Karroo formation is sharply defined by the outcrops of the Dwyka series, of which the well-known glacial conglomerate is the most important member. Though this group is thinner in the north than in the south the belt of country occupied by it is much wider in the former region on account of its lying horizontally there, while in the south the thicker (2,300 feet) representatives of the group present their edges at the surface.

There is a cardinal difference between the relationship of the Karroo formation to the underlying strata in the northern and southern areas. In the northern the conglomerate lies unconformably upon very much older rocks which had been metamorphosed by great granitic intrusions and folded into mountain ranges, of which the Asbestos Mountains and Langebergen are mere remnants, long before the Dwyka period commenced. In the southern districts, between Karroo Poort and the Gualana River, a thick band of shale and sandstone (the Lower Dwyka shales) intervenes between the conglomerate and the uppermost member of the Cape system, and no sign of discordance has been met with in traversing the upturned edges of the two formations. North of Karroo Poort the Lower Dwyka shales gradually disappear and the conglomerate comes to rest directly upon the Witteberg series, which in its turn disappears as it is followed northwards, and the two other members of the Cape system, the Bokkeveld and Table Mountain series, thin out in a similar manner, so that north of the Bokkeveld Mountain in Calvinia the conglomerate lies upon rocks of Pre-Cape age. This thinning out of the Cape formation as it is followed northwards along the western edge of the Karroo basin is mainly due to denudation in Dwyka and pre-Dwyka times. Whether it may be in part ascribed to lack of deposition towards the north is still doubtful. In neither the north nor south is the original position of the limit of the Dwyka series at the time of its maximum extension known. In the north, outliers have been found in the Kalahari Desert, and in the south the outlier south of the Worcester fault, along which it has been let down at least 10,000 feet against the Pre-Cape rocks, bears exactly the same relation to the Cape formation as in the southern part of the Karroo, viz., the Lower Dwyka shales intervene between the Witteberg beds and the conglomerate, and there is no discordance in the succession. It is probable that the Dwyka series once stretched further south than the present coast; the position of the outcrop of the series along the south of the Karroo is due to denudation having laid bare the strata involved in the folding that took place long after the deposition of the Dwyka series, probably some time during the Beaufort and Stormberg periods. The southern and south-western limits of the Karroo basin are defined by the great ridges produced by this late Karroo folding, but the northern edge of the basin is unaffected by these earth movements, and is a sinuous line whose position at any place marks the stage reached by denudation acting on horizontal or southerly-inclined strata which rest discordantly upon the ancient rocks of the north.

The Karroo basin, as we now see it, is therefore essentially due to deformation of the earth's crust at a period later than the deposition of the lower and most widely distributed of the rock series that occupy it. How far, if at all, the slight southerly dip of these strata in the northern portion of the basin is due to the circumstances of original deposition is uncertain.

The mountainous country round the south and south-west of the interior basin is a fairly-well-defined belt of folded rocks belonging chiefly to the Cape formation. Although the lower part of the Karroo formation is involved in the folds it is only preserved within the folded areas in a few synclines and where deeply sunk on the downthrow side of the Worcester fault; elsewhere, though it probably once stretched over the whole region, it has been swept away by denudation. The folded rocks have, broadly speaking, an east and west strike south of the Karroo basin, and north and south strike west of it, and the two systems of folds, called respectively the Zwartberg and Cederberg systems, from prominent mountain ranges produced by them, meet in the country between Karroo Poort and Cape Hangklip. This region where the two groups of folds meet is distinguished from other parts of the folded belt by diagonal ranges trending nearly north-east, and a less conspicuous set running north-west; these ranges represent the resultants of the two sets of forces which crumpled the strata in the south and west. The chief examples of the north (or rather north-north-west) trending ranges are the Cederbergen, Schurftebergen and Oliphant's River mountains; of the east trending ranges, the Zwartebergen, Langebergen, and Kouga mountains; of the resultant north-east ranges, the Hex River and Bier River mountains; and of the north-west ranges, the Groenland and Houwhoek mountains. The Cederberg folds are more or less symmetrical anticlines and synclines. and the Bokkeveld beds are still present in the Oliphant's River and Cold Bokkeveld synclines; the Zwartberg folds are much more pronounced, and overfolds and small thrust faults are frequent, so that inversion of the normal order of the strata involved is a conspicuous feature in the region in which they prevail.

The youngest strata found to have been involved in the Zwartberg folding are the Ecca beds, which lie at high angles along the northern flank of the northernmost ranges, and which occur on the downthrow (south) side of the Worcester fault in contact with the Malmesbury beds on the northern side. The oldest beds lying unconformably upon the folded rocks are the conglomerates of the Uitenhage series, and they are unaffected by the great fault near Worcester and by the analogous fault on the southern flank of the Zwartebergen; the Uitenhage beds pass undisturbed from the Pre-Cape rocks across the faults on to the Bokkeveld, Witteberg, Dwyka or Ecca beds, as the case may be, on the southern side of the dislocations, proving that before their deposition denudation had removed the whole of the Cape formation and the lower Karroo beds, some 14,000 feet of rock, from parts of the area. The Ecca beds are probably the equivalent of the upper Carboniferous and part of the Permian, and the Uitenhage conglomerates are not younger than the Wealden, according to the evidence given by the plant remains; so that during the Triassic and Jurassic periods the southern mountains came into existence and suffered a great amount of denudation. There is no direct evidence that any portion of the ranges south of the Karroo was exposed to the air before Ecca times: the large tracts of granite and other Pre-Cape rocks immediately underlying the Uitenhage conglomerates in the southern and south-western districts might be regarded as pointing in that direction, but the proof obtained in the Worcester area that the mountain building and the exposure of the Pre-Cape rocks in that district took place during the time interval between the Ecca and Uitenhage periods, renders it unnecessary to postulate a longer era for the production of similar results in districts where the chain of evidence is less complete. Neither the Beaufort nor the Stormberg beds have been recorded from the folded belt, and in the central basin these strata are only affected by small disturbances that cannot with certainty be correlated with the great earth-movements that gave rise to the southern ranges.

In the Cederberg region no outliers of the Uitenhage series have been met with, and though it is possible that the movements which culminated in the formation of the great anticline of the Cederberg commenced as far back as the Dwyka period, for evidence of the movement of ice, from west to east, over the lower portion of the Dwyka conglomerate, has been found in the western Karroo, the comparatively slight amount of rock removed from the anticlines negatives the idea that the area has been exposed to denudation from Triassic times to the present day. A satisfactory explanation of this question has not yet been found.

The overfolding and thrusting along the southern edge of the Karroo is towards the north ; when any fold, or group of folds, is followed from an area where the disturbance is slight to one where it is great, as in the Zwartebergen from the symmetrical anticline of Anysberg eastwards to the complicated area between Prince Albert and Klaarstroom, the arches are found to turn over northwards, so that most of the strata have a southerly dip and the younger are overlain by the older. This indicates a thrust or movement in the earth's crust from the south towards the north against a comparatively immovable block, the Karroo. In the west the movements did not reach such a magnitude, but the force probably acted in a similar manner, *i.e.*, towards the Karroo. It is interesting to note that the great dolerite intrusions, which occupy such a great extent of country within the Karroo basin, and which probably reached their present positions in late Stormberg times, barely encroach upon the folded belt. The only three dykes of dolerite of this type met with in the folded belt occur in the less-disturbed part of the Cederberg area ; others have been found in the Table Mountain sandstone of the Cape Peninsula, Van Rhyn's Dorp, and Pondoland, which lie outside the folded belt.

Though there is abundant evidence that the main portion of the movements that produced the southern ranges had taken place before the Uitenhage beds were formed, yet there are numerous localities known, from Swellendam in the west to Uniondale and Willowmore in the east, where the Uitenhage beds have been considerably disturbed along lines following approximately the direction of the earlier movements. These later disturbances manifest themselves in the northerly dips and faults with downthrow to the south affecting the Uitenhage beds as well as the older rocks, but the great crumpling and overfolding characteristic of the earlier period have not been detected in the Uitenhage beds, which were involved in the later disturbances alone. Beyond the fact that they are younger than the Uitenhage beds (Lower Cretaceous) and older than the highest gravel plateau (Sub-recent), the age of these later movements is unknown. As yet there is no evidence by which to correlate them with the Pondoland faults that let down the Dwyka and Ecca beds, and the Embotyi and Umzamba beds (Upper Cretaceous), respectively, against the Table Mountain sandstone.

That part of the south-east coast along which the sea has encroached upon the central basin is geologically similar to the tract stretching north-west from a point some miles east of Karroo Poort to the Bokkeveld escarpment west of Calvinia. The Pondoland coast belt, with the exception of the faults mentioned above, has the same structure as the Bokkeveld Mountain region; in each case the Dwyka conglomerate rests upon the Table Mountain series. In the Albany district, as in the Ceres and Worcester areas, the Bokkeveld and Witteberg series intervene between these two formations, so that there is a conformable succession throughout. This short statement of the facts shows that there is a much greater symmetry in the east and west sides of the extreme south end of the continent than appears to be the case from an inspection of a geological map. The greatest difference between the east and west is due to the faults in the east which run parallel to the coast and have the effect of dropping the strata towards the ocean. No similar feature has been found in the broad area between the Karroo basin and the Atlantic in the west, and, though that part of the Colony is not well known, we have sufficient information to make the occurrence of such faults very improbable. The known faults in the north-west are older than the Cape formation.

The Cape formation is the chief member of the rock systems in the folded belt, but inliers of the Malmesbury and Cango beds occur in the Worcester, Oudtshoorn, Mossel Bay, and Caledon Divisions south of the great ranges, and outliers of the Uitenhage series are of great importance in the same area. The Cape formation is divided up into three groups. The lowest or Table Mountain series consists of some 5,000 feet of sandstones, shales and conglomerates, of which the sandstones are by far the most important. One band of shale lies about 1,000 feet below the top of the group, and although it is only 300 feet thick it is of great interest on account of the well striated boulders that have been obtained from its lower part in Clanwilliam. These stones doubtless owe their peculiarities to glacial action, and probably reached their present position by means of floating ice; they are scattered at random through unbedded mudstone and shale. The other bands of argillaceous beds are of small extent. Conglomerates are seldom met with in the sandstones, though thick layers of conglomerate with a quartzitic matrix are known in Willowmore and Uniondale, and in the west coast districts. Well rounded white quartz pebbles irregularly scattered through the sandstone are a characteristic feature, but they occur at such wide intervals that the rock cannot be called a conglomerate. The Bokkeveld series follows the Table Mountain sandstone conformably, and contains the only Palaeozoic marine fauna known in South Africa. The fossils are of a Devonian type, and are more nearly related to those in the lower part of the Devonian beds of America than to those of later stages of that or of other countries.

The chief genera found in the Bokkeveld beds are *Phacops, Cryphaeus, Homalonotus, Dalmanites, Proetus, Stropheodonta, Orthothetes, Chonetes, Rensselaeria, Trigeria, Cryptonella, Spirifer, Ambocoelia Leptocoelia, Vitulina, Orthoceras, Bellerophon, Conularia, Palaeoneilo, Nuculites, Leda, Grammysia, Actinopteria, Modiomorpha.* The marine fossils are restricted to the lower half of the series ; the higher beds only contain a few poorly preserved plants. The Bokkeveld beds are mainly argillaceous, but there are also thick bands of sandstones which occur regularly over wide areas, but south of the Langebergen these sandstone bands are not so easily recognised as to the north, and the series becomes more argillaceous. The Witteberg series consists of quartzitic sandstones and shales from which a few plant remains are the only known fossils. The evidence obtained from the Cape formation shows that during the later half of Palaeozoic times the southern part of the Colonial area was undergoing slow depression and that great thicknesses of sands and muds were deposited under fluviatile and perhaps lacustrine conditions ; and also that at one stage the ocean gained access to this area, but soon gave place to fresh water. The fresh water conditions under which the Witteberg beds were deposited appear to have been maintained during the time represented by the Karroo formation. This great and continuous period represented by non-marine deposits probably lasted from well within the Devonian epoch to the early part of the Jurassic.

West of the folded belt and north of the Karroo basin the only rocks met with, except recent deposits and a few outliers of the Cape and Karroo formations, are older than the Cape system. On stratigraphical and lithological grounds these rocks have been divided into several series ; in the west we have the Malmesbury beds, a great group of phyllites, quartzitic rocks and limestones, about which there is but little known ; these beds have been greatly disturbed by earth movements and invaded by immense masses of granite. The metamorphism exhibited by the beds round the south end of the Namaqualand granite proves that the latter, perhaps the largest mass of granite in South Africa, is intrusive in the Malmesbury series. There are at least two other groups of Pre-Cape rocks, the Ibiquas and Nieuwerust series, in the west. The Ibiquas group consists of conglomerates, slates, shales, and sandstones ; the conglomerates contain boulders derived from the Malmesbury beds and from the granite. The Nieuwerust beds are quartzite, arkose, and shales ; the arkose is made up of fragments of the Namaqualand granite upon which these beds rest at certain places, but in other localities they lie upon the Ibiquas beds, and in others again on the Malmesbury. The areas of Nieuwerust beds at present known are characterised by the comparatively low dips of their strata and by the existence of numerous faults with downthrows towards the east. These faults are members of a group of dislocations surrounding the north and north-western sides of the Ibiquas area of Van Rhyn's Dorp and Calvinia, and they are certainly older than the Dwyka conglomerate, which overlies the rocks on either side of the fault on Ezel Kop Vlakte and Klomp Boomen. and they are very probably of Pre-Cape age.

The Cango beds are only known from the Cango district south of the Zwartebergen ; they consist of conglomerates, porphyroids and felspathic grits, slates and limestones. The conglomerates contain many varieties of rocks in the form of pebbles, including granite, but the source whence these came is uncertain. The Cango beds have been invaded by many dykes of basic and intermediate composition, but no intrusion of granite occurs in them.

In the northern divisions, from Prieska and Kenhardt to the borders of Rhodesia, there is an entirely different succession of pre-Cape rocks from those known in the south and west and it is still uncertain whether any one series of beds is common to the two areas. The oldest of the northern groups is probably the 'Keis series, quartzites and quartz-schists, which form some hills in Prieska, and which are unconformably overlain by the Campbell Rand group in Griqualand West. The quartzites and cherty limestones of the Campbell Rand series build up the escarpment of that name in Griqualand West, and are probably the direct continuation of the Black Reef and dolomite formations of the Transvaal. In Prieska the Campbell Rand beds are overlain conformably by the Griquatown beds, a series of banded quartzites and jaspers containing magnetite, and heavy ferruginous rocks in which the iron is not in the form of magnetite ; these beds form the Doornbergen in Prieska and the Asbestos and other ranges in Griqualand West. The well-known amphibole, crocidolite, and its various altered forms occur in veins in this series. It is probable that the Griquatown beds are the equivalents of the Pretoria series. Overlying the Campbell Rand rocks unconformably are the conglomerates and quartzites of the Matsap series ; they contain fragments of the magnetite rocks probably derived from the Griquatown beds. There is an important group of amygdaloidal lavas in Prieska and Griqualand West, which probably belong to the Ventersdorp series of the Transvaal, but in Prieska evidence has not yet been obtained to prove that the Zeekoe Baard amygdaloids underlie the Campbell Rand beds. A somewhat remarkable breccia in connection with these lavas was found at Ezel Klauw in Prieska during the survey of that Division, and the recent work in the Transvaal and Bechuanaland has shown that a similar breccia is associated with the Ventersdorp lavas below the Black Reef series.

There are many varieties of igneous rocks associated with the ancient sedimentary beds of Prieska and Griqualand West. Granite and gneiss are the most abundant, and they were apparently intruded after the Griquatown beds were laid down. Ampibolites, augite-granulites serpentines, and gabbros also occur. The Namaqualand granite is remarkable in being traversed by bodies of enstatite-bearing rock which contains copper ore as one of its constituent minerals.

The Pre-Cape rocks of the north form several important hill ranges whose trend is in the direction of the strike of the rocks, but these hills are evidently very much smaller than the mountains, of which they are the remnants. This great denudation took place mainly before the deposition of the Dwyka conglomerate, for outliers and tongues of the latter are found partially filling valleys in the hilly country, and the proportion of the rock removed since the old hills were again laid bare by the removal of the unconformably overlying beds is clearly insignificant compared with the results of the earlier denudation. The Dwyka conglomerate and the overlying shales are quite unaffected by the earth movements that folded the old rocks, though in the south of the Colony the conglomerate is involved in the folds that affect the Cape formation ; hence we see that the folded strata in the north were disturbed at a much earlier period than the Cape formation in the south, and a consideration of all the evidence leads to the belief that the northern folded rocks are themselves much older than the Cape formation.

In the southern districts the Pre-Cape sedimentary rocks do not make conspicuous features in the landscape. There the granite masses form the only conspicuous hills, with the exception of outliers of Table Mountain sandstone, in the area chiefly occupied by the Pre-Cape rocks outside the folded belt ; the Paarl Mountain is an example of these granite hills.

The Karroo formation is from some points of view the most interesting in the country. At its base are found the glacial deposits which afford more obvious evidence of glaciation on a grand scale in comparatively early times (Carboniferous) than any other known strata ; and the higher series contain a wealth of reptilian remains that are the more valuable on account of their preservation in a great vertical succession of strata probably laid down under more or less constant conditions. When one considers the results hitherto obtained by comparative anatomists from the material already collected, in many cases imperfectly and without sufficient record of stratigraphical position, it is certain that much greater results will be arrived at in the near future from the more systematic collecting that will probably be carried out.

The general distribution of the Dwyka series has already been described. The most important member of the series is the conglomerate which is both underlain and overlain by thinner groups of shale and sandstone south of the Karroo. The conglomerate has a dark bluish matrix in the southern districts, where the rock has been considerably altered from its original condition by hardening due to earth movements, but in the north and north-west the matrix is usually a grey mudstone. The matrix has been found to be laminated in places in each district where the conglomerate has been examined, but both in the north and south there are often considerable thicknesses of conglomerate without noticeable lamination ;

these thin-bedded portions are not known to be confined to particular horizons. It is rarely that definite bands of boulders occur; as a rule both the large and small boulders are scattered without any apparent arrangement through the matrix whether the latter be laminated or not. In the western Karroo a layer about eight feet thick of large boulders has been followed for several miles, and south of Laingsburg there is a similar bed. In the southern Karroo the lowest part of the conglomerate contains small pebbles only, and it differs from the upper part of the Lower Dwyka shales merely by the presence of these pebbles. The conglomerate in the south gives rise to outcrops of a peculiar appearance owing to the roughly-developed cleavage, which causes the outcrops to assume pillowy forms. The more or less lenticular masses bounded by curved cleavage cracks lie parallel to the strike of the beds and of the rocks forming the ranges south of the Karroo. Near Karroo Poort, where the east and west folds meet those which trend north and south, the conglomerate has no longer the usual pillow structure but a modification of it, and weathers out into conical masses with more or less circular sections instead of the elliptical sections given by the pillowy rock. Northwards from Karroo Poort the conglomerate loses this rough cleavage and becomes more and more like the rock seen near Prieska and Hopetown, a somewhat hardened mudstone. The pebbles and boulders were derived from a great variety of rocks of sedimentary, metamorphic, and igneous origin. In the south, south-west, and north there are amongst the boulders many varieties of rocks recognisable as belonging to groups that occur in Griqualand West, Prieska and Namaqualand. In the case of the Pondoland conglomerate there are fewer rocks whose sources are known, but some of the boulders may have come from the north of the Colony or the Transvaal. In every district where the conglomerate has been observed by the officers of the Geological Survey typically scratched blocks, such as are found in modern and Pleistocene glacial deposits in the northern hemisphere, have been obtained from it. These striated stones are more numerous, or rather, more easily found, to the north and west of the Karroo, where the conglomerate is a comparatively soft rock, than in the south, where earth movements have affected it, and where the pebbles usually break in the attempt to free them from their matrix. In Pondoland, again, the matrix becomes less hard, and well-striated boulders can be obtained with ease. In the country near the Orange and Vaal rivers the old rock surface on which the conglomerate rests is exposed at several places, and well preserved *roches moutonnées* have been found at Jackal's Water in Prieska, Vilet's Kuil in Hopetown, and at the junction of the Orange and Vaal rivers; these rock surfaces are of quartzite, volcanic rocks, and limestones respectively. In these localities the form of the surfaces and the direction of the striæ on them show that the ice moved southwards; this evidence is in agreement with that of a similar nature obtained in the Transvaal, and with our knowledge as to the probable sources of certain of the boulders in the conglomerate round the Karroo. In the west of the Karroo, at Eland's Vley, there is preserved a surface of previously-deposited conglomerate over which solid ice travelled; the superficial boulders were pressed down flush with this surface and striated in a direction parallel with well-marked shallow furrows on the matrix. This "boulder-pavement" is covered by a considerable thickness of later conglomerate.

The conglomerate is overlain by the so-called Upper Dwyka shales, which always include black shales that appear white at their outcrop owing to the oxidation of the carbonaceous matter in them. These beds are probably on the horizon of the coal measures of Vereeniging, but in spite of the numerous exposures round the Colonial portion of the Karroo basin and the labours of prospectors, no coal has been found in them within Cape Colony. At Vereeniging a fairly rich flora occurs in these beds or close above them, but in Cape Colony the only fossil that is certainly known from them is *Mesosaurus*, though several plants belonging to species that occur at Vereeniging have been found in the overlying Ecca beds in the north of the Karroo and at Worcester. In the south of the Colony the uppermost bed of black, white-weathering chert is taken as the top of the Upper Dwyka shales, but north-east of the Calvinia district this means of separating the two series has not yet been found. It has been found convenient to limit the term "Ecca beds" to the rocks that lie between the Upper Dwyka shales and the lowest beds that contain *Pareiasaurus*; thus defined the Ecca beds in the southern Karroo include a considerable (some 2,600 feet) thickness of sandstone and shale containing *Glossopteris*, *Gangamopteris*, and *Phyllotheca*, but the first and last named plants extend upwards into the Beaufort series. Calcareous nodules are abundant in many of the shales. The Ecca beds occupy the great Karroo south of a line drawn east and west near Prince Albert Road; near Laingsburg the thick sandstones belonging to the middle part of the series are conspicuous on account of their having been folded, and they appear in long high hog-back ridges on either side of the railway line. There is no obvious change in the country where the Beaufort beds come in. The chief interest of the Beaufort beds lies in the abundance of fossil reptiles contained in them. An account of these and of the Stormberg reptiles will be found in another chapter of this handbook, so we need here touch upon their stratigraphical value only. The exact position from which many of the species came is not known, but there is little doubt that the Beaufort and Stormberg beds will be divided up into definite groups by their help. At present it is known that *Pareiasaurus*, *Oudenodon*, and large Dinocephalians occur in the lowest part of the Beaufort series, and that these beds are followed by strata containing Anomodonts, of which *Dicynodon* is one of the more important, many Therocephalians and some other reptiles, as well as fish, *Palaeoniscus*, two genera of Lamellibranchs, *Palaeomutela* and *Palaeanodonta*, and the plants *Schizoneura* and *Glossopteris*; the uppermost (Burghersdorp) group of the Beaufort series is characterised by *Cynognathus*, *Microgomphodon*, *Batrachosaurus*, and *Dicynodon latifrons*, and the fishes *Semionotus*, *Cleithrolepis* also occur in them and not in the Stormberg beds, as was formerly thought to be the case. These groups of strata are ill-defined, and their exact limits, both vertical and horizontal, are unknown; *Glossopteris* occurs in the Burghersdorp beds, but it has not been found in the succeeding Molteno group, where the chief plants are *Thinnfeldia*, *Cladophlebis*, *Taeniopteris*, *Chiropteris*, *Baiera*, *Phoenicopsis*, and *Stenopteris*.

Some Phyllocarid crustaceans and wings of orthopterous insects allied to cockroaches have recently been found in shales included in the Cave sandstone, and a crocodile, *Notochampsa*, has been obtained from the Cave sandstone and Red beds; *Ceratodus* is found in the Red beds; Dinosaurs also occur in Cave sandstone and Red beds.

From the base of the Ecca to the top of the Burghersdorp beds there is little variation in the nature of the shales and sandstones, often slightly calcareous, that succeed each other in monotonous regularity. The thicker groups of sandstone strata in the Beaufort series give rise to more or less extensive plateaux and terraces on the face of the great Nieuweveld escarpment and its analogues. In the Molteno beds coal seams are of importance, but in the Beaufort series the only known coals are thin and not payable. The coarse sandstones in the Molteno beds differ from the sandstones at lower horizons in the larger size of their constituent grains and in the extensive deposition of quartz on the original quartz-grains, which has often produced small pyramidal crystals. The occurrence of pebbles, occasionally in sufficient abundance to form beds of conglomerate, is much more frequent than in the Beaufort or Ecca series. These facts prove that in Stormberg times the area of deposition within our borders was narrower than previously, and that the land was nearer the north-eastern part of the present Colonial watershed. It is very probable that the southern mountain belt was in existence during the deposition of the Molteno beds, and that it was connected with land which lay off the present coast of Pondoland and Natal.

Slight local unconformities are frequently met with throughout the beds above the Dwyka series; usually a hollow in shale or mudstone is filled in with sandstone belonging to the overlying bed. The sandstone is often underlain by a few inches of clay-pellet conglomerate, in which lumps of shale or mudstone are embedded in a sandy matrix; pebbles of granite or other rock are very rarely met with in these conglomerates but rolled pieces of bone are not infrequently seen. False bedding and ripple-marked surfaces recur again and again throughout the Karroo formation. The rocks were evidently deposited in shallow water, and as the maximum thickness of the Karroo formation, excluding the Dwyka and volcanic beds, is probably not less than 14,000 feet, the area of deposition must have undergone slow depression. The numerous local unconformities may mean that parts of the area were above the water for short periods in the form of mud islands, which sank or were washed away after a short existence.

The Red beds and Cave sandstone have different characters from the lower strata. The Red beds comprise a varying thickness of red shales and sandstones, and the Cave sandstone is a very peculiar thick-bedded yellowish-white sandstone. During the deposition of the Cave sandstone volcanic activity commenced in the Drakensberg region, for both lava and ash beds are intercalated with the sandstone, and at places the volcanic beds lie directly upon the Red beds, the Cave sandstone having been locally removed by denudation before the volcanic outburst. The volcanoes were spread broadcast over a large area, including Basutoland, lying north-west of the Drakensberg escarpment, only a few necks have been found on the coast side of the escarpment, and they lie within a few miles of it. Lavas were the chief product of the volcanoes, and they are basic andesites, basalts and dolerites. The necks are filled with volcanic tuff, breccias containing much material of non-volcanic origin, and lava. For a considerable time the lavas were poured out under water. The thickness of the volcanic series reaches 4,000 feet in the Colony, but a considerable part of the group must have been removed by denudation.

The Karroo formation cannot yet be correlated at all closely with European strata, but recent discoveries in Russia point to the *Pareiasaurus* and *Dicynodon* beds being of Permian age ; this is in agreement with the conclusion drawn by Seward from the Ecca plants, that they are probably of Upper Carboniferous age. The Dwyka series must therefore be regarded as of Carboniferous age. The Molteno plants are considered by Seward to belong to the Rhaetic, and the recently discovered *Notochampsa* from the Red beds and Cave sandstone is a crocodile according to Broom, and its nearest ally is *Pelagosaurus* of the Upper Lias ; true crocodiles are not known from the Trias. It is probable, therefore, that the upper part of the Stormberg series is of Jurassic age, and that the volcanic outbursts belong to that period.

The great similarity in palaeontological and lithological characters between the Karroo formation and the Gondwana beds of India and the related beds of Australia is one of the facts that point to very material differences between the distribution of land in former times, and that which now exists.

It is worthy of notice that though from the base of the Cape to the top of the Karroo formation a thickness of over 26,000 feet of sediment, marine fossils are known from only about 1,500 feet of the Bokkeveld series, and consequently the bulk of these beds was laid down in a non-marine area, yet there are no beds of soluble salts, such as gypsum and common salt, in them. The gypsum and other salts which are met with in the country occupied by the Dwyka series are products of weathering and not original constituents of the strata. We have, therefore, no evidence that any part of this body of rock was formed in a region without an outlet to the sea.

The volcanic beds of the Stormberg are traversed by dykes of dolerite, which apparently belong to the great group of dolerite intrusions that are very widely distributed north of the Great Karroo. Sheets belonging to these intrusions crown a great part of the Roggeveld-Nieuweveld escarpment and many of the flat-topped hills behind it. Their northern boundary is not known, but, with the exception of a few dykes in the less disturbed part of the folded belt and the Cape Peninsula, they no not occur south of the line marked on the accompanying map (p. 259). Individual sheets have been traced more than 100 miles through the country, and they may attain a thickness of 900 feet. The intrusion of these great masses of dolerite was not accompanied by great disturbances of the rocks; the dolerite seems to have welled up and along planes that offered but slight resistance to its passage.

The Cretaceous rocks occur only near the coast; they are not found north of the Zwartebergen. They are easily divided into two groups, an older and a younger. The older group is known as the Uitenhage formation; in the Uitenhage district it is composed of three members: the Enon beds, consisting of conglomerates and sands, at the base; the Wood beds, clays, sands and limestones, containing a number of fossil plants and a few mollusca; and the Sunday's River beds with a rich marine fauna. The maximum thickness of these beds is unknown, but it must be over 2,000 feet. There are important outliers of the series in Oudtshoorn, Knysna, Willowmore, Mossel Bay, Riversdale, Swellendam and Worcester. In all these cases the Uitenhage beds occupy old valleys excavated in the Pre-Cape, Cape and lower part of the Karroo formations; but the valleys have been deepened by earth movements, either in the form of a synclinal fold as in Uitenhage, or by normal faults with southern downthrow as in Willowmore, and probably also in several of the other outliers. These movements took place in post-Uitenhage times and followed the directions of the pre-Uitenhage disturbances, though they were on a much smaller scale. The plants of the Uitenhage beds have closer relationship to those of the Wealden of England than to those of Jurassic strata; the chief genera are *Onychiopsis*, *Cladophlebis*, *Sphenopteris*, and *Zamites*. The age of the marine fauna of the Sunday's River beds is shown by the genera *Hamites*, *Baculites*, *Crioceras*, *Olcostephanus*, certain *Trigoniae*, and *Ptychomya* to be Neocomian (Lower Cretaceous). These molluscs are almost restricted to the beds in the Uitenhage district, for *Trigonia conocardiiformis* is the only member of the fauna yet found elsewhere in the Colony, in the sandstones and conglomerate of Plettenberg Bay.

The Pondoland Cretaceous beds are found only on the coast north-east of St. John's River. They are faulted down against the Table Mountain series, below the Egossa Forest the Ecca beds, lying unconformably under the Embotyi beds, intervene for a short distance between them and the fault. The Umzamba, or marine series, is a group of sandy limestones, containing a large number of mollusca which point to the age of the beds being Upper Senonian. The Embotyi beds are conglomerates and sands; their chief interest lies in the boulders of dolerite contained in them, for the source of the boulders was evidently the intrusions of late or post-Stormberg age, and a later limit to the date of the intrusions is thus fixed.

Within the Colony there are many volcanic pipes of peculiar character scattered irregularly through the country. They occur between Matatiele on the east and Van Rhyn's Dorp on the west, and from Heidelberg in the south to Griqualand West. They are of various dimensions, and some are elongated and resemble dykes more than the usual form of volcanic pipes. The contents vary greatly; at Spiegel River in Riversdale, and in Sutherland melilite-basalt fills pipes and dykes, at places entirely, and at others only partly, the rest of the contents being breccia or tuff. Other pipes in Sutherland are filled with a serpentinous breccia which contains large pieces of ilmenite, augite, hornblende, mica, and of several varieties of igneous and sedimentary rocks. At Kimberley a somewhat similar serpentinous breccia contains diamond in addition to many minerals common to it and other pipes of this group. At Saltpetre Kop in Sutherland both the pipes and dykes are filled with breccia that was chiefly derived from sedimentary rocks, but some of the minerals found in the serpentinous breccia occur in these rocks also. Near Van Rhyn's Dorp there is a large pipe filled entirely with breccia made up of non-volcanic rocks. As to the age of these pipes there is not much known; the Spiegel River pipe is younger than the Uitenhage beds through which it passes; the other pipes traverse the Karroo or Pre-Cape formations. There are many intermediate stages between the extreme types of Spiegel River and Van Rhyn's Dorp, and all the pipes are characterised by a complete independence of the known tectonic structure of the country; they often, but not invariably, occur in groups, but their distribution seems to be quite sporadic.

The superficial sub-recent deposits of the southern part of the Colony are widely spread and include many varieties of rock, but a connected history of them has not yet been made out. The high-level gravels are of great importance in the country south of the great Karroo; they occur at levels of from 600 to 2,000 feet above the sea, and traces of still higher terraces have been observed. These are usually unfossiliferous gravels and quartzites; the quartzites have probably been formed in fresh water marshy places. Similar quartzites occur at very slight elevations in the Cape and Malmesbury Divisions. Along the coast raised beaches and hardened sand-dunes exist in many localities, and there is evidence to connect the oldest of these with the gravels and quartzites of the 600--1,200 feet plateau just behind the coast.

The most interesting fossil from the recent deposits is *Bubalus baini*, a gigantic ox, obtained from alluvial loam near the Modder River.

The chief conclusions to be drawn from the recent deposits is that the whole of the Colony, south of the main watershed at least, and probably the drainage basin of the Orange River also, has risen more or less continuously for a long period; a conclusion that is in agreement with the fact that many of the rivers have steep gradients to within a few miles of the sea; some fall through 1,000 feet in the last two miles of their courses.

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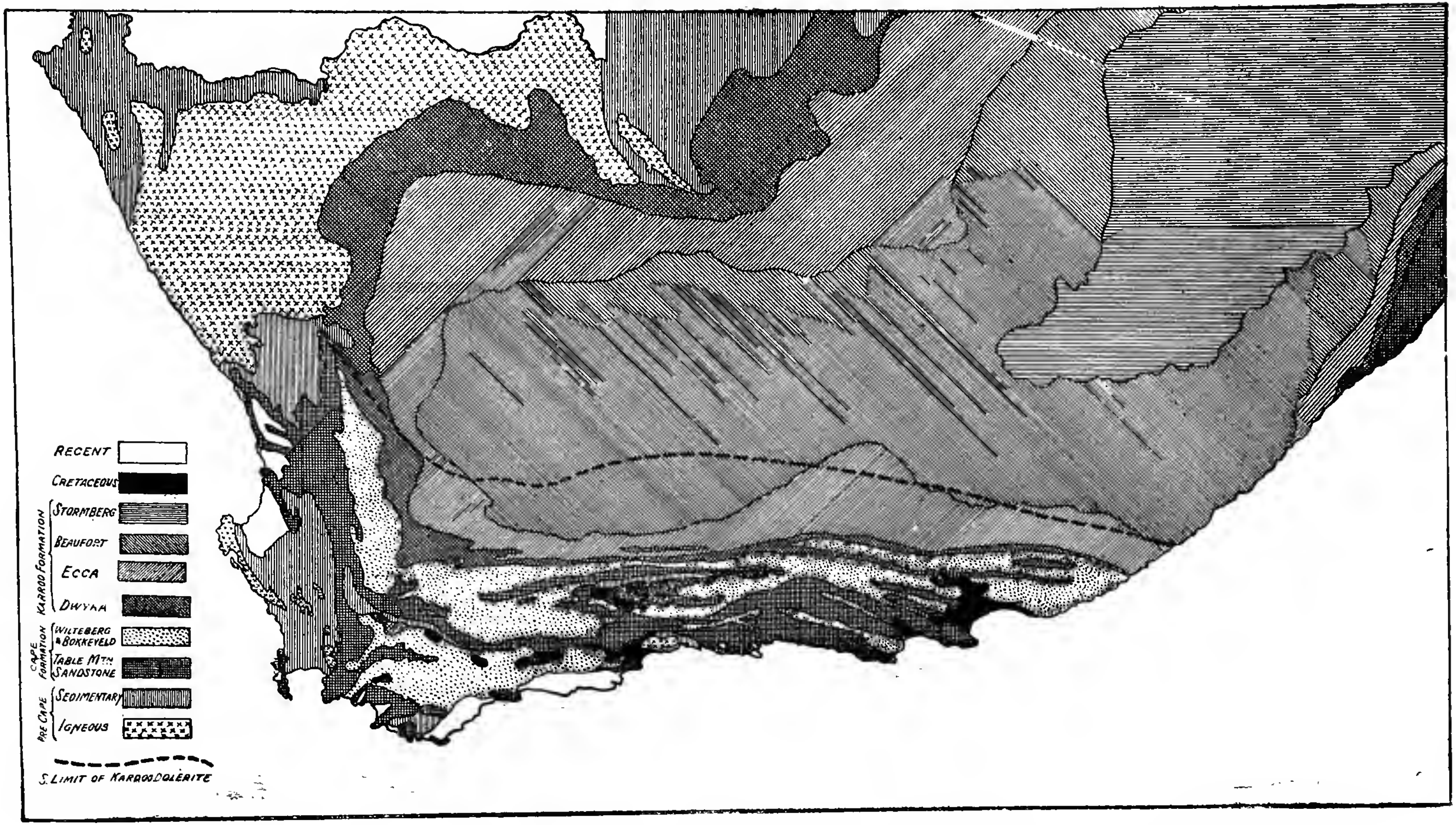
TABLE OF FORMATIONS.

			Approximate Maximum Thickness.	Probable European Equivalents.
Recent Deposits.		Alluvial and estuarine deposits of modern rivers.		
		Dune sands and limestones derived from them.		
		Sands of the Western Sandveld, and laterites.		
		High-level gravels and surface quartzites.		
Cretaceous System.	Pondoland Cretaceous Series.	Umzamba (marine) beds.		Cretaceous.
		Embotyi beds.		Cretaceous.
	Uitenhage Series	Sunday River (marine) beds		Cretaceous.
		Wood beds	... 1,400 ft.	Cretaceous.
		Enon beds	... 500 ft.	Cretaceous.
Karroo System.	Stormberg Series	Volcanic beds	... 4,000 ft.	Jurassic.
		Cave sandstone	... 800 ft.	Jurassic.
		Red beds	... 1,400 ft.	Jurassic.
		Molteno beds	... 2,000 ft.	Trias.
	Beaufort Series	Burghersdorp beds	5,000 ft. ?	Trias.
		Dicynodon beds		Permian.
		Pareiasaurus beds		Permian.
	Ecca Series	Shales and thin sandstones	2,600 ft.	Permian.
		Laingsburg beds		Carboniferous.
		Shales		Carboniferous.
	Dwyka Series	Upper Shales	... 600 ft.	Carboniferous.
		Conglomerates	... 1,000 ft.	Carboniferous.
		Lower Shales	... 700 ft.	Carboniferous.
Cape System.	Witteberg Series		... 2,500 ft.	Carboniferous.
	Bokkeveld Series		... 2,500 ft.	Devonian.
	Table Mountain Series		... 5,000 ft.	Devonian.

	(In North.)	(In West.)	(In South.)
Pre-Cape Rocks.	Matsap Series.	Nieuwerust beds.	Cango beds.
	....	....	....
	Griquatown Series.	Ibiquas beds.	Malmesbury beds.
	Campbell Rand Series.	....	
	Ventersdorp beds. ?	Malmesbury beds.	
	Keis Series.		



Map Showing the Areas Occupied by Different Geological Formations in Cape Colony.

2. GEOLOGY OF NATAL AND ZULULAND.*

BY WILLIAM ANDERSON, F.R.S.E., F.G.S., GOVERNMENT GEOLOGIST, NATAL.

A resumé of the papers dealing with the geology of Natal is published in the first report of the Geological Survey (1901). The earliest geological observations, recorded in 1855,[1] occur as far back as 1824, when Mr. H. F. Fynn discovered the fossiliferous Cretaceous deposits on the south-east coast of Natal, at the mouths of the Umtamvuna, Umzambani and Impenyati rivers. Up to the end of the century references to Natal geology were not of frequent occurrence. The most important of these are papers by Mr. C. L. Griesbach [2] and Dr. Sutherland.[3] In the case of the former an admirable sketch of Natal geology, accompanied by a geological map was published in the Journal of the Geological Society of London. Dr. Sutherland, during his tenure of office as Surveyor-General, produced a number of valuable papers, dealing with subjects of special interest in the geology of South Africa. Within later years Natal has received much more attention from South African geologists, owing to the interest which has been taken in her coal resources, together with the fact that during the war the country became known as a feasibly-accessible area.

The physical configuration of Natal and Zululand results from a series of plateaux, occurring at various levels between the coast and the high plateaux of the Orange River Colony and the Southern Transvaal. The principal rivers have their sources on the eastern slopes of the Drakensberg Range, which culminates within 160 miles of the coast in Mont-aux-sources, 11,500 feet above sea level. In their course to the ocean they have carved the main valleys in a more or less south-easterly direction, through the series of plateaux, and therefore across the various formations, whose outcrops generally run parallel to the coast. In the majority of cases they are deeply cut, and present, particularly in the lower part of their courses, extremely rugged features, where they have been eroded through the Palæozoic formations and the granites. The mountains are, in all cases, mountains of denudation, while the sand dunes of the littoral are hills of accumulation. They are very diverse in form, but a prevailing feature, which occurs in almost every district, is the flat, table-topped mountain or hill, usually resulting from the presence of sandstone or basalt as a capping.

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* For List of Authorities see end of Paper.

In Zululand the interior does not rise to so great a height, the highest point in the Province being the Qudeni Mountain in the Nkandhla district, which is about 6,000 feet above sea level. The flat, sandy littoral varies from 5 to 50 miles in width, while some of the sand hills fringing the coast line are said to attain a height of 600 feet. The principal river, the Umfolosi, which enters the sea at the outlet of Saint Lucia Lake, drains nearly half the area of the Province. Lakes of large size occur along the littoral, of which St. Lucia, Kosi and Sibayi are the largest. The two first are salt, while the last-mentioned is quite fresh and has no surface opening to the sea. The Umhlatuzi lagoon at the mouth of the river of that name has been proposed as a harbour for Zululand.

The general geology is of a very simple character. It consists of an axis of granitic and metamorphic rocks, which are exposed by denudation, at a varying distance from the coast, from St. John's River mouth through Natal, Western Zululand into Swaziland. This outcrop gradually widens as it is followed northwards, until it forms the chief rock exposure in Swaziland. Flanking both sides of this axis, geologically the most ancient portion of the East Coast, the oldest sedimentary formations rest unconformably against each other. These are representatives of the Lower Witwatersrand Series, the Table Mountain Sandstones, and the Ecca Glacial Conglomerate. To the west of this axis the older Palæozoic rocks are covered by a conformable series, beginning with the Ecca Shales, the Beaufort Beds, the Stormberg Beds, the Red Beds, the Cave Sandstones, and finishing, on the top of the Drakensberg Range, with the basaltic lavas, which rest unconformably on the top of the whole Karoo Series. The newer Secondary and Tertiary rocks only occur as isolated outliers fringing the coast of Natal, and in Zululand form, below the Pleistocene sands, the rocks of the littoral, which, in the north, extend 50 miles inland. These younger rocks never occur on the higher plateaux of the uplands, while rocks of more recent age are only present on the coast as sand dunes, raised beaches, etc., and inland as lake and alluvial deposits.

The following is a list of the geological formations which, up to the present, I have observed in this Colony and Zululand. In reference to the Cretaceous, the beds from the three different localities are not arranged chronologically :—

Recent and Pleistocene.	Cave deposits with remains of primitive man, river and lake alluvial deposits, diatomaceous earth, surface ironstone, raised beaches and wind-blown sands of coast.
Tertiary.	Calcareous marls, clays and lignites with variously coloured sands, sandstones and conglomerates containing a marine fauna; Foraminifera, Mollusca, Crustacea, Pisces, Reptilia and Mammalia. Calcareous sandstones of the Bluff, Durban (probably here).

Cretaceous.	Umtamvuna Beds, South-East Coast, Natal. Littoral of Zululand. The Bluff, Durban (in bore).
Upper Karoo.	Plateaux Basalts, top of Drakensberg Range. Cave Sandstones, Drakensberg Range. Red Beds, Drakensberg Range.
Lower Karoo.	Stormberg Series, Drakensberg Range. Beaufort Beds, west centre of Colony.
Permo-Carboniferous.	Ecca Coal-bearing Series. Ecca Shales. Ecca glacial conglomerate.
Silurian.	Table Mountain Sandstones.
Lower Transvaal.	Hospital Hill Series, Nkandhla District and Umfolosi River, south of Ulundi, Zululand.
Swaziland Series.	Gneisses, schists, marbles, etc. Granites.

(The black lines show unconformities.)

The oldest series of rocks on the East Coast consist of granites, gneisses and schists, which outcrop over large areas in each of the three divisions of this Colony. They form a wide north-east and south-west belt, extending through Natal and crossing the Tugela River into Nqutu, Nkandhla and the Melmoth districts of Zululand, while in Vryheid and Utrecht districts, their exposures are very extensive.

The granites are usually porphyritic, hornblendic or micaceous, and either grey or red in colour. The grey granites are more common than the red, and among both there is great variety, as regards texture and composition. A large mass of red granite appears to the south of Park Rynie in the Umzinto district, which has been used in Durban as a building stone. In the Glendale Valley in Victoria County they are much sheared and garnetiferous, and contain a pinkish felspar. At Inchanga they are grey and porphyritic. Inland from Umzinto, in the neighbourhood of Dumisa, gold-bearing quartz reefs have been worked in the granite, but without payable results. The degradation of these granites often produces, locally, many remarkably-shaped monoliths of enormous size, which are in some instances grouped together so as to present a wonderful likeness (although on a much larger scale) to the Druidical remains of Europe. One such group occurs near Isidumbeni Police Camp, a few miles to the east of the Noodsberg Mountains, close to the main road between Pietermaritzburg and Stanger.

The gneisses and schists usually occur in close association with the granites. They vary greatly in composition, being hornblendic or micaceous or contain sericite, andalusite and many other minerals.

In some districts the presence of felspathic veins is a marked feature. This is so in the Engoye Mountains, near Eshowe, in Zululand, where these rocks appear to be seamed with them in a most extraordinary manner. In most of the granitic areas the exposures of the gneisses and schists are of no great extent, but in the Engoye Mountains, in the valley of the Tugela River below its junction with the Buffalo, and in the lower reaches of the Umzimkulu River in Natal they outcrop very extensively. In the two last-named localities metamorphic limestones occur among them. These should be of considerable value, as calcareous rocks of this kind are seldom or never present in any of the other formations of the Colony; with the exception of the limited outcrops of the calcareous sandstones and limestones associated with the Cretaceous and Tertiary rocks of the coast.

These rocks are entirely distinct from the less metamorphosed rocks, which will be mentioned later on and which usually occur resting upon them. In fact, it has always seemed to me, since I began the study of the metamorphic rocks of the East Coast, that it was more than probable that this series of gneisses and schists with inter-bedded marbles would prove to be a distinct series between the Lower Witwatersrand Beds and the granites. They are probably equivalent to the Swaziland Series of Mr. Hatch,[4] which he describes from Mont Marè, near Pietersburg.

In the north-western part of the Melmoth district, which chiefly consists of the ancient granites, gneisses and schists, overlaid by Table Mountain Sandstones and local patches of Ecca Glacial Conglomerate, the next youngest series of rocks appears. They occur on the Umhlatuzi River, between Melmoth and Nkandhla, and also on the White Umfolosi River, above Ulundi Plains. They are usually highly tilted and consist of quartzites, altered conglomerates and jasperoid slates. They are only exposed over a very small area in Zululand but across the border, in the Vryheid district, they are extensively developed. Both the quartzites and conglomerates, the latter of which are true banket in character, have been known to carry gold, but not, so far, in payable quantities. It is probable, as Dr. Molengraaff has suggested, that they represent some portion of the Witwatersrand Series, probably about the horizon of the Hospital Hill Series. They have not, however, yet been worked up, but there is little doubt that their study will prove of a most interesting character, as it has been suggested, by some Transvaal geologists, that the Witwatersrand Series may prove to be the equivalents of the Table Mountain Sandstones, so well developed in this district, which therefore lends itself to the investigation of a very important and interesting problem.

Some of the most important formations in the Transvaal and Cape Colony are absent in Natal and Zululand. The chief among these is the upper Witwatersrand Beds and the Klip River Amygdaloid, the whole Transvaal System, consisting of the Black Reef Series, the Dolomites, the Gatsrand and Magaliesberg Series, Red Granites and Waterberg Sandstones. Of the Cape Colony formations the omissions are the Ibiquas and Cango Series, and above the Table Mountain Sandstones the Bokkeveld and Witteberg Series.

The Table Mountain Sandstones rest unconformably upon the more ancient granites and metamorphic rocks. Their outcrop is very extensive, chiefly close to the coast, but it extends inland as far as Table Mountain near Pietermaritzburg and further north to the Noodsberg and Krantz Kop districts and to the western border of Zululand near Melmoth. To the east of the latter place the beds attain a thickness of about 2,000 feet but, as a rule, there are only a few hundred feet of the basement beds left. The formation is characterised by the almost complete absence of shales and it is very rarely quartzitic. The beds are usually thin and false bedded. This can be well seen at the railway ballast quarry near Pinetown. The section exposed in the railway station at Inchanga exhibits a typical example of the occurrence of the shales, when they are present among these sandstones. In all cases they are horizontal, and often the basement conglomerates of the series are, to a certain extent, gold-bearing. This is the case in Victoria County near Umhlali where there has lately been an effort to establish a gold-field. These beds have been confounded by the uninitiated with the banket of the Witwatersrand Series, but the differences are very wide. In the first place the former are still in their original horizontal position and are entirely unmetamorphosed; while the latter, the Rand banket, are usually highly tilted, and have undergone extensive metamorphism. Again, the gold in the former is entirely alluvial gold, derived from the degradation of the granites and metamorphic rocks on which they rest, and from which the material was derived to form them; while in the latter case, besides the original alluvial gold, there has been subsequently introduced into the banket, probably during its metamorphism, quantities of gold in solution, which has entered into chemical combination with the pyrites, so plentifully distributed through the banket. In many other districts similar occurrences have been met with, but none of them have ever turned out to be paying concerns, purely from the fact that the gold is distributed widely in patches through the conglomerate and not concentrated, as it would be if found in the alluvial of an old river channel.

A magnificent example of, the effects of denudation on, and the occurrence of the Table Mountain Sandstones in their relation to the granites and gneisses, is to be seen from the main line of railway immediately to the south of Botha's Hill Station, which is situated on the narrow neck forming the watershed between the Umgeni and Umlaas rivers. Immediately the train leaves this station going towards Durban, the railway line descends a cutting in the lowest beds of the Table Mountain Sandstones. For about a mile the view to the north-east is marvellous in its comprehensiveness; for 30 miles the eye wanders over the valley of the Umgeni River and the Inanda division, over a thousand feet below, formed of low, beautifully-rounded hills, and many similar hills of some magnitude, while away on the sky line the Table Mountain, the Noodsberg and the coastal plateau of Victoria County show up as precipitous scarps, as if enclosing this immense area of well-rounded hills of granite with an encircling wall of Table Mountain Sandstones. The view is an example of the most picturesque scenery of Natal and of the most important kind of the effects of denudation, for over the entire area of exposed granitic hills the Table Mountain Sandstones have been at one time continuous.

A huge unconformity exists between the Table Mountain Sandstones and the succeeding formation present in Natal, the Ecca Glacial Conglomerate. This gap in the succession is represented by the Witteberg and Bokkeveld Series of Cape Colony, and indicates an extended period of time when the East Coast area was not submerged. These terrestrial conditions obtained right through the Ecca glacial period, except that most of the land surface became covered with ice, the evidences of whose presence is still well seen in the beautifully-striated pavements and *roche moutonnèe* so frequently present on exposed surfaces of Table Mountain Sandstones, and the relics of whose action are the extensive deposits of morainic material which we now know as the Ecca Glacial Conglomerate.

This glacial deposit occupies extensive areas in all three divisions of the Colony. It is present from near the coast of Zululand right across that Province to the north-west part of the Vryheid district. In Natal its western limit is roughly a line parallel to the coast drawn through Pietermaritzburg. Further westward it is covered by the younger Karoo formations. Its outcrop flanks both sides of the metamorphic area from St. John's River mouth to the Tugela River, and isolated outliers of it are dotted along the coast, as far north as the latter river. It rarely attains any great thickness, but in some cases, owing to the position it occupies with regard to the old land surface, where it rests upon a slope, it simulates great thickness. A case in point occurs at the junction of the Umquabane and Umkomaas rivers to the west of Richmond where it outcrops over the whole of the hill in the fork formed by their junction. It seems as if its thickness was equal to the height of the hill, but it is quite evident that it is only a comparatively thin deposit resting upon an old Palæozoic slope. With regard to the relative positions in which the outcrops in one district occupy to one another, it is an exceedingly common thing to find that the various outcrops occur at many different levels. A case in point occurs some miles to the north of Eshowe, in the Umhlatuzi River valley, where the river is now cutting its course through the Ecca Glacial Conglomerate, while the hills of Table Mountain Sandstone on its southern side are capped by the same conglomerate. The distance between the two is only a few miles and the difference of level over 1,500 feet. Shaley deposits never occur either below or in the conglomerate ; occasionally sandy deposits of local and limited extent are present in it, as at Ulundi. No coal or carbonaceous deposits are known to occur in immediate association with it, as they do at Vereeniging on the Vaal River. In fact, no carbonaceous beds are present until near the top of the overlying Ecca Shales. One of the finest outcrops of the Ecca Glacial Conglomerate is in the Umgeni Quarries, the stone of which is used by the Corporation of Durban for street work and harbour purposes. The quarries are some 3 miles above the mouth of the Umgeni River. On the south side they are cut into the north end of the Berea ridge which consists entirely of glacial conglomerate. The thickness of the deposit is here considerable, and on the northern bank of the river, where the other quarry has been opened, the face presented some time ago an interesting section, where there was passing diagonally across it, at a low angle, a layer over a foot thick of boulders, very uniform in size, but much bigger than the ordinary pebble and with very little fine material forming a matrix, thus contrasting with the ordinary conglomerate where the matrix usually predominates.

The Ecca Series, with the Beaufort Beds above, are the most widely distributed of all the formations in Natal, occupying over two-thirds of the western portion of the Colony. This is also the case in Zululand and the Vryheid district. The upper portion of the Ecca Series contains our productive coal measures. There is a slight unconformity between the glacial conglomerate and the Ecca Shales. These are barren of fossils and pass up conformably into the Upper Ecca Coal-bearing Sandstone Series. The following fossil remains have been obtained from the Natal Coal-bearing Series (Ecca), proving it to be of Permo-Carboniferous age :—

Glossopteris Browniana var Indica, *Bunbury.*
Glossopteris Browniana var angustifolia, *Brong.*
Glossopteris damudica var stenoneura, *Feist.*
Glossopteris retifera, *Feist.*
Glossopteris acuta, *Dun.*
Glossopteris spatulo-cordata, *Feist.*
Phyllotheca Zeilleri, *Eth. fil.*
Angiopteridium spatulatum, *McClelland.*
Estheria Greyii, *Jones.*
Ganoid scales and teeth.

Although these beds have a very extensive development it is only in certain districts that payable coal occurs. The same horizon exists on the coast of Natal, the town hill at Pietermaritzburg, in the Dundee and Newcastle districts further north, in many parts of the Vryheid district, and at the Somkele coal-field in Zululand, but only in the three latter areas has payable coal been met with. In many other localities not mentioned here, thin, impure seams of coal are known to occur, but they are useless for marketable purposes. The quality of the seams varies much, in Zululand they are almost entirely anthracitic, while the best quality comes from Dundee and Newcastle where they are bituminous. In 1889 the coal production of the Colony was only 25,609 tons, which has steadily increased to 713,548 tons for the year 1903. The entire output from the Somkele Mine in Zululand from December, 1903, to the end of February, 1905, was 7,354 tons. The major portion of this coal was won from development work alone. This semi-anthracitic coal has found a ready market in Durban for household purposes.

The investigation into the coal industry of this Colony is one of the most important from a financial and economic point of view of any of the mining ventures at present being developed, because it is by far the largest and probably the most lucrative. The areas in which payable coal is known to occur are extensive in the three divisions of the Colony. Besides the Dundee and Newcastle districts in Natal, large areas of coal-bearing rocks, with good coal among them, are present in the new territory (the Vryheid and Utrecht districts), and already we have the knowledge of the payable character of the semi-anthracitic coal of the St. Lucia coal-field in Zululand. At Somkele, where this coal is worked, the known portion of the field occupies only a very limited area of the coal-bearing series, so extensively developed in Zululand, but which has only been prospected in the most desultory manner, and therefore the practical knowledge of the presence or absence of payable coal-seams is at present quite hypothetical. At the same time now that there is a chance of an influx of Europeans into the Province we may, I think, look, with justice, to a much more intimate knowledge of a country which even at the present day is little known except to a few officials and isolated store-keepers. This knowledge is certain to produce a more accurate knowledge of such things as outcrops of coal-seams, or other deposits of value, which, when locally known, have a chance of development which at present they have not.

A similar development should result from the attention which has been directed, since the close of the war, to the coal-bearing areas of the Vryheid and Utrecht districts, where the Upper Ecca Shales are known to carry, in numbers of localities, coal-seams, which there is no reason to suppose would not prove, if developed, as remunerative as the Natal coal-seams. In many cases the analysis of individual seams and their extent geologically would encourage the idea, that there seems no reason why, with the investment of the necessary capital and the energetic carrying out of the necessary work, they should not be of a payable character. This would certainly obtain locally, but until the advent of railway communication with the localities in which they occur, a wider market would be impossible. It is certainly the fact that many of the best qualities of coal over this area are at present beyond the limits of practical mining, when competing with the Natal coals, because of the outlying districts in which they occur, and therefore the want of facilities for developing an outside market.

Besides the local consumption, the chief outlet for Natal coal is Cape Colony, where it is largely used on the Government Railways, while considerable quantities are taken by the Transvaal and Orange River Colonies. The shipping from Durban is extensive. During the year 1904, 12,431 tons were shipped from Durban, while 383,147 tons were bunkered at the Point and 99,514 tons were exported overland. Coal is put on the wharf at the Point at 15s. 6d. per ton, but with greater facilities, improved appliances and expedition in loading, even this price may quite likely be reduced, while it is certain that the amount of exported coal will increase enormously.

In most of the districts where the Ecca coal-measures are developed, iron ores occur, sometimes in large quantities and of good quality. The only desideratum is the presence of lime in some form suitable for iron smelting. Iron ore of exceptionally good quality is known in the Natal coal-field where the analysis is exceptionally high, but the position of the deposit is not located sufficiently close to the railway and the limestone to make the development even feasible, at least, at present. In very many districts in Vryheid and Zululand large superficial areas are covered with pisolitic ironstone which has been derived from the ferruginous material, of the decomposed rocks, chiefly basalts, etc., of these areas. These secondarily-deposited pisolitic ironstones are often of considerable thickness, but the percentage of iron is usually low, and they also contain a large amount of earthy matter.

There is no well established line of demarcation between the Ecca Series and the Beaufort Beds immediately above. The latter consist of highly-coloured shales and sandstones and are characterised by the abundance of fossil Reptilian remains, chiefly Dicynodont. Their principal development is in the western part of Natal, where they outcrop from the base of the Drakensberg Range and extend for an irregular distance eastward, in some instances crossing the main railway line, as in the Mooi River district, where at Weston, Dr. Sutherland records the presence of Dicynodon remains which were discovered by Dr. Addison in 1854. In Zululand these beds are not nearly so extensively developed, as the highest sedimentary series exposed in the uplands is the coal-bearing Ecca Series.

In the higher portions of the Biggarsberg, in the Newcastle district, and on the middle and upper slopes of the Drakensberg, along the entire length of its Natal aspect the Stormberg Series outcrops. It consists of shales and sandstones with occasional coal-seams, containing a fossil flora entirely distinct from the Ecca flora. Little has yet been done either as regards its fossil-flora or its coal-seams, but the chief forms that occur are *Thinnfeldia odontopteroides*, Morr., and a *Pterophyllum* sp., which point to a Rhaetic or Lower Jurassic age. Hitherto no reptilian remains have been noted from these beds, but there is no doubt they occur, as they do in the Stormberg Beds of Cape Colony.

The sequence from the Stormberg Beds through the Red Beds and Cave Sandstones to the basaltic lavas capping the Drakensberg can be well seen along the upper part of the eastern flank of the range. There are, however, very few positions, particularly along the Basuto border, where it is possible, because of the ruggedness of the country to approach the outcrops of these series; and, therefore, little is known about them on this side of the mountain range. There are a few passes through these mountains, such as the three Bushman passes, which are, however, exceedingly difficult of access. In the Harrismith district, where the Natal Railway passes into the Orange River Colony, there are good exposures of the Red Beds and Cave Sandstones, owing to the extensive denudation of the overlying basalt. These rocks occur in no other part of the Colony or Zululand. The fossil remains obtained from them are chiefly Reptilian, which are occasionally very plentiful locally. In both the Stormberg and Cave Sandstones, Bushman rock-shelters are frequent, and some fine representations of the life of these people are reproduced with great fidelity on the walls and roofs of the shelters. It is, however, often very difficult to distinguish the authentic Bushman paintings from the reproduced copies of later days.

The Cretaceous rocks of Natal possess a particular interest from the fact that they werethe first rocks which were recorded from this Colony. In 1855 W. H. Baily described a collection of fossils from them. Since that time little or nothing has been done on them, until the Geological Survey discovered that they cover a large area of the littoral of Zululand. They are entirely littoral in their occurrence as small outliers, but in the northern portion of Zululand they are present in more than one locality—at the base of the Lebombo Range, at Umtini close to the junction of the Inguavuma and Pongola Rivers, and also where the Mkusi River breaks through the range, about 50 miles from the coast. In no case has a trace of Cretaceous rocks been met with anywhere on the uplands of the Colony.

The localities where they occur in Natal are at the mouths of Umtamvuna and Impenyati rivers on the south coast. Lately they have been cut in a bore which was sunk on the sea aspect of the Bluff, Durban. The core showed undoubted Cretaceous fossils, and the series was passed through at nearly 800 feet from the surface. In all cases they rest unconformably on the rocks below, usually Ecca Shales, Table Mountain Sandstones or granites.

In Zululand the Cretaceous formation is extensively developed. Below the Pleistocene sands of the littoral it occupies the whole area from the Umlalaas River mouth north to Portuguese Territory, bounded by the sea-coast on the east and the rising uplands on the west. The outcrops over this area are few and far between, but in almost all cases they are fossiliferous and rest unconformably on the rocks below.

A list of fossils, identified by Mr. R. Etheridge, from the Cretaceous deposits of Umkwelane Hill, Zululand, is given below :—

Pelecypoda.

Ostrea, sp.
Exogyra, sp.
Neithea, sp.
Melina Andersoni, *Etheridge*, sp. nov.
Gervillia, sp.
Pinna, sp.
Mytilus, sp.

Pelecypoda—(continued).

Trigonia umkwelanensis, *Etheridge*, sp. nov.
Trigonarca umzambaniensis, *Baily*, sp.
Latiarca (?) Natalensis, *Baily*, sp.
Cardium Bullen-Newtoni, *Etheridge*, sp. nov.
Protocardium Hillanum, *J. Sby*, sp. var.; umkwelanensis, *Etheridge*, var. nov.
Eriphyla lenticularis, *Goldfuss*.
Eriphyla Rupert Jonesi, *Etheridge*, sp. nov.
Cytherea kaffraria, *Etheridge*, sp. nov.
Cicatrea, sp.
Tapes, sp.
Donax Andersoni, *Etheridge*, sp. nov.
Mactra Zulu, *Etheridge*, sp. nov.
Corbula, sp.

Gasteropoda.

Alaria (?) Bailyi, *Etheridge*, sp. nov.
Fulguraria, sp.
Zaria Bonei, *Baily*.
Pyropsis, sp.
Patella, sp.
Cylichna Griesbachii, *Etheridge*, sp. nov.
Cylichna fusuliniformis, *Etheridge*, sp. nov.
Actæonina Atherstonei, *Sharpe*, var.; umkwelanensis, *Etheridge*, var. nov.
Gyrodus, sp.
Chemnitzia, sp.
Solarium, sp.

Cephalopoda.

Placenticeras kaffrarium, *Etheridge*, sp. nov.
Placenticeras umkwelanensis, *Etheridge*, sp. nov.
Creniceras (?), sp.
Hamites, sp.
Baculites, sp.

Pisces.

Lamna, sp.
Fish spine indeterminable.

This list is only the first and a small one of the fossils from the Cretaceous of Zululand. It represents only a limited portion of the collection already in hand, but there is no doubt that the Cretaceous deposits will prove exceedingly prolific in fossil remains.

Rocks of Tertiary age are unknown from Natal, unless the calcareous sandstone forming the Bluff, Durban, prove to be of this age. It rests upon Cretaceous rocks which are not exposed at the surface. During last year's field season I discovered, at certain points on the Zululand coast, a series of marls, sands, shales, calcareous rocks and lignites of considerable thickness, some members of which contain abundant fossil remains, consisting of marine Mollusca, Foraminifera, Crustacea, Pisces and Mammalia, the last including Rhinoceros, Elephant, etc. These beds are, unfortunately, only exposed at very low tides and are difficult of access, but will eventually prove exceedingly interesting from a palæontological point of view.

Igneous rocks are present in almost every district. They are intrusive in all the formations above the Cretaceous, in which I have never seen evidences of intrusive rocks. They are in the form of dykes and sills and are always basaltic. If any section of the country were taken the sedimentary rocks would be seen to be traversed by a perfect network of them. Denudation has exposed these rocks much more plentifully in some districts than in others. Two districts which are typical of this are the Impendhla and Ladysmith districts. In the latter the presence of the denuded boulders of basalt provided the natural protection to the Boers during the siege of that town. The presence of these rocks can readily be recognised by the chocolate colour their decomposition gives to the soil. In texture they vary from glassy tachylites to coarse porphyritic dolerites, while in composition there is great diversity. In all our rivers the waterfalls are usually produced by the presence of either a sill or dyke of this rock. The Umgeni Falls at Howick, the Edendale Falls near Pietermaritzburg, the Tugela Falls near Colenso, are good examples. In Zululand and the New Territory similar sills and dykes occur. The only example of a volcanic lava known from Natal is that which caps the Drakensberg Range. Of other igneous and volcanic rocks there are few representatives. In the northern part of Zululand the Lebombo Range is formed of a Rhyolitic lava which can be traced for a long distance northwards through Portuguese and German territory into the interior of Central Africa. To the south of the Lebombo Range a series of mountains, called the Queme Range, consists of a set of igneous rocks which are unlike anything else we have in the Colony. They are chiefly felspar, augite rocks, with many varieties, and are evidently old rocks, as the Lower Ecca shales rest unconformably against them.

There are many problems, both of a purely scientific and economic kind which await solution in the geology of the East Coast of Africa. Not one of the least important will be the working out of the stratigraphy and the correlation of the East Coast formations, particularly the older, with those of the Transvaal and other parts of South Africa, thus ensuring an accurate knowledge of the probabilities and prospects of analogous economic developments. Another of these, of great importance to the Colony, is the investigation of the local occurrences, extent and variations of the coal-bearing areas of our coal-fields. Numbers of other problems present themselves, many of them of minor and local interest. Investigations as to the intrusive rocks will, in many cases, be of great utility in the elucidation of many obscure points in the superficial and economic geology of the Colony. The solution of many of these will also have an important bearing on the larger questions which are being worked out with regard to South African economic geology as a whole. As yet East African geology has only been touched upon, and the little knowledge we have been able to bring together merely shows us what a vast amount of geological work there is still to be done before a thorough understanding of the economic possibilities of this part of Africa is obtained. The work is slow and laborious for want of workers, but there is no doubt that ultimately this initial work will bear fruit, in the realisation of the fact that without a foundation no superstructure can be built, that will last.

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3. GEOLOGY OF THE TRANSVAAL AND THE ORANGE RIVER COLONY.

By Herbert Kynaston, B.A., F.G.S., Director of the Geological Survey, Transvaal.

Introductory.—In the following account of the geological features of the Transvaal and Orange River Colony it has naturally only been possible to treat the subject in a very general manner, and it has seemed advisable only to enter into detailed description, where well-known centres are concerned, such as Johannesburg and Pretoria. As regards the Orange River Colony, very little recent geological work has been done, and our information is exceedingly scanty. The broad outlines of the geology of the Transvaal, however, are now, thanks to the labours more especially of Dr. G. A. F. Molengraaff and Dr. F. H. Hatch, pretty well known, though there are still extensive tracts, chiefly in the central and northern portions of the Colony, about which geologists as yet know very little. Moreover, in the present state of geological enquiry in this country, it is not easy to set down any scheme of classification of the geological sequence that would be generally acceptable. Dr. Molengraaff, the main lines of whose classification have been followed in the following pages, recognises in the Transvaal the following four main divisions in ascending order :*—

1. The South African Primary System, Rand System, or Archæan System.
2. The Vaal River System.
3. The Transvaal System.
4. The Karroo System.

These may be sub-divided as follows :—

1. South African Primary System, &c.	Crystalline schists and granite. Barberton and Swaziland Series.		=Archaean (Hatch).†
	Witwatersrand Series.		Heidelberg System (Hatch).
	(*Unconformity*).		
2. Vaal River System.	Klipriversberg Amygdaloid. Ventersdorp Boulder Beds, &c.	Ventersdorp Series (Hatch).	

* See Molengraaff, Geology of the Transvaal, p. 3.

† Hatch "The Oldest Sedimentary Rocks of the Transvaal," Trans. Geol. Soc. S.A., Vol. VII., p. 147.

3.	*Unconformity.*
Transvaal System.	Black Reef Series. Dolomite ,, Pretoria ,, *Strong unconformity.* Waterberg Series.
4.	*Strong unconformity.*
Karroo System.	Glacial Conglomerate. Ecca Series. Beaufort Series. Stormberg Series, in Orange River Colony.

In the present state of our knowledge, it has not been thought advisable to attempt any general scheme of correlation with the formations of the neighbouring colonies. With certain formations, such as those of the Karroo System, we are on fairly safe ground, but on the whole the writer considers that, though all such attempts are suggestive and useful as incentives for further enquiry, we have still much to learn and many gaps to fill up before complete correlation can be satisfactorily established. In cases, however, where there is substantial evidence for correlation, the representative of any Transvaal formation in adjacent territories has of course been pointed out.

It has been the writer's endeavour to give the reader a general idea of the present condition of geological investigation in the Transvaal and Orange River Colony. No historical review of this investigation has been attempted, and only the most recent literature has been made use of, references to which will be found in the text.

The account of the Karroo System has been written by Mr. E. T. Mellor, of the Geological Survey, and I am further indebted to the writings of Dr. Molengraaff, Dr. Hatch, and various members of the South African Geological Society, for much of the information relating to the more recent additions to our knowledge of Transvaal geology.

For maps the reader is referred to Dr. Molengraaff's sketch map of the Colony, accompanying the recent English edition of his geology of the Transvaal, Dr. Hatch's Geological Map of the Southern Transvaal, and the maps and sections published in the Annual Reports of the Geological Survey.

We are now at the commencement of a new era of geological activity and systematic investigation, and we may be fully assured that it is one full of promise of fresh discoveries and progress.

The Older Rocks.

In dealing with the older rocks of the Transvaal, that is to say, with those rocks older than the Black Reef Series or lowest division of the Transvaal System, it is to be regretted that there is still a want of a definite and complete agreement as to the relationships which the different series or groups bear to one another. Geological enquiry in the Transvaal has certainly been pushed forward with great and renewed vigour during the last few years, but with regard to these older rocks it is still in somewhat the same position as Cape Colony geologists find themselves with regard to the so-called Pre-Cape rocks.

In the Transvaal, as is well known, attention has mainly been directed, and for obvious reasons, to the Witwatersrand Series, and our knowledge of that series, as developed in the more favoured areas, has most certainly been very much increased, but sufficient work has hardly yet been accomplished in other areas, such for instance as the Barberton district, Swaziland, and the Zoutpansberg district, to enable us to group all the older rocks from all parts of the Transvaal into a systematically correlated and classified sequence. Various opinions have naturally been advanced as to the relative ages and relationships of the different series, but unanimity of opinion among geologists has not yet been secured.

It will be sufficient for our present purpose to point out that below the Black Reef Series we find the following groups :—

(1) A series of crystalline schists, sheared quartzites, phyllites, altered shales, and conglomerates, with intrusive granite. This includes the Barberton Series of Molengraaff and the Swaziland Series of Hatch.

(2) The Witwatersrand Series, consisting of a lower division or the Hospital Hill Series, and an upper division, which includes the auriferous Conglomerate Series of the Rand.

(3) The Vaal River Series. This is the Vaal River System of Molengraaff or the Ventersdorp Series of Hatch.

According to Dr. Molengraaff* there is no sharp line of demarcation between Groups 1 and 2. Together they make up his South African Primary System, Rand System, or Archæan System, and he considers the Barberton Series as, at least in part, the equivalent of the Hospital Hill or Lower Witwatersrand Series. Dr. Hatch,† however, classifies the Barberton or Swaziland Series as an older group altogether than the Hospital Hill Series, since he considers that the older granite is intrusive in the former, but not in the latter. It is quite possible, however, that some of the various separate masses of the older granite, although of the same general petrological type, may belong to different periods of intrusion.

Apart from their well-known development in the southern and south-western Transvaal, the older rocks occupy extensive areas in

* Molengraaff, Report of State Geologist for 1898, pp. 4 and 5.

† Hatch, "The Oldest Sedimentary Rocks of the Transvaal," Trans. Geol. Soc. S A., Vol. VII., p. 147.

the Zoutpansberg District, in the eastern low country, and in Swaziland, but as our knowledge of these latter areas is still very imperfect it will perhaps be as well for our present purpose to confine our attention to the better known districts.

Throughout the Central and Southern Transvaal the Witwatersrand Series, together with boss-like protrusions of the older granite, is overlain unconformably either by the Transvaal System or by rocks of Karroo age, and crops out more or less in the form of inliers surrounded by the younger rocks. It occupies a considerable extent of country, which may conveniently be divided into the following geological areas :—

1. The Witwatersrand area.
2. The Heidelberg area.
3. The Klerksdorp area.
4. The Venterskroon or Vaal River area. (Here the Witwatersrand Series is found forming a semi-circle about the Vredefort granite, and extending across the Vaal River into the Orange River Colony.)

Of these areas the Witwatersrand is by far the best known to geologists, and we will therefore give a short account of the succession of strata that are there met with. In this area two divisions are generally recognised in the Witwatersrand Series, the Lower, or Hospital Hill Series (lower quartzite and shale group of Gibson),* comprising the strata from the Main Reef Series downwards, and the Upper Witwatersrand Series, comprising the beds from the base of the Main Reef Series upwards. The strata of both divisions in this area, appear to be free from any folding on a large scale, though in certain beds minor contortions occur, for example in the contorted bed of the Hospital Hill slates, and further, the general succession of the entire series, if we except the Elsburg Beds, apart from local duplications caused by faulting, is apparently uniform and conformable.

Starting from the granite, north of Johannesburg, and proceeding in a southerly direction across the strike of the series and in the direction of the dip, we traverse the following beds in ascending order. Firstly:

Sericitic and talcose schists.—These are found between the granite and the lowest quartzite of the Rand. It is doubtful, however, whether these rocks represent highly-altered shales and form part of the Lower Witwatersrand Series, or whether they belong to an older series of rocks. Sometimes they are absent, in which case we find immediately upon the granite the quartzite of the Rand proper or, as it is usually called, the

Orange Grove Quartzite.—This quartzite constitutes a strikingly conspicuous ridge, which may be followed for a considerable distance along the northern edge of the Witwatersrand. Its northern

*W. Gibson, "Geology of the Gold-bearing and Associated Rocks of the S. Transvaal." Q.J.G.S. Vol. XLVIII., p. 404.

face forms an abrupt and very steep escarpment, from the summit of which the Magaliesberg and other ranges of the Pretoria Series, to the north of the granite, are often clearly visible. The ridge consists of two thick belts of hard whitish quartzite, with an intervening band of indurated shale. The average thickness of the whole is about 500 feet.

The Orange Grove quartzites are followed by a series of ferruginous shales, often rich in magnetite, termed by Drs. Hatch and Corstorphine* the *Water Tower Slates*, from the fact that in Parktown, one of the northern suburbs of Johannesburg, the two service water towers are situated upon these beds. These are followed by a comparatively thin band of quartzite, termed the *Ripple-marked Bed*, which is easily recognisable to the north of Johannesburg by its forming a peculiar wall-like outcrop coinciding with the steep dip-slope. Overlying this bed is a considerable thickness of ferruginous shales, somewhat soft and usually of a reddish colour at the surface—*the Red Shales*—separated from the overlying series by a thin quartzitic band, known as *the Speckled Bed*. This latter is remarkably persistent, and is characterised by the presence of small reddish or brown patches due to the weathering of kaolinised felspar fragments. Above this lie the *Hospital Hill Slates*, containing near their base the well known banded and contorted bed, composed of alternating layers of jasper, quartz, specular iron, and magnetite. This is one of the most characteristic and leading beds of the Witwatersrand, and is especially well exposed at the entrance of the Agricultural Society's show-ground.

South of the Hospital Hill Slates we have another and important zone of quartzites, known as the *Green Quartzites*, owing to their frequently showing a greenish colour at the surface; but as this feature is not always very apparent, perhaps the term *Hospital Hill Quartzite*, adopted by Dr. Hatch, is more appropriate. This zone forms the conspicuous ridge on which the Meteorological Observatory and the Indian Monument stand, and is largely developed in the West Rand, in the Roodepoort and Krugersdorp areas. Overlying these quartzites we have shales with subordinate quartzites, the *Doornfontein Beds* of Drs. Hatch and Corstorphine,† passing to the south into the Red Bar, a reddish sandstone, which immediately underlies the Main Reef Series. To the east of Johannesburg all the strata from the Ripple-marked quartzite to the Doornfontein Beds, inclusive, are duplicated by an oblique fault, which coincides with the general trend of the Bezuidenhout Valley, namely north-east and south-west. We thus find these strata repeated on the south side of the valley.

The Upper Witwatersrand Beds, which commence with the Main Reef Series, consist mainly of quartzites and thin conglomerates with some shales. It is these conglomerates which constitute

*Hatch and Corstorphine, "The Geology of the Bezuidenhout Valley and District East of Johannesburg," Trans. Geol. Soc. S.A., Vol. VII., p.99.

†Op. Cit., p. 101.

the auriferous bankets, which have made the Witwatersrand so famous throughout the world. The gold is found principally in these conglomerates, only rarely and to a less degree in the quartzites, and in the conglomerates it appears to be mainly confined to the pyritic matrix in the immediate neighbourhood of the contained pebbles.

The Main Reef Series of auriferous bankets is so far the most important from an economic point of view. It lies on the south side of Johannesburg, and is followed in ascending order by the Livingstone and Bird Series, the Kimberley Series, and the Elsburg Series. The Elsburg Series, however, is very different from the others; the conglomerates are thicker and coarser, and contain a greater variety of pebbles, those of the lower series being thin, well defined, and consisting mostly of small or medium-sized quartz pebbles. Recent researches, moreover, make it extremely probable that this series is uncomformable to those below, and it may very possibly belong, as suggested by Dr. Hatch,* rather to the succeeding group of the Vaal River Series than to the Witwatersrand Beds.

The exact relation of the Lower Witwatersrand Series to the boss-like masses of granite of the southern Transvaal, on which the lowest beds almost invariably appear to rest, has not yet been demonstrated beyond all room for doubt. In the Witwatersrand and in the Heidelberg district, the evidence so far available tends rather to show that the granite is not intrusive in these beds. The evidence from the Venterskroon district, however, would seem on the other hand to be opposed to this view. The different masses of granite, although petrologically similar, may be, however, not all of the same age.

A roughly circular exposure of this granite lies between Johannesburg and Pretoria. It is generally a biotite or hornblende-biotite-granite, occasionally with muscovite. Microcline is also a common constituent, and pegmatite veins are of frequent occurrence.

Vaal River Series.

It is only quite recently that a series of rocks, occurring in different parts of the southern Transvaal, whose relationships had always been somewhat obscure, have finally been awarded a position in the geological sequence, and grouped, together with the well-known Klipriversberg Amygdaloid, into one formation lying between the Witwatersrand Beds and the Black Reef.

Dr. Molengraaff† was the first to refer (in September, 1903) to these rocks as an independent and distinct formation, and to assign them to their proper position; while Dr. Hatch,‡ in a brief

*Hatch and Corstorphine, Op. Cit., p. 108.

†Molengraaff, "Preliminary Note on a hitherto unrecognised Formation underlying the Black Reef Series," Trans. Geol. Soc. S.A., Vol. VI., 1903, p. 68.

‡Hatch, Trans. Geol. Soc. S.A., Vol. VI., p. 69.

note of the same date described a section, showing rocks identical with some of those mentioned by Molengraaff, from near Reitsburg in the Orange River Colony, as an unusual basal development of the Black Reef. Later in the same year Dr. Hatch* gave an admirable description of the same series from the neighbourhood of Ventersdorp, where he was able to recognise its unconformable relations both to the Witwatersrand Series below and to the Black Reef above. He at the same time proposed the term "Ventersdorp Beds" to include both these rocks and the Klipriversberg Amygdaloid. Dr. Corstorphine† described similar beds belonging to the same geological horizon in the Heidelberg district, and Mr. Luttman-Johnson‡ noticed them in the Fortuna Valley in the same area. Dr. Dorffel§ described the boulder beds of Kromdraai, north of Krugersdorp, with reference to their true position as a member of this formation, and still more recently, Drs. Hatch and Corstorphine** have assigned the Elsburg Beds, usually regarded as constituting the uppermost member of the Upper Witwatersrand Beds, to the same formation.

Dr. Molengraaff†† in his "Geology of the Transvaal" describes these rocks under the term Vaal River System, and points out that the amygdaloidal rocks of the Vaal River were originally referred to by the name of "Vaalgesteine" by Cohen. As a local name, Dr. Molengraaff's term certainly seems more appropriate for this formation than Dr. Hatch's term "Ventersdorp Beds," but the advisability of assigning these rocks to the rank of a separate system seems from certain considerations, somewhat doubtful.

The Vaal River Series, as we would prefer to call it, consists largely of rocks of igneous origin. The principal types are amygdaloidal diabase, of which the rock of the Klipriversberg, south of Johannesburg, may be taken as an example, basalt, porphyrite, quartz-porphyry, felsitic rocks, tuffs, chert, igneous breccia, shales, very coarse conglomerates or boulder beds, and grits. The most remarkable of these rocks are the coarse conglomerates, which occasionally attain an enormous thickness, for instance, 400 feet, near Reitsburg in the Orange River Colony, and about 500 feet at Kroomdraai, north of Krugersdorp. In the neighbourhood of Ventersdorp, where they are admirably exposed, Dr. Hatch‡‡ recognises "two distinct types of the boulder formation .

*Hatch, "The Boulder Beds of Ventersdorp," Trans. Geol. Soc. S.A., Vol. VI., p. 95.

†Corstorphine, "The Volcanic Series underlying the Black Reef," Trans. Geol. Soc. S.A., Vol. VI., p. 99.

‡Luttman-Johnson, "On the Geology of the Fortuna Valley, Heidelberg," Trans. Geol. Soc. S.A., Vol. VII., p. 136.

§Dorffel, "The Kromdraai Quartz Reef," Trans. Geol. Soc. S.A., Vol. VI., p. 101.

**Hatch and Corstorphine, "The Geology of the Bezuidenhout Valley and the district East of Johannesburg," Trans. Geol. Soc. S.A., Vol. VII., p. 97.

††Molengraaff, "Geology of the Transvaal," 1904, pp. 19-23.

‡‡Hatch, "The Boulder Beds of Ventersdorp," p. 96.

namely, a conglomerate type and a breccia type. In the conglomerate type the boulders are completely rounded or water-worn, and consist chiefly of Witwatersrand conglomerates, quartzites and slates, while the matrix consists of an aggregate of sub-angular grains of quartz. . . . In the breccia type the boulders are angular blocks, showing no signs of abrasion." This rock Dr. Hatch classes as an igneous breccia, both from microscopial evidence and from the fact that it is associated with basaltic flows. There is little doubt that the whole formation is essentially a volcanic one, and indicates a great volcanic period which partially bridges over the gap between the Witwatersrand Series and the Black Reef. Its commencement was marked by the tremendous outpourings of basic vesicular lavas, exemplified by the Klipriversberg rocks, and so extensively developed in many parts of the southern Transvaal

The Vaal River Series occupies considerable, though usually detached areas, in the Southern Transvaal. Towards the southwest, however, it becomes more continuous and covers a large portion of the districts of Lichtenburg, Wolmaranstad and Bloemhof, and extends into the north-west part of the Orange River Colony and Cape Colony, and into Griqualand West and Bechuanaland. Dr. Hatch* describes its distribution in the Marico district and along the Bechuanaland border, and includes in this formation the boulder beds of Mafeking, hitherto regarded as Dwyka conglomerate. These latter rocks have been described recently by Dr. Siegfried Passarge† who, however, still prefers to regard them, though with some hesitation, as Dwyka. Further south, Mr. G. G. Holmes‡ has found amygdaloidal diabases and volcanic breccias, belonging to the Vaal River Series, lying between the Black Reef and the older granite in the neighbourhood of Vryburg. In Griqualand West the amygdaloids, quartzites and quartz-porphyries, found in the Kimberley Mines beneath the Lower Karroo, very probably belong to the same series.

Transvaal System.

We now come to the consideration of a series of formations which occupy considerable areas in the central and southern Transvaal, and which were laid down unconformably upon the older rocks already described. These formations consist of the Black Reef, the Dolomite, and the Pretoria Series, and constitute the system formerly erroneously designated Cape System by Dr. Molengraaff, but now termed Transvaal System by that author and Dr.

*Hatch. "The Geology of the Marico District," Trans. Geol. Soc. S.A., Vol. VII., p. 2.

†Passarge, "Beitrag zur Kenntnis der Geologie von Britisch Betschuanaland," Zeitsch. der Ges. fur Erdkunde zu Berlin, Bd. XXXVI., 1901, p. 22.

‡Holmes, Geology of part of Bechuanaland west of Vryburg. Trans. Geol. Soc. S.A., Vol. VII., p. 130.

Hatch. The former also includes the Waterberg Sandstone formation in the same system, and formerly regarded it as overlying the Pretoria Series in a conformable manner. But it has now been shown by the work of the Geological Survey, and from the observations of independent workers,* that there is a considerable break between these two formations, and moreover the distribution of the Waterberg Sandstone, taken in connection with this unconformable relation, indicates that it was deposited under somewhat different geographical conditions.

The Black Reef, Dolomite, and Pretoria Series almost invariably occur in close association and show a continuous and uninterrupted sequence in their constituent strata. The outcrop of these three series, taken together, appears to form, to the north of the Witwatersrand, the margin of a gigantic basin, occupied mainly by igneous rocks, and constituting the greater portion of the Central Transvaal. To the south, however, the distribution of these series is more complicated, and they have been thrown into minor anticlines and synclines. which are apparently intimately related to the axes of elevation of the older rocks of the Witwatersrand.

The south-eastern margin of the central basin is hidden by the overlying beds of the Karroo System, which here constitute the typical high veld country of the Standerton, Ermelo and Middelburg districts. On the north-west, again, in the Waterberg district, the outcrop and behaviour of the Black Reef, Dolomite and Pretoria Series, appear to indicate the existence of a subordinate basin, the central portion of which is covered by the Waterberg sandstones of the Palala Plateau.

On the southern boundary of the Transvaal, the rocks of this system may be traced across the Vaal River, on the east and west sides of the Vredefort granite, for some distance into the Orange River Colony. To the west and south-west of the Transvaal this system has an extensive development in Bechuanaland and in Griqualand West.

The Black Reef Series.

The Black Reef Series is composed of varying thicknesses of grey quartzite, sandstone. arkose. slates and conglomerate. Formerly this series was known by various names in different parts of the country. before it had been ascertained that these different portions could be connected together and correlated. The term "Black Reef" was originally given by the Rand miners to the

*See Ann. Report Geol. Survey of Transvaal for 1903, pp. 1 and 11-13.
Also D. Dorffel, "The Balmoral Cobalt Lodes," Trans. Geol. Soc. S.A., Vol. VI., p. 94.
,, E. T. Mellor, "The Waterberg Sandstone Formation, &c.," Op Cit., Vol. VII., p. 42.
,, E. Jorissen, "The Dolomite and Chert Series in the N.E. part of the Rustenburg district," Op. Cit., Vol. VII., p. 37.
,, G. G. Holmes, "Notes on the Geology of the Northern Transvaal," Op. Cit., Vol. VII., p. 56.

auriferous conglomerate at the base of this series south of Johannesburg, as it was of a darker colour at the surface than the auriferous conglomerates or bankets of the Rand. In the Klerksdorp district this series was called the Boschrand Series, to the north of the Witwatersrand the Kromdraai Series, while in the Eastern Transvaal it was referred to as the Kantoor sandstone and the Drakensberg sandstone. Later, in 1898, the name of Black Reef was extended by Dr. Molengraaff to apply to this formation throughout the whole country.

The Black Reef series lies directly upon various members of the older rocks, with a well-marked unconformity and overlap. To the south of Johannesburg, however, where the Black Reef series overlies the Klipriversberg amygdaloid, the strike and dip of this series are so nearly identical with those of the older rocks below, that it was not until other areas had been investigated that the unconformity was recognised. In the Potchefstroom district it rests upon various beds, belonging to the Witwatersrand Series or to the Vaal River Series, and similar relations are found in the Krugersdorp district. To the south of Pretoria the Black Reef is seen resting immediately upon the older granite. Along the eastern escarpment of the central plateau, and to the south of Pietersburg, it rests sometimes upon the granite, sometimes upon crystalline schists, and sometimes upon the upturned edges of the strata of the Barberton Series.

The Black Reef series varies greatly in thickness. Thus, to the south of Pietersburg, in the mountains of Makapan and Chunie, where it forms the northern escarpment of the mountainous belt bounding the northern portion of the great central basin, or Bush Veld, its thickness may be roughly estimated at about 1,600 feet, and at Lydenburg it attains an average thickness of 1,000 feet. Further south, at the Devil's Kantoor, the thickness decreases to about 200 feet, while in the Southern Transvaal it probably nowhere exceeds 100 feet, and in certain localities it may be represented merely by a comparatively slight development of quartzose material, associated with the base of the dolomite.

At the base of the Black Reef there is frequently developed a bed, or several thin bands, of conglomerate, more or less auriferous. This conglomerate is of no great thickness, and consists of small pebbles of the various older rocks enclosed in a quartzose matrix. It has been worked for gold to the south of the Klipriversberg and in the Klerksdorp and Lydenburg districts, but the gold was found to be very unequally distributed. Between Johannesburg and Pretoria the conglomerate is very poorly developed and only contains small traces of gold, the basement beds, which rest against the granite, consisting frequently of a coarse arkose containing fragments of vein quartz and granite. The line of junction with the older granite is again well exposed in certain localities on the northern slopes of the Chunie Mountains, south of Pietersburg, and here, too, it is easy to see that the lower beds are almost entirely made up of derived fragments of the underlying rocks.

The Black Reef Series passes gradually upwards into the dolomite, in fact, from some points of view it may be regarded as constituting the basement beds of that formation. Messrs. Rogers and Schwarz, in their interesting account of the Prieska District,* speak of beds of quartzite conformably underlying the limestone portion of the Campbell Rand Series in the Doornbergen, and there is good reason to consider this limestone of the Campbell Rand Series in the Prieska district and Griqualand West as the equivalent of the Dolomite of the Transvaal. The quartzite is seen on the south-west side of the Doornbergen, " forming a belt nearly a mile in width," dipping under the limestone, and the authors further remark that " the thickness of the quartzite below the limestone varies very much," for in one locality is it probably only 200 feet thick, while in another " there must be at least 2.000 feet." It is probable that in this quartzite we have the representative of the Transvaal Black Reef Series.

The Dolomite.

This formation consists of beds of a dark bluish grey magnesian limestone, alternating with thin bands of chert. The rock is known as " Olifants Klip " by the Boers on account of the general resemblance of the weathered surface of the limestone to the hide of an elephant.

The numerous layers of chert form a very characteristic feature of this formation, and being very much harder and less easily attacked by denudation than the dolomite, they often stand out as sharp ridges parallel to the planes of stratification. In the lower portion of the formation the beds of dolomite are often thick and massive and comparatively free from chert, while in the upper portion the layers of chert are exceedingly numerous and often tend to predominate over the limestone. This predominance of the chert is often apparently enormously increased by the solvent action of surface and sub-surface waters upon the dolomite, the latter being gradually removed while the chert remains. It is doubtless owing to the results of this process that previous observers have tended to exaggerate the importance of the chert as a geological member of this series, for frequently kopjes and ridges, consisting almost entirely of blocks and masses of chert, overlying the more massive portions of the formation, are conspicuous features in the dolomite country. For instance, a few miles south of Pretoria extensive areas belonging to the upper portion of the series are often covered with cherty *debris*, which may occasionally extend to some depth without any accompanying limestone. Thus, to this formation Penning† gave the name of " Chalcedolite."

*See Ann. Report Geol. Comm. C.C. for 1899, pp. 77 and 80.

†Penning, Sketch of the Goldfields of Lydenburg and De Kaap, Q.J.G.S., Vol. XLI. 1885, p. 569.

A nodular mode of occurrence of the chert, in parallel rows, resembling the arrangement of the flint in the chalk of Europe, has occasionally been observed.*

The lower beds of the Dolomite, being comparatively unprotected by the hard layers of chert, usually form a gently rolling country in which the actual rock is more or less concealed by superficial deposits, whereas the upper beds, containing the chert layers, tend to stand out in more elevated ground and characteristic escarpments. These features are well seen in a traverse of the Dolomite formation to the south of Pretoria. The surface soil covering a Dolomite area is, moreover, always distinctive and characteristic, and is of a dark red colour, tinged with black streaks and patches of oxide of manganese. The chert blocks lying loose in the soil are also frequently coloured black by a coating of the same material.

The landscape of an area occupied by the Dolomite shows many characteristic features, recalling those so well known in the limestone districts of many other parts of the world. Thus, sink-holes or swallow-holes (the so-called "Wondergaten" of the Boers) gorges, and caverns abound. The streams often disappear from the surface to continue their course in subterranean channels and extensive caverns. Thus, the Mooi River, of the Southern Transvaal, disappears near Wonderfontein to re-appear with increased volume owing to the supply from underground tributaries, about twenty miles further on. In this way, owing to the chemical action of natural waters, and to the consequent formation of extensive caverns and ramifying subterranean channels, the Dolomite affords natural conditions for the accumulation and storage of underground waters of enormous capacity, and of the greatest economic value to the country. Natural reservoirs are thus formed for the storage of waters derived from the heavy rains, which fall during the summer months. The surplus of the collected waters finds its way again to the surface and forms the strong and constant springs to which so many of the perennial rivers of the Transvaal owe their origin, as for instance the Malmani, the Marico, the Klip, Mooi, Schoonspruit, and the Aapies rivers.

The Dolomite as a rule shows constant and uniform characters over enormous distances, and is easy to recognise on the surface. It therefore affords a convenient and reliable starting point from which to study the stratigraphy of different parts of the country. It lies with perfect conformability upon the Black Reef and covers extensive areas in the Southern and Western Transvaal. In the east it forms a broad belt stretching north and south through the Lydenburg district, disappearing to the south beneath the Coal Measure rocks of the High Veld, and on the north gradually bending round westwards towards Pietpotgietersrust, and forming part of the mountainous country on the north side of the Great Oliphants River.

*Molengraaff, Geology of the Transvaal, Johannesburg, 1904, p. 29.

Interstratified shales and slates sometimes occur near the base, and in the upper portion of the series, *e.g.*, the Tweefontein slates, occurring near the base of the series south of Krugersdorp. In the northern area south and south-east of Pietersburg, a zone of banded ferruginous quartzite is persistent in the Dolomite for a considerable distance.

Dr. Molengraaff* gives the following thicknesses for the Dolomite formation in different parts of the country:—

In the basin of the Witwatersrand ..	2,600	feet
In the neighbourhood of Pretoria	5,000	,, †
Near Godwan, on the eastern railway line..	1,650	,,
Near Lydenburg	2,600	,,
In the Makapan Mountains	4,000	,,

Outside the Transvaal the Dolomite has been shown by Mr. G. G. Holmes‡ to have an extensive development in Bechuanaland, and further south in Griqualand West we may safely correlate the Dolomite of the Transvaal with the Campbell Rand Series of Stow, and in the Prieska district of the north-west provinces of Cape Colony with the limestone series of the Doornbergen, described by Messrs. Rogers and Schwarz.§ According to these latter authors "the greatest thickness of the limestone series, measured from the quartzites below which no limestone is seen to the lowest jaspers or magnetite quartzites of the Griqua Town Beds, must be about 5,000 feet. This thickness is largely made up of quartzites interbedded with the limestone, and to a much smaller extent of cherts."

Considerable numbers of metalliferous veins occur in the Dolomite in certain districts. An interstratified quartz vein, containing gold, associated with pyrites and manganese, is found in the zone of slates, known as the Tweefontein slates, to the north of Krugersdorp. The auriferous deposits of Barretts Berlin, in the Eastern Transvaal, also belong to one of the lower horizons of the Dolomite. In the Lydenburg district auriferous quartz veins are fairly numerous and contain, besides gold, ores of iron, copper and manganese. These veins lie parallel to the bedding planes of the Dolomite. In the Marico district, however, the metaliferous deposits in the Dolomite occur in true vertical reefs. The quartz here carries a variable quantity of gold together with small quantities of copper ores. Lead ores also occur in veins and pockets in the Dolomite in certain districts.

Igneous Rocks.—Dykes and intrusive sheets of basic and intermediate rocks are of not uncommon occurrence in the Dolomite. The large Dyke which traverses the Dolomite at Wonderfontein, south-west of Krugersdorp, is described by Dr. Molengraaff¶ as a "nepheline-syenite-porphyry, a kind of foyaite," and the same

*Molengraaff, Op. Cit., p. 34.
†This is probably considerably overestimated.
‡Trans. Geol. Soc. S.A., Vol. VII., p. 130.
§Annual Report Geol. Comm. C.C. for 1899, p. 78.
¶Molengraaff, Op. Cit., p. 35.

author also describes a dyke of quartz-gabbro from near Ottoshoop. In the Lydenburg district intrusive sheets are a common feature, and several occurrences have been met with in the lower portion of the Dolomite south of Pretoria. These latter consist of gabbro and rocks of a dioritic type allied to tonalite.

The Pretoria Series.

The strata which succeed the Dolomite formation consist essentially of alternations of shales, flagstones, and quartzites, with numerous intrusive sheets of diabase. These rocks have formerly been referred to by the local names of Gatsrand Series, from the Gatsrand district south of the Witwatersrand, and Magaliesberg Beds, from the range of hills of that name north of Pretoria. The name Pretoria Series, however, adopted by Dr. Molengraaff, appears to be the most suitable, as these beds are perhaps more typically developed at and in the neighbourhood of the capital than anywhere else in the Transvaal.

The Pretoria Series rests conformably upon the Dolomite, and in the central Transvaal constitutes the innermost of the three series belonging to the Transvaal System, which almost encircle and dip towards the great basin of the Bush Veld.

In the immediate neighbourhood of Pretoria the beds dip to the north and strike east and west. This strike is maintained with very slight modification for a considerable distance to the west of the town. A few miles to the east, however, the strata are bent round somewhat abruptly to the south-east. This change of strike is accompanied by considerable faulting, the strata being repeatedly shifted by oblique lines of dislocation, so as to produce frequent duplications at the surface.*

In the Gatsrand, between the Witwatersrand and Potchefstroom, the Pretoria Series is again exposed, overlying the Dolomite with a southerly dip, and is here part of the southern limb of the great anticline, of which the beds at Pretoria represent part of the northern limb.

Since the Pretoria Series may be said to be typically developed at Pretoria, a short description of the succession in that neighbourhood will be of interest. On the west side of the town the beds are exposed in their normal undisturbed sequence. On the east side, however, the whole series, as already pointed out, is cut up by oblique faults, which have produced very marked features in the landscape, owing to the repetition at the surface of some of the harder and more important series of strata.

To an observer stationed on the summit of one of the conspicuous eminences to the south of the town a most striking panorama is presented by the surface features of the Pretoria Beds,

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*These faults are admirably illustrated on the Geological Map of the environs of Pretoria, recently published by the Geological Survey.
For a description see explanatory Memoir to this Map.

illustrating in an admirable manner the close dependence of these features upon geological structure. To the west of the town three conspicuous and parallel ranges of hills, separated by broad valleys, at once arrest the eye. These ranges are the escarpments formed by the three main quartzite zones of the series, and are respectively, from south to north, the Timeball Hill Range, the Daspoort, and the Magaliesberg Range. The intervening hollows and valleys are occupied by the less durable and more easily disintegrated shales, flags, and intrusive basic rocks. On the west side of the town the regularity of these features is very marked. On the east side, however, the quartzite ranges, although still showing a general parallelism, are frequently interrupted or abruptly terminated, to re-appear in different positions, the eastern area in this way showing very clearly the effect of the displacements due to the faulting already referred to.

Resting upon the uppermost chert layers of the Dolomite formation, there is often found a thin bed of breccia or conglomerate, consisting of angular and sometimes well-rounded fragments of chert in a somewhat sandy matrix. This bed is followed by banded sandy flags and shales passing gradually into a well-marked zone of dark grey argillaceous flagstones, which are quarried at several places to the south and south-east of Pretoria. Shales, weathering to yellowish and purplish colours, succeed these flags, associated with one or more quartzite bands of a brownish or purplish colour at the surface. We then find two well-marked bands of black magnetite quartzite, separated by paler quartzite and thin shales. These magnetite quartzites are of no great thickness, but form a very conspicuous feature among the strata of the Timeball Hill Range, their black outcrops contrasting strongly with that of the pale quartzite which immediately overlies them. The rock is rich in magnetite, which constitutes the cementing material between the quartz grains.

Overlying the Timeball Hill Series and forming the hollow, lying between that hill and the Daspoort range, and in which the town of Pretoria and its principal suburbs are situated, we find a series of shales and intrusive sheets of Diabase. On the southern slopes of the Daspoort range some thin bands of hard ferruginous shales are seen, and above these some beds of indurated, banded shales are quarried for building material. The crest and northern slopes of the range are formed by a hard yellowish quartzite, immediately overlying a rather coarse diabase. The succeeding hollow to the north is again occupied by shales and diabases, until we reach the conspicuous Magaliesberg escarpment, consisting of some 600 to 800 feet of massive yellowish and pale grey quartzites. A short distance beyond the Magaliesberg range the quartzites are succeeded by diabasic rocks which, when traced northwards, gradually merge into an extensive area of gabbro and norite, which forms part of the great igneous series of the Bush Veld.

The Pretoria Series shows fairly constant characters in the central and eastern part of the country. Thus, some of the characteristic and leading beds may be identified as far distant as the Lydenburg district, about 150 miles from the capital, by the same features which they show near Pretoria. In the Gatsrand area the quartzites apparently predominate largely over the shales, and there is an extensive development of diabase. If, however, we follow the series westwards from Pretoria into the Marico district, the shales are found to become more and more ferruginous and sometimes show a strong general resemblance to the banded ferruginous slates of the Hospital Hill Series. Beyond the south-western border, in Griqualand West, the Pretoria Series is represented by the Griqua Town Series of Stow, which succeeds the dolomite of the Campbell Rand. The beds are here very hard and ferruginous, and in places consist largely of jasper. In the Prieska district of Cape Colony* there is a continuous outcrop of the Griqua Town Series for a distance of nearly sixty miles, and they cover all the higher parts of the Doornbergen and much of the low ground between that range and the Orange River. The whole series is extraordinarily rich in magnetite, which in the lower part of the series is associated with quartzite generally rich in haematite, and in the upper part usually with jasper. The top of the Griqua Town Series is not seen in the Prieska district, but, according to Messrs. Rogers and Schwarz, it must be some thousands of feet in thickness. In the neighbourhood of Pretoria Dr. Molengraaff has estimated the thickness of the Pretoria Series at nearly 10,000 feet, and along the eastern railway line at about 4,000 feet.

The Waterberg Series.

The Waterberg Series, although it plays an important part in the geology of the Northern Transvaal, has hardly as yet received the attention which it undoubtedly deserves. The first reference to the Waterberg sandstones as an independent formation is found in a short note by Mr. Harger in the Transactions of the South African Geological Society for November, 1897.† Dr. Molengraaff, in his report for 1898, describes the development and the relationships of this formation in the Waterberg district; and the same author gives a short general description of the formation in the last edition of his Geology of the Transvaal.‡ In 1903 considerable additions to our knowledge of these rocks were derived from the field-work of the Geological Survey to the east and north-east of Pretoria, the main results of which were embodied in a paper by Mr. E. T. Mellor, read before the Geological Society in May, 1904.§ In this paper Mr. Mellor describes very clearly the unconformity, already referred to, between the Waterberg Sandstone and the

*See Ann. Report Geol. Comm. C.C. for 1899, p. 80.

†Harger, Trans. Geol. Soc. S.A., Vol. III., pp. 107-108.

‡Molengraaff, Report for 1898, pp. 20-26, and Geol. of Transvaal, pp. 58-60 and 89-90.

§Mellor, E. T., Trans. Geol. Soc. S.A., Vol. VII., p. 39.
Also Ann. Report of Geol. Survey for 1903, pp. 4, 10-17, and 31.

Pretoria Series, and also points out that the red granite at Balmoral, which is identical in character with that of the Bush Veld, has been intruded in the from of a laccolite into the lowest beds of the Waterberg Series.

The general features of this formation are, on the whole, strikingly characteristic, uniform and persistent. Mr. Mellor describes these features as follows :—" The Waterberg Series . . . . consists essentially of an extensive succession of fine to coarse-grained, usually massive, sandstones and grits. The sandstones are usually moderately soft, but harder quartzitic beds and quartzites are frequently met with. Near the base of the series very coarse and irregular conglomerates and breccias are usually met with. Higher up in the series, and associated with the sandstones, more regular conglomerates, persistent over large areas and consisting of well-rounded pebbles, rarely exceeding 4 or 5 inches in diameter, are common. Shales are not usually much in evidence, but occasionally occur and may reach 30 feet or more in thickness. . . . . Perhaps the most striking feature of the Waterberg Series is its very characteristic coloration. In this respect it is comparable with such formations as the Old Red Sandstone or the Triassic Sandstones of European geology, closely resembling the latter both in the suite of prevailing colours and in lithological characters. . . . . The most prevalent colour of the Waterberg Series is a brownish red similar to that of the Old Red Sandstone. This colour frequently varies to a deep-chocolate brown on the one hand, or to a brownish purple on the other, a purple tinge being rarely absent in rocks of the Waterberg Series."

The hill features in a Waterberg area, owing to the average low dip of the rocks, generally have a plateau-like form and terminate in abrupt escarpments, while outlying masses of the sandstone often form characteristic, almost flat-topped kopjes, such as the Kranskop near Nylstroom. The valleys are deeply dissected, and the streams flow frequently in narrow gorges or kloofs of considerable depth. These features, combined with the deep red colour of the rocks lend a striking character to the landscape.

In the Northern Transvaal and especially in the Waterberg district extensive areas are occupied by rocks belonging to this series. They rest here usually upon red granite or upon felsite. In the Zoutpansberg district Waterberg sandstone has been noticed by Dr. Corstorphine resting upon the older grey granite. The great plateau of the Waterberg district, known as the Palala Plateau, consists of Waterberg sandstones, which here have an average thickness, as estimated by Dr. Molengraaff, of 3,300 feet. Still further north somewhat similar sandstones have been noted and may very possibly belong to the same formation.

To the south-west of the Transvaal it seems highly probable, as has been suggested by Dr. Corstorphine* and Mr. A. W. Rogers,†

*Corstorphine, "History of Stratigraphical Investigation in S. Africa," Rep. S.A.A.A.S. for 1904, p. 145.

†Rogers, Geology of Cape Colony, 1905, p. 78.

that the Waterberg Series is represented by the Matsap Series of Stow, which forms the Langebergen in Griqualand West, and the Ezel Rand in the Prieska district of Cape Colony. The geological position of the Matsap Series lies between the Glacial Conglomerate and the Griqua Town Series (the equivalent of the Pretoria Series of the Transvaal), and there are some important points of resemblance between it and the Waterberg sandstone. Thus, according to Messrs. Rogers and Schwarz,* the Matsap rocks consist essentially of quartzites and grits with a conglomerate below. The conglomerate contains numerous fragments of typical rocks of the Griqua Town Series in a deep reddish purple matrix, and is overlain by " beds of grey and purple mottled grits with pebbles of quartz, quartzite, and jasper scattered through them."

The Igneous Series of the Bush Veld.

Under this head we will describe briefly the great series of plutonic and volcanic rocks which occupy the greater part of the great central basin of the Transvaal, known as the Bush Veld, which includes large portions of the Pretoria, Rustenburg, Middelburg, Lydenburg and Waterberg districts. In this area we have a vast petrographical province occupied by a complex of igneous rocks, which have played a most important role in the geological and physical history of this portion of South Africa. These rocks consist of granites, syenites, gabbros, norites and other closely allied varieties, together with volcanic rocks mainly of acid types.

Taking, first of all, the more plutonic types, we find that a general survey of the area which they occupy shows that in the more central portions of that area the more acid types predominate, while the more intermediate and basic types tend rather to appear at or near the margin. Thus the granites occupy the centre and by far the greater portion of this vast igneous area, while the syenites, gabbros and norites occur in the more peripheral region. We have here, therefore, an additional illustration of an igneous phenomenon, already recorded in many other parts of the world, namely, an intrusive magma showing increasing basicity from centre to margin.

It should be stated, however, that up to the present time, apart from numerous isolated observations, only a very small portion of this vast area has been examined in any detail. It is probable, therefore, that many new and important facts will be brought to light, as systematic and connected geological work advances, and it is also therefore very possible that many of our present views may in the future require modification.

The Basic Rocks.—In travelling northwards from Pretoria, after traversing the quartzitic beds of the Magaliesberg range, forming here the highest visible members of the Pretoria Series, one finds to the north of the quartzite escarpment an extensive

*See Rogers and Schwartz, " On Geology of the Orange River Valley in the Hope Town and Prieska Districts," Ann. Report Geol. Comm. Cape Colony for 1899, p. 82.

belt of basic rocks. Close to the Magaliesberg quartzite these appear to consist of exactly similar rocks to those which form the numerous intrusive sheets, so characteristic of the Pretoria Series. They are in fact rocks of diabasic type, between which and the intrusions to the south of the Magaliesberg little or no distinction can be drawn. Further north, however, at a distance of about a mile from the boundary of the quartzite, the diabase gradually passes into varieties of gabbro and norite, which constitute a belt of about six miles in breadth, with a general east and west trend. This belt is succeeded on the north by the syenites and granites.

An especially characteristic feature of this basic zone is the line of rugged and often nearly pyramidally shaped kopjes (the Pyramids, Zwartkopjes, etc.) which are so prominent in the otherwise somewhat monotonous landscape to the north of the Magaliesberg. This type of kopje is easily recognisable at considerable distances, and forms a reliable indication of the occurrence of these basic rocks.

On either side of this line of kopjes, to the north of Pretoria, the basic rocks form flat or gently-sloping ground, covered with a deep red soil, and showing occasional rounded boulder-like outcrops. To the north-east of Pretoria the basic zone dies out to the north of Hatherley, and the norites appear again to pass into gabbro and diabase. When traced to the west, however, the basic rocks are found to follow the general trend of the Magaliesberg range, as far as the neighbourhood of Rustenburg and Zeerust. They are again found near the eastern margin of the plutonic basin in the Middleburg and Lydenburg districts, and along the northern margin in the valley of the Oliphants River, and in the neighbourhood of Pietpotgietersrust.

These basic rocks have been studied in detail by Henderson.* The normal rock is a diallage-norite, consisting essentially of a basic plagioclase, diallage, hypersthene, and frequently also a pale augite, and magnetite. Biotite and a small quantity of interstitial quartz are also sometimes present. A very characteristic feature of this rock is the frequent intergrowth of the diallage and the hypersthene. Enstatite is present in some varieties. Pyroxenites, composed entirely of enstatite, are found associated with the norite, in the Marico district and near Potgietersrust. In the latter locality another variety of the norite also occurs consisting mainly of diallage and enstatite, together with some greenish hornblende and biotite, and only a very small quantity of felspar. A dark mottled serpentine is also of fairly common occurrence in the same district.

Of special interest in connection with these norites is the occurrence in them of narrow zones of magnetite which may often be traced for considerable distances across country. To the north of Pretoria, and on the north side of the Zwartkopjes range, the out-

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*Henderson, "Certain Transvaal Norites, Gabbros, and Pyroxenites," London, 1898.

For further references see Ann. Report Geol. Survey, Transvaal, for 1903, p. 32.

crops of two and sometimes three distinct parallel bands of magnetite may be followed with great clearness. They vary in thickness from about 10 to 20 feet, and follow the same trend as the belt of norite in which they occur. These magnetite bands are evidently the result of a process of differentiation from the norite magma. Deposits of iron-opal and chromite are also occasionally found associated with the norite.

Intermediate Rocks.—Syenitic rocks are frequently found at or near the periphery of the huge central mass of the red granite of the Bush Veld, and in certain cases appear to constitute a transitional phase between the granite and the norite. But by far the most interesting types connected with this series are elaeolite and anorthoclase-syenites,* which occur as bosses, intrusive either in the Magaliesberg quartzites or in other igneous rocks belonging to the Bush Veld Series. The best known example of this variety of syenite forms a complex, boss-like intrusion, situated on the farms Leeuwfontein and Zeekoegat, a few miles north of Hatherley and north-east of Pretoria. A large portion of this intrusion consists of elaeolite-syenite, which, according to Molengraaff, is of the foyaite type. Another portion constitutes the anorthoclase-syenite, for which Henderson proposed the name Hatherlite† (the term being unsuitable, however, owing to an error of locality). The foyaite type is also found in the Pilandsberg to the north of Rustenburg.

The Acid Rocks.—These consist mainly of granite and closely allied varieties, and occupy a vast area to the north of the Magaliesberg, in the Bush Veld. The granite is usually a coarse reddish rock, consisting of orthoclase, some plagioclase, quartz, and hornblende or biotite in varying proportions. A highly perfect micrographic structure is very characteristic, many of the rocks, and especially the finer-grained varieties, being granophyres rather than granites. A porphyritic structure is also common.

In the granite country the more low-lying ground is usually occupied by the coarse facies, while on the higher ground we more usually find the finer-grained varieties, such as granophyre, microgranite, granite-porphyry, etc., and these in certain localities appear to pass gradually into a rock which might almost be designated a felsite. It is possible that these fine-grained modifications may represent a marginal facies.

In the earlier geological descriptions of the Transvaal no clear distinction was made between the red granite of the Bush Veld and the much older and usually grey granites, such as are found between Pretoria and Johannesburg, near Heidelberg, near Klerksdorp, at Vredefort in the Orange River Colony, and in the Low Country.

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*For detailed description see Henderson, Op. Cit., p. 45.
Also Wulfing. Untersuchung eines Nephelin-syenit aus dem mittleren Transvaal, Sud-Afrika, Neues Jahrb., 1888, p. 16.
,, Molengraaff, Geology of the Transvaal, p. 45.
,, Ann. Rep. Geol. Survey, Transvaal, for 1903, p. 33.

†Henderson, Op. Cit., p. 46.

But in 1898 Dr. Molengraaff,* in his annual report as State Geologist, very clearly pointed out the differences in character and geological position between these two groups of granitic rocks, the older grey granites being clearly of earlier date than the deposition of the Black Reef, while the red granite, according to the latest evidence, was intruded subsequently to the formation of the Waterberg Series, but considerably prior to that of the Glacial Conglomerate at the base of the Karroo System.

Volcanic Rocks.—These have so far not received very special attention from geologists. They consist mainly of felsitic rocks and are well developed in the hilly country of the Waterberg district, to the north-west of Warmbaths and north of Nylstroom, and in the Pienaars and Elands River valleys to the north-east of Pretoria.† A most interesting series is found in the valley of the Pienaars River, and is well exposed on the farm Roodeplaat, due east of Waterval Station. Here we find a series of bedded felsites, often showing a well-marked flow-structure, andesitic rocks, banded ashes or tuffs and agglomerates, resting upon quartzites belonging to the upper Pretoria Series and succeeded by a series of dark shales. These rocks are occasionally traversed by dykes of felspar-porphyry and basic rocks. Further north, on the farm Walmansthal, the felsites have been invaded by an intrusion of elaeolite-syenite. To the east they are overlain by Waterberg sandstones.

The geological position of these felsites is still a matter of some uncertainty, especially owing to the liability of confusing them with the felsitic and probably marginal modifications of the granite. In the Pienaars River Valley they would appear to belong to the base of the Waterberg Series. In the Waterberg district a somewhat similar series of felsites is found underlying the Waterberg sandstone, and the conglomerates at the base of the latter often contain numerous pebbles of felsite of precisely similar character.

The Karroo System.

From a purely geological point of view the Karroo System may perhaps be considered one of the most interesting of those occurring in the Transvaal. It is the only series of rocks in the Colony which has so far yielded determinable fossils, and consequently the only one whose geological position as compared with European formations can be definitely stated. It is also the only one which can as yet be correlated with certainty with any of the formations occurring in the sister colonies of South Africa. It further shows a close agreement with corresponding formations in other parts of the Southern Hemisphere, notably in India, Australia, and in South America.

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*Molengraaff, Ann. Rep. State Geologist, 1898, p. 3, and Geology of of Transvaal, pp. 42-45.

†Molengraaff, Ann. Rep. for 1898, pp. 4 and 5, and Geol. Transvaal, p. 48.

Also Ann. Report Geol. Survey of Transvaal for 1903, p. 34.

Although not so extensively developed in the Transvaal as in the Orange River Colony, and in the region from which it takes its name, it still occupies a very large proportion of the surface, occurring, not only as a more or less continuous sheet covering much of the south-eastern Transvaal, but also in smaller detached areas scattered throughout the greater part of the remainder of the Colony. Over a wide area to the north of the eastern railway line it occurs as extensive outliers on the Waterberg Sandstones and the Red Granite, and includes probably certain sandstones occurring on the Springbok Flats.

Near the Portuguese border along the course of the "Great Eastern Fault," a long strip of Karroo rocks, including beds of coal of economic importance, has been preserved in the Eastern Transvaal. Associated with the sedimentary rocks are extensive volcanic flows consisting largely of amygdaloidal basalts.

In the Orange River Colony the Karroo System also attains a very wide development, occupying almost the whole of the surface.

In that portion of the Transvaal where it attains its most extensive development, the Karroo System of rocks is the main factor in the production of a special type of country known as "High Veld," possessing scenic and physical characteristics more or less peculiar to itself, and dependent partly on its exceptional elevation and partly upon its geologic structure.

The enormous unbroken stretches of soft horizontal sandy strata give rise to vast and gently undulating expanses of country usually unbroken by any sharply marked surface features. Trees are of rare occurrence, and the thick growth of high grass which clothes the High Veld during the greater part of the year tends still further to accentuate its uniformity of colour and outline. In common with much of South African scenery the High Veld, in spite of its monotony, possesses a special charm of its own in its magnificent simplicity, the full appreciation of which is aided by the prevalent clearness of the atmosphere, which helps to intensify the impression of illimitable space upon which so much of the charm of the South African veld depends.

Along the great eastern escarpment of the High Veld more active and more advanced denudation has produced types of country at once more varied, both in their physical aspects and in their geological interest. The deeply dissected country traversed by the eastern rivers offers a strong contrast to the almost unbroken surface of the High Veld, and affords magnificent sections of extensive series of strata forming part of this system. In its western, and particularly in its northern extension, the Karroo System diminishes very considerably in thickness. It is here, however, very interesting to the geologist from the fact that the progressive denudation of the Karroo rocks leads to the re-appearance of a land surface, whose main features date back as far as Carboniferous times.

In the classification of the Karroo Rocks as developed in the Transvaal, geologists are still far from unanimity, especially regarding the upper portion of the system, and in particular with regard to the coal-bearing horizon.

On account of its more extensive development, the occurrence of more complete natural sections, and the longer period over which the study of this system has extended in Cape Colony and Natal, a more or less complete classification has been established in these neighbouring colonies. The attempt to adjust the classification of the Karroo System of the Transvaal to these more complete classifications has not yet met with complete success. There is a very great thinning out of the whole series of rocks from east to west, and the complete correlation with the more comprehensive eastern sections of the comparatively feeble, or possibly incomplete development of the system in those parts of the Transvaal where it has as yet been most studied, will perhaps only be settled when fuller data with regard to the intervening phases are available. The correlation of the Transvaal coal-bearing rocks with portions of the Stormberg Series of Cape Colony having been eliminated by the recent work of Seward,* Zeiller,† and others, on their respective fossil floras, the question remains as to where between the Stormberg Series and the Glacial Conglomerates the Transvaal coal horizon is to find a place.

From the consideration of certain sections at Vereeniging, Dr. G. S. Corstorphine has advocated an interglacial position for the Transvaal coal horizon.‡ Dr. Molengraaff's later views** are represented in the classification given in the recently published English edition of his "Geology of the Transvaal" which is as follows :—

Upper Karroo : Fluviatile and Lacustrine.

Stormberg Beds, not developed in the Transvaal, containing coal seams in the Cape Colony.

Hoogeveld Series, probably Beaufort Beds, containing coal seams in the Eastern Transvaal ; thins out towards the west.

Lower Karroo : Glacial and Interglacial.

Ecca shales, very well developed in the Eastern Transvaal, thinning out towards the west, and not developed at Vereeniging.

Dwyka conglomerate, containing locally (interglacial) sandstones, with coal seams at Vereeniging.

In the following description the formation will be treated chiefly with reference to its more characteristic Transvaal developments.

*A. C. Seward, "On the association of Sigillaria and Glossopteris in S. Africa," Q.J.G.S., Vol. 53, p. 315, 1897.

†R. Zeiller, "Etudes sur quelques fossiles des environs de Johannesburg," Bull. Soc. Geol. de France, 1896," Vol. 54, p. 315.

‡G. S. Corstorphine, "Note on the Age of the Central South African Coalfield," Trans. Geol. Soc. S.A., Vol. VI., 1903.

**Molengraaff, G. A. F., "Geology of the Transvaal," English translation, 1904, p. 82.

The Glacial Conglomerates (*Dwyka*).—In the eastern sections the Dwyka Conglomerate, both in its mode of occurrence and in its petrological characters, resembles closely the better known occurrences in the north-eastern portion of Cape Colony, and in Natal.

Though probably very generally present at the base of the Karroo System throughout the higher portions of the Transvaal, the Glacial Conglomerate participates in the general thinning out of the whole system from east to west. Good natural exposures are comparatively rare, and the rock frequently shows marked local modifications: its constitution being largely influenced by the formations upon which it lies or from which its materials have been derived.

Extensive areas covered by the conglomerate have recently been described and mapped in the district lying north and south of the Eastern Railway line between Pretoria and Middleburg,* where, owing to the almost complete removal by denudation of the overlying sandstones and grits of the High Veld Series, the Glacial Conglomerate remains in broad patches which, were the conditions prevailing in other parts of the country unknown, might easily, by their mode of distribution and general relationships to the underlying formations, convey the impression of belonging to a period of comparatively recent glaciation.

The former wide extension of the Glacial Conglomerate is shown by the occurrence of isolated patches 80 miles further north than Johannesburg.†

In the southern portions of Cape Colony the Dwyka Conglomerate has the characters of a sub-aqueous deposit composed of materials of glacial origin,‡ while in the northern portions it represents a true ground-moraine, which is also the case in the Transvaal,§ including the district referred to above. Here the Glacial Conglomerate presents all the characters of a deposit, produced, not by the action of a number of separate glaciers, but rather of an ice-sheet of very great dimensions.||

The conglomerate contains an abundance of typical glacial boulders of very miscellaneous composition and often of very large size. In nearly all cases the rocks of which the boulders are composed are only met with *in situ* to the north of their present position. Thus the Red Granite and the hardest quartzites and conglomerates of the Waterberg Series have furnished the majority of the boulders occurring in a belt lying to the south of the area

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*Ann. Reports Geol. Survey of Transvaal, 1903, 1904.

†E. T. Mellor, "Outliers of the Karoo System near the junction of the Elands and Olifants Rivers in the Transvaal," Trans. Geol. Soc. S.A., Vol. VII., 1904, p. 133.

‡Ann. Report Geol. Comm., Cape of Good Hope, 1899.

§G. A. F. Molengraaff, "The Glacial Origin of the Dwyka Conglomerate," Trans. Geol. Soc. S.A., Vol. IV., 1898, p. 103.

||E. T. Mellor, "Glaciated Land Surfaces in the district between Pretoria and Balmoral," Trans. Geol. Soc. S.A., Vol. VII., 1904, p. 8.

mainly occupied by those rocks, while south of the long escarpments of the eastward extension of the Magaliesberg quartzites, huge boulders derived from these beds play a very prominent part wherever exposures of the Glacial Conglomerate occur.

The progress of denudation of these more northerly occurrences of the Glacial Conglomerate frequently lays bare the striated surfaces of the underlying rocks. Many fine examples have recently been found among the outcrops of hard quartzites in the Waterberg and Pretoria Series.* Distributed over an area of 300 square miles, these striations show a remarkable consistency of direction, pointing to an ice-movement from N.N.W. to S.S.E.

The general appearance of the Glacial Conglomerate and the character of its matrix in these more northerly districts differs somewhat from that of the eastern examples.

The rock is usually of much softer character and of a yellowish colour, and the matrix contains a large proportion of sandy and quartzitic material, and further shows less induration and crystallisation. These effects are probably in great measure due, partly to the materials of the conglomerate having been largely gathered from an area in which the prevailing rocks are sandstones, quartzites and granites, and partly to the lesser weight of superincumbent strata to which the conglomerate has been subjected.

The Ecca Shales.—The series of shales which succeeds the Dwyka Conglomerate and which is well represented in practically all the eastern sections is, in the more central portions of the Transvaal, very poorly developed or frequently apparently absent altogether, as at Vereeniging.

Small local developments of shales quite similar to the typical examples of the eastern districts occur in various localities, as at the Douglas Colliery, 45 miles east of Pretoria, where about 6 feet of such shales succeed the Glacial Conglomerate.†

In the present state of our knowledge, however, it is diffiuclt to say how far this portion of the Karroo System is represented in various portions of the Transvaal.

Upper Karroo (High Veld Series).

In the central portions of the Transvaal the Upper Karroo is represented by the series of shales, sandstones and grits which occur in immediate association with the coal seams. The thickness of this series now present in any particular locality varies considerably according to the extent to which the local denudation of the series has progressed. Usually the thickness is from 100 to 400 feet. The prevailing rocks are shales, often carbonaceous, and fine and coarse sandstones. Very coarse, massive grits composed almost entirely of somewhat angular quartz grains also frequently occur, and are very characteristic of the coal districts between Pretoria and Middelburg, where by weathering they give rise to small

*Loc. Cit. Also An. Reports, Geol. Surv. Transvaal, 1903, 1904.
†Ann. Report Geol. Survey of Transvaal, 1903, p. 23.

"kranzes," and striking groups of huge blocks forming conspicuous surface features.

In the more continuous areas covered by this series it gives rise to the rolling, somewhat sandy, high-veld country already referred to, a characteristic feature of which is the occurrence of numerous more or less circular shallow depressions, known as "pans," the origin of which has given rise to much discussion. In comparison with the Karroo System in Cape Colony and Natal, igneous intrusions, whether in the form of dykes or sheets, are perhaps not so conspicuously developed, especially in the more northerly districts.

The disposition of the coal-measures is almost everywhere horizontal, with a tendency to a slight undulation of the beds, rarely giving rise to dips exceeding 5°. Faulting except on a small scale is infrequent.

*The Coal Seams.**—The general thinning out of the Karroo System in the Transvaal fortunately does not apply to the coal seams which are often of great thickness, most of the seams at present worked being from 6 to 20 feet thick.

Like most South African coals, those of the Transvaal appear to be mainly of drift origin, and to have been deposited by current action in more or less extensive basins. To this mode of origin is probably due the frequently banded appearance of most of the Transvaal coals, as well as the somewhat high percentage of ash. Hitherto no good examples of typical underclays or of fossil trees *in situ* have been found, although boulders of the Dwyka Conglomerate at Vereeniging frequently show markings apparently due to the roots of coal-measure plants.

The coal is at present mainly worked in the following localities: at Vereeniging, near the border of the Orange River Colony; at Boksburg and Springs, east of Johannesburg; at a large group of collieries situated near Witbank Station, west of Middelburg; and at Belfast.

The shales and sandstones accompanying the Transvaal coal-seams contain abundant fossil plants.

Many of the best specimens have been obtained from Vereeniging,† and have been described by Seward and Zeiller, by whom the coal horizon is assigned to a Permo-carboniferous age. Characteristic members of the fossil flora of the Transvaal coal measures include Glossopteris browniana, Gangamopteris cyclopteroides, Noeggeratheopsis Hislopi, Sphenopteris, Sigillaria Brardi, etc.

Owing, however, to the rarity of natural outcrops of these fossiliferous beds, and to the comparative ease with which the coal is obtained, obviating the necessity for any extensive workings in beds other than the coal itself, the collections of fossils hitherto made in this Colony have not been very extensive.

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*For descriptions of Transvaal Coalfields see also :—
M. E. Frames, Trans. Geol. Soc. S.A., Vol. II., p. 87.
D. Draper, " " " " " III., p. 128.
A. R. Sawyer, Trans. Inst. Min. Eng., 1898.

†T. N. Leslie, "The Fossil Flora of Vereeniging," Trans. Geol. Soc. S.A., Vol. VI., p. 82.

The Diamond Pipes.

In concluding this very incomplete description, a short reference to the diamondiferous vents or pipes will not be out of place, especially as one of these, the Premier, has now deservedly attained a world-wide celebrity and interest. Several diamondiferous vents are now known to the east of Pretoria, and are situated on the elevated ground, lying between the upper waters of the Pienaars and Elands rivers, and occupied by some of the uppermost quartzites, shales, and diabases of the Pretoria Series. Of these the Premier pipe is not only by far the largest known diamondiferous vent in the world, but, as everyone knows, it has produced a most marvellous record in diamonds.

This pipe is situated on the farm Elandsfontein (85), about 7 miles north of Van der Merwe Station and about 22 miles E.N.E. of Pretoria. At the surface the outline of the pipe forms an irregular oval, the longer diameter of which measures just over half a mile. The area of diamondiferous ground at the surface has been calculated at 350,000 square yards (equal to 3,280 claims of 30 by 30 Cape feet). The pipe is almost entirely surrounded at the surface by felsitic rocks, which form the upper portion of a large sheet intrusive in quartzites of the Pretoria Series. In addition to the felsite a small patch of quartzite is found cropping out on the northern edge of the vent.

Nine bore-holes have been put down into the pipe to depths varying from 300 to 1,001 feet, and these have all traversed typical blue-ground or Kimberlite of excellent quality. The level of the blue-ground varies in different parts of the pipes. In the open workings it is seen within fifteen feet of the surface, but usually it is struck at a depth of about 35 to 40 feet. Nearly all the blue matrix is soft and weathers rapidly, and no hard blue, or "hardi-bank," has been met with except in one of the bore-holes at a depth of slightly over 500 feet.

A considerable amount of foreign material also occurs in the vent in the form of "floating reef." This consists of masses, up to over 100 feet in thickness, consisting mainly of purple quartzite, with some conglomerate, breccia, and a reddish felsitic rock. In the open workings masses of purple quartzite, indurated grit, and conglomerate are well exposed. An interesting point in this connection is the close resemblance which these masses of conglomerate and quartzite bear to similar types of the Waterberg Sandstone Series, the nearest outcrop of which to the Mine lies about 3 miles to the north-east. It is quite possible that the Waterberg rocks may at one time have extended over the area where the pipe is situated, and that the included masses within the vent represent fragments of these Waterberg rocks, broken from the former higher portions of its walls.

Apart from the Premier pipe, we may mention the following vents, all however of comparatively small size, occurring in the same district :—the Schuller, Kaalfontein, Montrose, Zonderwater, and

Pienaarspoort. Of these the Schuller and Kaalfontein pipes are the most interesting geologically, and show very clearly the junction between the diamondiferous ground and the country rock. The walls are well defined and often show traces of slickensiding. In connection with the Kaalfontein pipe, a tendency of the quartzite beds to curve upwards at their contact with the vent has also been observed.

The Schuller No. 1 pipe consists to a great extent of very hard blue-ground, resembling the Kimberley "hardibank," and this may be seen cropping out at the surface as a hard dark bluish-black rock, containing angular fragments and the characteristic minerals usually associated with the diamond. A microscopic and chemical examination of the rock has shown it to be a highly serpentinised peridotite-breccia. More detailed information regarding these interesting vents will be found in the report of the Geological Survey of the Transvaal for 1903, and in a paper by Messrs. Kynaston and Hall, read before the Johannesburg meeting of the South African Association for the Advancement of Science.*

In the Orange River Colony several vents occur in the western and north-western portions of the Colony, the Lace Mine, in the neighbourhood of Kronstad, being especially interesting. These vents have pierced strata belonging to the Upper Karroo System.

There appears to be very little doubt that the Transvaal and Orange River Colony vents belong to the same class as those of Kimberley, and are probably all of approximately the same age. The Transvaal vents, disregarding superficial formations, would represent, therefore, the most geologically recent rock in that country, of which we have any record.

The Pretoria Diamond Fields are situated in an area which has been one of considerable earth-movement and disturbance. There may be good reason, therefore, for supposing that the faulting, which has taken place in this area, has set up lines of weakness, which have finally been taken advantage of by the volcanic forces to which the vents owe their origin.

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* See Annual Rep. Geol. Survey of Transvaal for 1903, pp. 43-48. Also Kynaston and Hall, "The Geological Features of the Diamond Pipes of the Pretoria district," Rep S.A.A.S., 1904, pp. 182-196 and Plates VII. and VIII.

4. GEOLOGY OF RHODESIA.

By F. P. Mennell, Curator of the Rhodesia Museum, Bulawayo.

The geological features of Rhodesia are not at present known in any great detail, and the unravelling of the intricacies of the metamorphic rocks presents a problem at least as complicated as that of the Scottish highlands, the solution of which is only now being attempted. If, however, the schists are looked upon as one big group, though they include both truly "archæan" and "eparchæan" types, the broad outlines of the geology of Rhodesia appear to be of comparative simplicity, and may be summarised in a few words.

North-east by south-west there runs through the country a narrow tableland which marks the axis of a huge anticline falling away to the Limpopo and the Sabi on the south and stretching towards the Zambesi on the north. The plateau, or "high veld," reaches a height of about a mile above sea-level, and is composed almost entirely of igneous and metamorphic rocks, showing the extent to which the axial portion of the anticline has been denuded, though it still maintains its position to the extent of forming the highest ground. The plateau was probably outlined at the time the Rhodesian coal beds were laid down, as it does not seem likely that their distance from the anticlinal axis is to be attributed to subsequent erosion. That the present elevation of the plateau is, however, due to comparatively recent earth-movements is conclusively shown by the outliers of forest sandstone which occur upon it, such as the conspicuous hills of Taba-z-Induna and Umfazumiti, which are prominent features in the landscape near Bulawayo. It may be mentioned that no rock of marine origin is known to occur in Rhodesia, unless among those of Archæan age.

The stratigraphy may be roughly summed up as follows:—

Laterite, hot spring deposits, etc.	*Recent.*
Forest Sandstone	*? Tertiary.*
Coal Series	*Permian.*
? Dwyka Conglomerate *Sandstones and Shales*	? Upper Palæozoic.
(great unconformity)	
Conglomerate, etc. *Banded Ironstone series* Bulawayo schists	Archæan.

The rocks classed as Archæan are no doubt equivalent to the Malmesbury beds of the Cape. The true schists are probably, from their composition, in part old sediments and in part of igneous origin ; the eparchæan rocks, on the other hand, are obviously as a rule of sedimentary origin. The slaty beds seen at Cape Town are, in fact, lithologically almost identical with the less-altered portions of the rocks here termed Banded Ironstone. These banded rocks are the northward extension of beds called Griquatown series by the Cape Geological Survey and Hospital Hill Beds in the Transvaal. They are now usually silicified to such an extent as to resemble cherts, but the least metamorphosed parts are obviously fine-grained mechanical sediments. They are sometimes transformed in the granite contact zones into andalusite and other schists, but these in no way resemble the normal hornblende, mica, talc and chlorite schists which unconformably underlie them, and their progressive alteration is well shown. The conglomerates and coarse sandstones which overlie the banded ironstones often approximate in structure to true schists ; in fact, a microscopical examination of the matrix, disregarding the pebbles, would often result in the rock being set down as a hornblende schist, or even sometimes as an igneous rock. The pebbles, which are sometimes large and in other cases small and beautifully rounded, like river gravel, include quartz, " halleflinta," granite, granophyres, talc and chlorite schist, and sometimes much banded ironstone. The conglomerate, as first pointed out by the writer, is evidently the stratigraphical equivalent of the Rand banket; and it has lately been discovered to contain payable gold in several localities, notably at Lomagundi.

The oldest ordinary sediments are much younger than even the granites which are " intrusive " in the archæan rocks, and which are now exposed at the surface over great part of Rhodesia. They probably include equivalents of the Pretoria beds, etc., of the Transvaal, but have so far been little studied owing to their remote situation in basins of the Sabi, Sengwe and Tuli rivers.

The Coal Beds are underlain in the Tuli district by what is almost certainly the Dwyka conglomerate, so well known in the Transvaal and Cape Colony, and usually considered to be of glacial origin. The coal series is itself presumably of Permian age, and is the oldest fossiliferous formation in Rhodesia, having yielded the fish *Acrolepis molyneuxi*, the freshwater mollusc *Palæomutela*, and the plants *Glossopheris* and *Calamites*, as well as a few indeterminate reptilian bones. It consists of sandstones with some shales and rare bands of limestone, besides seams of coal which are thick and of good quality, and appears to extend, though not in unbroken continuity, all through the north of Matabeleland and near the Limpopo from Tuli to the Sabi River.

Overlying the coal beds are series of red and white sandstones, partly of desert and partly of lacustrine origin, which contain numerous inter-bedded sheets of basalt and other lavas. From the freshness of these latter, and other considerations, it is probable that the beds are of Tertiary age. The "Forest Sandstones" cover most of the lower-lying parts of the country, and outliers occur, as already noted, even on the plateau.

The remaining rocks are those whose formation is even now in progress. The laterite so common in all tropical countries, is here often found over-lying the igneous and metamorphic rocks, and the hot springs of the Zambesi basin form interesting calcareous and siliceous sinters. The rivers, however, may be almost left out of account, as, owing to the recent elevation of the plateau and their consequently almost torrential nature, they give rise to few accumulations of gravel or sand. The soil of the country, too, owes nothing to "drift" deposits, but is purely the result of disintegration *in situ* of the underlying rocks.

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5. THE FOSSIL REPTILES OF SOUTH AFRICA.

By R. Broom, M.D., D.Sc., C.M.Z.S., Professor of Geology and Zoology, Victoria College, Stellenbosch.

The conditions which prevailed in South Africa during Permian and Triassic times must have been for the most part singularly suitable for reptilian life; and the remains of the reptiles have on the whole been beautifully preserved in the extensive shale beds which were laid down during these long epochs. It thus happens that, probably in no part of the world, have we such an uninterrupted history of the land vertebrates of Permian and Triassic times; and as it was in these times that the great radiation took place which gave rise to the various reptilian orders and even to mammals and possibly birds, there is no period in reptilian history of which it is more important that we should have a thorough knowledge.

The oldest rocks from which reptilian remains have been obtained are the Upper Dwyka shales of possibly Lower Permian ages, and these have yielded so far only a single form, *Mesosaurus*. This was a slender aquatic reptile about 2 feet long, and of a very primitive type. The jaws were long and pointed, and armed with numerous long slender teeth. The limbs were feeble, and, though no doubt mainly used for swimming, were probably still strong enough to enable the animal to move on land without much difficulty. The ribs were very thick and heavy, and but loosely attached to the vertebrae. Though there is some difference of opinion as to the relationships of the form, it seems probable that it was an aquatic modification of a primitive land reptile somewhat allied to *Palæohatteria* and *Procolophon*. A very similar form, *Stereosternum* is known from the Permian beds of Brazil.

About 2,000 or 3,000 feet above the beds in which *Mesosaurus* occurs, we come to strata in which reptilian remains are abundant, and which are called the Beaufort Beds. From the lowest stratum in which land reptiles occur there is a continuous series of shale and sandstone beds measuring about 10,000 feet, and possibly containing the records of at least two millions of years. In this long period there can be traced a number of fairly distinct faunas, and a clearer idea of the life may be gained by the consideration of the different faunas than by considering the reptiles systematically

In the lowest of the Beaufort Beds the fauna is characterised by the presence of a number of large heavily built land reptiles, of which the most prominent and best known form is *Pareiasaurus*. This large reptile measured about 9 feet in length and stood about 3½ feet in height. The head is broad and moderately flat above with the temporal region completely roofed over. The orbits are small and round. There are fourteen to sixteen fairly equal flattened teeth, with notched edges, on each jaw. The limb bones and vertebrae are very massive, and are specially interesting, in that they resemble the bones of mammals more than they do those of reptiles. *Pareiasaurus* was probably a slow moving animal that lived in the marshes of the great inland sea of the time. A species of *Pareiasaurus* has recently been discovered in North Russia; and *Elginia* and *Sclerosaurus* of Europe are allied forms.

Associated with *Pareiasaurus* is another possibly allied form of even larger size, *Tapinocephalus*. Unfortunately, it is very imperfectly known. More is known, however, of one or two large carnivorous reptiles which probably preyed on the slow moving *Pareiasaurus*. Of these, *Titanosuchus* and *Scapanodon* probably stood about 5 feet in height. They were armed with large and powerful incisors and canines. A smaller allied carnivorous form was *Delphinognathus*. With this peculiar fauna of large types, which may be called the *Pareiasaurus* fauna, we have a few forerunners of the next—the *Dicynodon* fauna.

The *Dicynodon* fauna is the richest of the Karroo faunas, and lasted for a very long period. It differs from the preceding in that all the members of it are of comparatively small size, the largest being probably under 3 feet in height. The herbivorous forms, which are by far the most numerous in individuals, belong to the order of Anomodonts, of which *Dicynodon* is the typical genus.

Dicynodon is a genus of mammal-like reptiles, of which there are many species, varying in size from forms under a foot in length to others as large as a wild boar. Though heavily built animals, the bones of the skeleton are strikingly like those of mammals, and even the skull is fundamentally of the mammalian type. The resemblance, however, is much obscured by the fact that the upper canines are developed as tusks, while the rest of the margin of the jaws have been covered with horn as in the tortoise. The Dicynodons were probably sluggish animals that lived in the marshes and fed after the manner of tortoises.

Allied to *Dicynodon* and associated with it were many species of *Oudenodon*, a somewhat more slenderly built genus which differed in being devoid of any trace of tusks. *Oudenodon* appeared in South Africa a little earlier than *Dicynodon*, and is only met with in the lower Beaufort Beds.

A considerable number of other genera are met with allied to *Dicynodon* and *Oudenodon*, but with a number of molar teeth. These are placed in the family of the Endothiodonts, and the best known genera are *Endothiodon*, an animal about the size of a moderate-sized pig, but with a disproportionately large head; and *Opisthoctenodon*, a slenderly-built little form about the size of a rat.

Living with the Anomodonts and no doubt preying on them, were large numbers of carnivorous reptiles, varying in size from forms smaller than a cat to others as large as a hyæna. These all belong to a group of primitive mammal-like reptiles called the Therocephalia. They are characterised by having the teeth divided into incisors, canines and molars, as in mammals. The skull is fairly mammal-like, but differs in having a single occipital condyle, a well-developed quadrate bone, and a palate of the Rhynchocephalian type. The Therocephalians were active animals, and unlike the Anomodonts had the toes armed with powerful sharp curved claws. The best known members of the group are *Cynodraco*, *Lycosuchus*, and *Ictidosuchus*.

Towards the close of this period a number of curious small Anomodonts appear—the Kistecephalians—but they survived only a short time.

In the strata above those in which *Dicynodon* and *Oudenodon* are so abundant, we find an entire change in the fauna, but whether this is due to the old forms having died off, or merely to the fact that the rocks preserved, represent deep water conditions rather than littoral, cannot at present be decided with certainty. In these rocks the principal and almost the only reptile is an aquatic form of Anomodont called *Lystrosaurus*. It is characterised by having large eyes placed near the top of the head, and the nostrils also placed high. The limbs are short, and the joints cartilaginous. *Lystrosaurus* may be regarded as a reptilian seal. The remains are so very numerous that specimens are to be found in every collection.

Above the *Lystrosaurus* beds a very distinct land fauna is met with quite unlike the old *Dicynodon* fauna. This for convenience may be called the *Procolophon* fauna.

Procolophon is a lizard-like reptile, about 18 inches in length. Though the beds in which it is found are probably Middle Triassic, it is apparently a survival from Lower Permian times and is one of the most primitive types of reptile known. The skull is broad, with large orbits and with a roofed temporal region. There are on each jaw from nine to twelve fairly uniform teeth, the incisors pointed and the molars broad topped. As in *Sphenodon* and many lizards, the teeth are anchylosed to the bone. The palate resembles that of *Sphenodon*. The shoulder girdle retains a well-developed precoracoid, but has lost the cleithrum. The pubis and ischium are plate-like. The digital formula is as in *Sphenodon*, and there is a further resemblance in the presence of abdominal ribs. The vertebrae are notochordal. *Procolophon* may be regarded as a form intermediate between the American Cotylosaurs and the primitive Rhynchocephalians, such as *Palæohatteria* of Europe.

With *Procolophon* are associated one or two other small forms, among them a small Stegocephalian, *Micropholis* and the earliest known true lizard, *Paliguana*.

In the same beds occur the earliest Cynodont reptile *Galesaurus*, a small carnivore which doubtless preyed on *Procolophon*.

Another most interesting form occurring here is the imperfectly known *Proterosuchus*. This is regarded by some as belonging to the same group as *Belodon* and other primitive crocodile-like forms, and by others as a Rhynchocephalian. The truth probably is that it is intermediate between the two groups. The skull is about a foot in length.

In the uppermost of the Beaufort Beds we again get a fairly distinct fauna which may be called the *Cynognathus* fauna. It is exceeding rich, and as the result of the researches of Kannemeyer and Brown it is fortunately now pretty well known. The most striking and characteristic members of the fauna are the extremely mammal-like Cynodonts, or as they are usually called "Theriodonts."

Cynognathus, which may be taken as the type of the Cynodonts, was a large carnivorous form about the size of a hyæna, but with a proportionately larger head. The skull and most of the bones of the skeleton are almost typically mammalian. The teeth are divided into incisors, canines, pre-molars and molars. There is a well-developed secondary palate, and the lower jaw is formed almost entirely by the dentary. The quadrate bone is rudimentary, and though the hinge is still between the articular and the quadrate, the dentary almost reaches the articulation. The skull is supported by condyles as in manuals. The shoulder girdle still retains the precoracoid, and the pelvis is more mammal-like than in any other reptilian group, there being a large obturator foramen.

Closely allied to the truly carnivorous *Cynognathus* are a number of other genera which differ in having flat-topped molars. The best known of those are *Gomphognathus*, an animal of about the size of a Collie dog; *Diademodon*, a slightly smaller allied form; and *Trirachodon*, an animal about the size of a cat. These have well-developed incisors and canines, and crushing but apparently not grinding molars. As they were also provided with large temporal muscles, it seems more probable that they were carrion-eating forms than herbivorous, as has been suggested.

Two other genera, *Sesamodon* and *Melinodon*, though closely resembling the Cynodonts proper, have been provided with grinding molars and must thus have had a loose articulation for the jaw, and probably belong to a group intermediate between the Cynodonts and Mammals.

One or two species of a Procolophon-like genus, *Thelegnathus*, occur in fair numbers, but they are very imperfectly known.

Better known is a very interesting Gnathodont or Rhynchocephalian reptile called *Howesia*. This is a little form about 2 feet in length somewhat allied to *Sphenodon*, but differing in having four or five rows of small teeth on the jaws. In this it agrees with the European and Indian genus *Hyperodapedon*, of which it may possibly prove to be the ancestor.

A few Anomodonts of large size reappear in these upper Beaufort Beds. There is a large species of *Dicynodon*, *D. latifrons*, and a very large imperfectly known form which probably belongs to a new genus.

A considerable number of Stegocephalians are met with, possibly belonging to five or six genera. The best known are *Rhytidosteus*, *Batrachosuchus*, *Cyclotosaurus* and *Bothriceps*.

It seems remarkable that in this Upper Triassic fauna there are apparently no Dinosaurs or Phytosaurs.

Above the Beaufort Beds are the Stormberg Beds, and here we find again an entirely distinct fauna. There is some difference of opinion as to the age of the Stormberg Beds, but recent evidence points to their being Lower Jurassic.

The Stormberg fauna is at present not very thoroughly known, and Dinosaurs are the most prominent types. Remains have been discovered of two or three small carnivorous forms, the best known being *Hortalotarsus*, an animal which stood about 4 feet high, and which is allied to the American *Anchisaurus*. A much larger carnivorous Dinosaur is the imperfectly known *Massospondylus*. *Orinosaurus* is possibly a gigantic Dinosaur allied to *Megalosaurus*, but is very imperfectly known. Another large form is *Euskelesaurus*, but there are different opinions as to its affinities. Prof. Marsh believed it to be a Stegosaurian.

A number of bones have recently been discovered which appear to be those of a large species of *Belodon* or an allied genus.

There have also recently been found the remains of a small true crocodile, *Notochampsa*. This is a little animal about 2 feet in length, with sharp snout and with long legs. Its nearest ally seems to be *Pelagosaurus*, but it is much specialised and probably lived mainly on land.

Another interesting form which was apparently discovered in Stormberg Beds is *Tritylodon*. By Seeley and others it is believed to be a reptile, but it was originally described by Owen as a mammal, and Owen's view is still supported by some anatomists.

The Uitenhage Beds, which are considered to be of Wealden age, have so far yielded very few vertebrate remains. The greater part of a Plesiosaurian was discovered a number of years ago, but has not yet been described. Recently a moderate-sized Opisthocoelian Dinosaur, *Algoasaurus*, has been found. It closely resembles the American forms, but is of much smaller size. There are also evidences of carnivorous Dinosaurs and other reptiles.

In the Pondoland Beds, which are believed to be Senonian, there have been discovered the remains of Chelonians and Pythonomorphs, but they have not as yet been described.

The majority of the types of the South African reptiles are in the British Museum, London, but though the collections in South Africa contain fewer types they are perhaps of greater interest to the comparative anatomists.

In the South African Museum, Cape Town, is an almost perfect skeleton of *Pareiasaurus*, and a number of imperfect skeletons, and also skulls and portions of the skeletons of *Titanosuchus* and *Delphinognathus*. The types of most of the Therocephalians recently described are also to be seen here, including the fine skulls of *Glanosuchus* and *Scylacosaurus*. Among Anomodonts, the most interesting specimen is the fairly complete skeleton of *Endothiodon bathystoma*. Here also are the very interesting though imperfect skull of *Proterosuchus*, and one of the three wellpreserved specimens of *Mesosaurus*. The Stormberg reptiles are better represented than in any other collection, there being here the only known specimens of the crocodilian *Notochampsa*, the portions of the South African Phytosaur and a large part of the skeleton of *Hortalotarsus*, and other Dinosaurian remains.

In the Albany Museum, Grahamstown, are a large number of Cynodont remains, including the types of *Gomphognathus kannemeyeri* and *Trirachodon kannemeyeri*. The most valuable series of specimens from the point of view of the comparative anatomist is the large collection of the remains of *Procolophon*. The museum also contains the types of *Hortalotarsus*, and of the primitive lizard, *Paliguana*. There is also a fine series of *Lystrosaurus* remains.

In the Port Elizabeth Museum are the remains of the Cretaceous Dinosaur, *Algoasaurus*.

The private collection of Mr. Alfred Brown, of Aliwal North, is one of the most valuable in South Africa from the scientific point of view. Its most noteworthy specimens are the types of *Batrachosuchus*, of the small Triassic mammal, *Karoomys*, of *Howesia*, and of *Sesamodon* and *Melinodon*. Mr. Brown has also a very fine collection of fossil plants, and by far the best collection of South African fossil fish.

At Stellenbosch, either in the museum of the Victoria College or in Dr. Broom's private collection are a few noteworthy specimens, especially almost complete skeletons and many skulls of *Oudenodon*, the type of *Ictidosuchus primævus*, the type of *Lycosuchus vanderrieti*—the most perfectly preserved Therocephalian skull at present known—a fine specimen of *Mesosaurus*, and the type of *Cyclotosaurus albertyni*.

In Bloemfontein Museum are two or three good specimens of *Bothriceps* and some Dinosaurian remains.

SECTION VI.—MINERALOGICAL.

1. SOUTH AFRICAN METALLURGY.

By Edward H. Johnson, Vice-President Chemical, Metallurgical and Mining Society of South Africa

Considering the lavish manner in which Nature has distributed mineral wealth throughout South Africa, it is somewhat disappointing that the metallurgy of gold only has, so far, developed to any considerable dimensions. The great diamond industry—although of the greatest mineralogical interest—scarcely enters the domain of metallurgy. The methods of separation of the diamonds, however, are entirely analogous to the metallurgical operations of concentration, and the grease method of detaining the diamonds during washing, which has come into extensive use in Kimberley, resembles the Elmore process which has proved so successful on certain ores of copper.

The constant value of gold, and the ever-growing area of exploitation, have proved too attractive to the capital and energy available to permit any considerable development of the baser metals, but a growing interest is being taken in these metals, and they will undoubtedly assume considerable economic importance as the supply of labour increases and means of communication improve.

Of the metals other than gold which have received metallurgical attention and, what is perhaps of equal importance, which are of potential economic value, the following are the most important :—

Notes on Base Metals Found in the Transvaal.

Lead.—Lead exists in the form of galena in many parts of the Transvaal, and in three mines at least it has actually been worked. From various causes all are now shut down except one in the neighbourhood of the Premier Mine, almost due east of Pretoria. The name of the mine is Edendale, and the galena—which is sent to Europe for smelting—carries from 10 to 20 ozs. of silver. From this same neighbourhood a considerable quantity of galena was sent to the Rand Central Ore Reduction Co., and by them made into pipes, sheets, etc., etc.

Zinc.—Zinc is also found in various parts of the country, but the only deposit of any consequence is the Malmani one, on the farm Witkop. The blende is exceedingly pure, and the width of the reef varies from 2 to 3½ feet. Proposals have been made to reduce it in the Transvaal itself, where there is a very large market for zinc.

Copper.—Copper occurs in nearly every part of the Transvaal, but nowhere in sufficient quantities to warrant the erection of extraction plant. Most of the deposits are too far removed from the railway to justify exploitation, but, as the country is better served with railways, this drawback will be remedied. Copper has been worked for the last half century in Namaqualand, originally concentrated by jigs and buddles, but latterly matte smelting has been adopted, obtaining a matte for shipment containing about 40 per cent. copper.

Iron.—North of the Delagoa Bay Railway there are enormous tracts of pure haematite upon which experts have expressed the most favourable opinion. Adjoining these deposits, coal and lime of good quality are generally found, so that there is a potential industry of incalculable magnitude. Immediately the railway is extended to the district, it is the intention to erect blast furnaces for pig iron manufacture, but it is bound to be several years before this consummation is reached.

Tin.—Owing to the high prices for tin which have been prevailing during the last few years, considerable interest has been taken in the prospecting for this metal on the eastern borders of the Transvaal. Several large pegmatite veins have been discovered carrying a varying percentage of tin. With very favourable mining conditions payable properties may be found. These pegmatite veins have so far been found at the head waters of rivers which flow into Swaziland, and in some of these rivers, especially the Babaan and the Little Usutu, alluvial tin in large quantities has been found. The creeks in the neighbourhood of these rivers have been prospected, and previous to 1899 about 700 tons of cassiterite had been shipped. Work has been resumed, and it is hoped that a profitable industry will be started. It is interesting to note that with the cassiterite several rare metals have been found, such as monazite and euxenite, but sufficient work has not yet been done to prove whether these minerals exist in payable quantities.

Bordering on the Congo Free State and Rhodesia is a tract of country known as the Tanganyika Concessions, where platinum, palladium and the associated metals are said to be found in considerable quantities. On the same concession gold, tin and copper are being found. Nature apparently once formed a mineralogical museum about this region.

Gold.—The metallurgy of gold must necessarily be of paramount interest in South Africa for some considerable time to come, not only from the magnitude of existing and prospective operations, but also from its being largely of local growth. The history of the development of the gold industry up to 1890 followed much the lines of similar industries in other countries, beginning with the alluvial of Pilgrim's Rest and Devil's Kantoor, followed by the mining of rich leaders on a small scale around Barberton and in the Lydenberg districts. A small stamp-mill was taken up to Tati (now part of Rhodesia) as early as 1868. The true metallurgical interest commenced with the larger mills erected by the Sheba and Oriental

Companies in the Barberton district in about 1887, followed so closely by the rapid development of the Witwatersrand. With the larger mills came the desire for closer saving of the values. To the plate amalgamation various concentrating devices were added, such as blanket strakes, buddles and later the more scientific Embry and Frue vanners. In the first instance amalgamation in grinding pans was resorted to (following the practice then in common use in Australia) for the recovery of the gold from the concentrated product. This did not prove entirely satisfactory, about (it was a very variable quantity, generally not checked by assay) 50 per cent. of the value being obtained, with a considerable loss of mercury. The Newberry-Vautin barrel chlorination process was introduced on the Rand in 1889, but was commercially unsuccessful. In May, 1890, the Mc.Arthur-Forrest process of extraction by cyanide was introduced by the South African Gold Recovery Syndicate, and after some demonstration and experimental work at the Salisbury G. M. Co. larger works were erected for the treatment of tailings at the Robinson G.M. Co., Witwatersrand, and the Sheba G.M. Co., Barberton, in December, 1890, and February, 1891, respectively. Both works proved the eminent commercial value of the process,and works soon commenced to be erected at other mines.

A large Plattner Chlorination plant (vat system, with chlorine gas under pressure) was also erected during 1890 at the Robinson G.M. Co. for the treatment of the pyritic product from the Frue-Vanner concentrating plant, it being then generally believed that the cyanide process, so successful on oxidized ore, would be ineffective on auriferous pyrite. The chlorination works at the Robinson Co. are still in active operation.

From the introduction of the cyanide process the metallurgical history of South Africa has been a steady record of progress, and during the whole period investigation and experiment, with a view to improvement, have been unceasing. That these efforts have been effective the modern Rand metallurgical plant, which has influenced the world's gold metallurgy, plainly testifies.

After the successful demonstration of the process in treating the tailings sand, two problems still confronted the local metallurgist, viz., the treatment of the rich pyritic portion of the ore (concentrates) and the poor, clayey portion, slime. The possibility of the successful treatment of the concentrates on a commercial scale was first demonstrated at the Langlaagte Estate on vanner concentrates by Mr. J. R. Williams in 1892. Mr. Williams, in conjunction with Mr. Herman Jennings, at the Crown Reef, subsequently introduced the far cheaper method of hydraulic classification to effect concentration, which yielded a product peculiarly suited to a percolation process. The latter method is now in general use on the Rand.

The slime problem presented greater difficulties, and it was not until 1896 that it was finally demonstrated on a commercial scale at the Crown Reef G.M. Co. (v. Chem. and Met. Socy. Trans., Vol. II., p. 92). The principal difficulty was the low value of the slime, which necessitated extremely economical treatment to be profitable.

Another difficulty was that the settled slime was impermeable to solution except under pressure. These difficulties were eventually overcome by utilising the flocculating effect of lime in solution to cause rapid settlement to enable decantation of the solution from above the settled slime. This involved the use of a much larger volume of cyanide solution than was customary in sands treatment. To avoid excessive loss of cyanide this large quantity of solution required to be kept very low in cyanide contents. The zinc process of precipitation at first proved ineffective to deal with solutions low in cyanide, and consequently the electrolytic process invented by Dr. Wm. Siemens was adopted. In this process the anode is of sheet iron and the cathode of lead foil. The current density used is 0.05 amp. per square foot of anode surface, and the voltage 4 to 4.5. The gold is precipitated as a thin adherent film on the lead foil, which is periodically removed from the boxes and melted into bars, which are subsequently cupelled. The iron anodes gradually decompose, forming Prussian blue in combination with the cyanogen. This remains in the boxes, carrying with it some gold. There is considerable waste of electrical energy as evinced by the evolution of hydrogen, showing much decomposition of water. This is almost inevitable considering the low metallic contents of the solution—rarely more than 0.0007 per cent. The electrolytic process did not prove entirely successful in this connection, and in 1898 the method of forming a zinc-lead couple was adopted by Mr. W. K. Betty for dealing with these low-grade solutions (v. C. and M. Soc. Trans., Vol. II., p. 446), which has since come into general use. This method—originally patented by McArthur in 1894, but subsequently abandoned—consists in bringing the zinc into contact with a lead-salt in solution, thereby forming a porous coating of lead on the filiform zinc which is electrically active in contact with cyanide solution. This method has proved, commercially, extremely effective.

Other precipitation processes that have been tried locally, but have not gone beyond the experimental stage, have been : the Molloy electrolytic production of sodium amalgam in contact with auriferous solution, the Zerener—similar to Molloy's, but applied as a sodium-mercurial shower through the solution, and the Moldenhauer—aluminium in the presence of caustic alkali, or aluminium-mercury couples.

The usually-accepted equation for the solution of the gold is Elsner's

$$4KCy + Au_2 + O^1 + H_2O = 2KAuCy_2 + 2KOH$$

Boedlander suggests the following :—

$$2Au + 4KCy + 2H_2O + 2O = 2AuCyKCy + 2KOH + H_2O_2$$

the hydrogen-peroxide acting on further gold as

$$2Au + KCy + H_2O_2 = 2\ AuCyKCy + 2KOH$$

That oxygen is essential for solution of the gold is evident from either equation, hence all reducers in the ore—ferrous compounds are the most common—are the particular " bete-noir " of cyaniders, The halogens serve as substitutes for oxygen as shown in the successful applications of the Bromo-Cyanogen process. The original McArthur theory was that solution was effected by nascent cyanogen.

The precipitation of the gold from cyanide solution by zinc is generally expressed—

$$2KAuCy_2 + Zn = K_2ZnCy_4 + 2Au$$

The actual consumption of zinc is largely in excess of this equation, and the following (nascent hydrogen theory) has been suggested as a more satisfactory explanation, which would also explain the precipitating efficiency of sodium-amalgam (Molloy and Zerener's process), aluminium-mercury couple (Moldenhauer), and the zinc-lead, zinc-copper and other zinc couples :—

$$Zn + 4KCy + 2H_2O = K_2ZnCy_4 + 2KOH + 2H^1$$

$$2KAuCy_2 + 2KOH + 2H^1 = Au_2 + 4KCy + 2H_2O$$

The evolution of molecular hydrogen is evidence of excess energy as in the electrolytic process.

The solution of gold is essentially an oxidation process, and the precipitation one of reduction (v. Chem. and Met. Journal, Vol. IV., p. 51).

The production of bullion from the copious precipitate obtained in the zinc process was for a considerable time very unsatisfactory. Up to 1895 the method adopted was calcination of the zinc precipitate to oxidise the zinc, and subsequent smelting in plumbago crucibles with borax, sand and carbonate of soda. The reducing action of the plumbago caused a considerable amount of the zinc and practically all the lead to pass into the bullion—the lead derived from the 1% to 1½% usually contained in commercial zinc. The bullion obtained usually did not exceed 60% to 70% fine gold. Liquation of the base metal also rendered satisfactory sampling of this bullion difficult. In 1895 solution of the zinc contained in the precipitate was obtained by means of sulphuric acid. This brought the bullion value to 80% to 83% fine gold, the lead contents still remaining, however. At the end of 1897 the lead was successfully eliminated by using manganese-dioxide in the flux which oxidizes the lead causing it to pass into the slag. This also necessitated the use of clay liners within the plumbago crucibles to avoid the reducing action of the latter. This brought the bullion value equal to that produced by amalgamation. Some silver was lost by oxidation into the slag, but the slag value was materially lowered as compared with previous results. During the past two years a method, originally in use in dealing with the zinc-crusts formed in the Parkes desilverization of lead process, and applied to the zinc-gold precipitate by Mr. Tavener at the Bonanza G.M. Co. has come into use. This consists in melting the zinc-precipitate down with litharge (Pb O) and reducers in a reverbertory pan furnace, forming auriferous-lead bullion, which is subsequently cupelled.

A useful application of the cyanide process to certain very friable, oxidized ores has been in use for some time at Barrett's Berlyn

G.M. Co. (Transvaal) and the Little Wanderer Mine (Rhodesia). This consists in coarsely crushing the ore through a rock-breaker (a large proportion of the ore is pulverant as it leaves the mine) to, roughly, walnut size, and treating it directly with cyanide solution. This method is, of course, only applicable to certain naturally-porous ores containing very finely-divided gold, but where applicable is extremely economical, as shown by the Barrett's working costs of 9s. per ton, including mining and all expenses. This enables profits to be made on very low-grade ores, where applicable.

Modern Metallurgical Equipment (Witwatersrand).

we consider the metallurgical work as a gradual process of concentration of the gold contents of the ore by a number of successive and differing methods, the sequence of operations will be more easily understood.

The main operations are :—

1. Hand-sorting to remove barren rock.
2. Stamp-milling of the ore to pass screen of 600 to 900 holes to the sq. ins.
   Amalgamation of the free gold.
3. Hydraulic separation of the pulps leaving the mill into three classes :
   (*a*) Concentrates, gold dissolved by cyanide (percolation).
   (*b*) Sand, gold dissolved by cyanide (percolation).
   (*c*) Slime, gold dissolved by cyanide (agitation and decantation).

1. The ore on being raised from the mine is carried to a considerable height above ground-level and automatically "tipped" over a grizzly—*i.e.*, a strong iron grating of flat iron bars placed edgewise about 1½ inches to 2 inches apart, and at an angle of 45° to 50°. This device serves to separate all ore fine enough to pass direct to the stamp mill, the fines falling through the grating to a bin beneath, and the coarse rock passing over the grating to the sorting table. Several forms of this device are in use. One, a circular sheet-iron table about 30 feet in diameter, on which the ore falls and which slowly rotates passing a number of natives who pick out the lumps of barren rock in passing; the pebble constituent of the conglomerate forming an admirable indicator to the native sorter. Another form is a continuously-travelling belt on which the same operation is performed. In either case means are provided for the ore to be automatically removed to be fed into crushers to reduce the size to a maximum of 2-inch cube to pass to the stamp mill.

2. The stamp-mill is an archaic institution which has passed through many modifications, but in which the original conception has been maintained—*i.e.*, the crushing effect of a pestle being allowed to fall on material fed into a mortar in which the falling pestle operates.

A modern stamp-mill will have stamps weighing 1,300 lbs. each, and each stamp will drop 8 inches 95 times per minute. The crushing force exerted therefore by a 200 stamp mill is in the neighbourhood of 16½ million foot pounds per minute. This force is not exerted by any direct mechanical pressure, but by the direct force of gravity, the power being utilised in lifting the stamp. The motive force required is slightly in excess of the gravity foot-pounds developed. The crushing efficiency of a mill is largely limited by the fineness of the screen used, height of discharge (*i.e.*, water-level in mortar box above die [anvil]), amount of water used per ton of ore crushed, weight of stamp and height of drop of stamp.

Immediately below the discharge from the mortar-box screen of each unit of five stamps is placed an amalgamated copper plate, over which the ore-pulp (consisting of one of ore to seven to eight of water) is passed, the free gold uniting with the amalgam on the plate. Mercury is periodically added to the plate to maintain the necessary plasticity of the amalgam to retain further gold.

The gold caught in the mill amounts to, roughly, 60 per cent. of the total obtained. This is in the form of amalgam containing 33 per cent. of gold. The amalgam is retorted in closed cast-iron retorts, and the distilled mercury condensed and re-used. The spongy gold is smelted into ingots in plumbago crucibles.

3. The pulp on leaving the mill is usually again elevated by means of a "tailings-wheel"—a modern development of the ancient Egyptian irrigation wheel. The pulp then passes through a series of hydraulic classifiers (based on Rittinger's spitzkasten) which deliver the coarser and heavier material to special tanks arranged for their reception. The pulp then freed from the pyritic and coarse product runs to collecting tanks where the sands are collected and the slimes eliminated. The effluent water from the collecting tanks then runs to the slime-collecting tanks, where the slime is collected and the clear, overflow water returned for re-use to the mill. The respective products will consist of 10 to 12 per cent. concentrates, 60 to 65 per cent. sand, and 30 per cent. to 23 per cent. slime, and the respective values, approximately, to 12 dwt. concentrates, 4 dwts. sand and 2 dwts. slime. The concentrates are given treatment by cyanide lasting over eighteen to twenty-one days, the sands six to eight days. Both these by percolation. The slimes are successively agitated in cyanide solution by two washes, the unprecipitated solution of the second wash being used for the agitation of the first, thereby enhancing the value of the solution before precipitation.

All solutions (excepting the second wash of the slimes) are passed through the zinc boxes, and a 200 stamp plant will require to deal with 2,200 tons of solution per day. The precipitate from this amounts to a considerable bulk and is,usually, cleaned up twice to three times per month. This entails considerable labour in collection and treatment by acid to remove zinc and subsequent smelting.

The total cost per ton for metallurgical treatment of the ore on the Rand, including sorting, milling and cyaniding, is under 7s., and the total extraction on modernly-equipped plants slightly over 90 per cent.

Future Development.

It has long been recognised among local metallurgists that the higher values in residues were contained in the coarsest product leaving the mill. In 1895 the author demonstrated that on regrinding the residues of spitzlütte product (hydraulic classifiers) after three weeks' treatment by cyanide, free gold could be exposed, showing the existence of gold enclosed in matrix which was unexposed to the solvent. Earnest efforts were commenced in 1899 to overcome this difficulty and the late Major Seymour (then consulting mechanical engineer of the Eckstein and Rand Mines group) was engaged on devising regrinding machinery to cope with this difficulty. The war intervened and Major Seymour was killed at Zand River. The work was recommenced in 1903 by the introduction of tube-mills, which had in the meantime proved successful in dealing with the Westralian tellurides. Tube-mills will, undoubtedly prove effective, and raise the total extraction some 4 per cent. to 5 per cent., but whether they are the most economical method of dealing with the difficulty is still to be proved. In the meantime Mr. Caldecott, Consulting Metallurgist of the Consolidated Gold Fields Corporation, has shown that practically the same results may be obtained in the stamp mill at a sacrifice of 10 per cent. of the milling efficiency, but with the same result as far as total recovery is concerned. It then remains an economical problem as to whether an increase of mill by 10 per cent. or introduction of tube mills will be the more effective. With the characteristic courage of the Rand financier there is no lack of funds forthcoming to demonstrate the most desirable method.

There are still advocates of close concentration by mechanical means, and the East Rand Proprietary Group are experimenting with Wilfley concentration tables, with a view to subsequent fine grinding in tube-mills or chlorination. Also in slime treatment the General Mining and Finance Group are breaking away from the customary decantation process and substituting the filter-press process in use in Westralia, but originally tried and abandoned in 1893 on the Rand.

All these varied views and experiments, involving large expenditure of capital, where only a residual value of one pennyweight is concerned, show that the metallurgical interest of the Rand of South Africa is by no means moribund, and with the free interchange of ideas obtained through the means of the local technical societies, something very near finality in the economic treatment of local ores should eventually be reached.

The metallurgy of iron, copper, lead, silver and tin should soon be added to the active metallurgical interests of South Africa. Given railway facilities and the necessary labour they will undoubtedly soon be in evidence.

2. THE DIAMOND MINES OF KIMBERLEY.

By Gardner F. Williams, General Manager, De Beers Consolidated Mines, Ltd.*

It is not my intention to go into the history of the discovery of diamonds in the alluvial soil along the Vaal river followed by the finding of diamonds in the "dry" mines, as the discoveries at Kimberley were called. The history of these mines has been written and re-written, besides the space allotted for this article is too small to give more than a cursory sketch of the formation of the mines and the occurrence of diamonds.

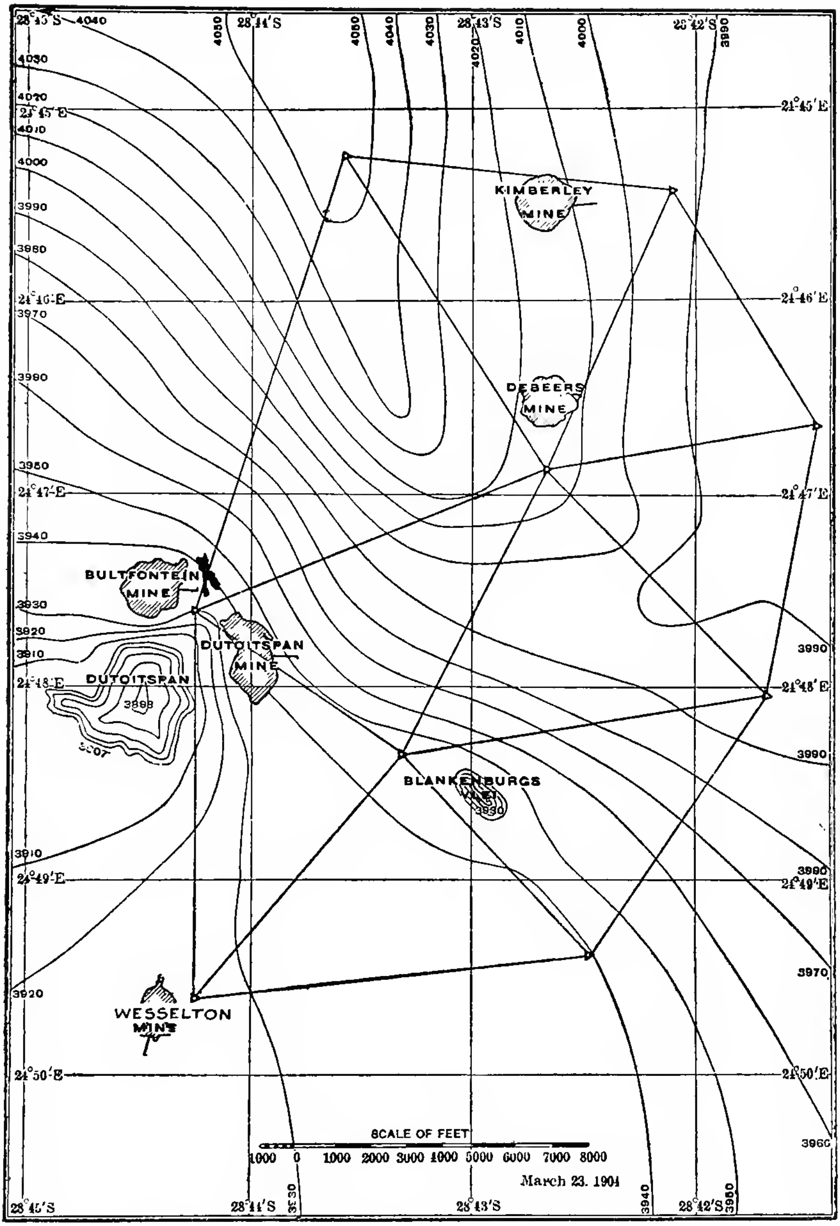
The mines are situate between longitudes 24° 45′—24° 50′ E. and between latitudes 28° 42′—28° 45′ S., and are distant by rail 647 miles from Cape Town and 485 miles from Port Elizabeth. The elevation of De Beers and Kimberley mines is about 4,000 feet above tide level, and the elevations of Dutoitspan, Bultfontein and Wesselton mines are 3,975, 3,958 and 3,936 feet respectively.

The geological sections of the rocks through which the diamond-bearing pipes pass are as follows:—The surface is covered with either a few feet of red soil or of calcareous tufa. Underlying these we find diabases and basalts which are, in places, worn away down to the shale. There is no great difference between these two rocks; some are diabasic in structure, some are olivine, others quartz diabases. The basalt varies in thickness from a few feet to a little more than 100 feet. It rests upon bituminous shale, which is from 200 to 280 feet in thickness. The constituents of the shale are small clastic grains of feldspar and quartz and much opaque or dark brown translucent material, probably of organic origin. The minerals of secondary development are kaolin, serpentine, white mica, and calcite. This is known as the Kimberley shale. Below the shale and resting on an amygdaloidal rock is a layer of small angular, or more or less rounded boulders, known as the Dwyka or glacial conglomerate, which varies from 3 to 10 feet in thickness as determined in various shafts in the Kimberley mines. It is composed of fragments of quartz, feldspar, chert, shale, quartzite, quartz, porphyry, and other rocks. The amygdaloidal rock is melaphyre (or olivine-diabase of Stelzner) and is about 400 feet thick.

* Author of "The Diamond Mines of South Africa," New York, The Macmillan Co.; London, The Macmillan Co., Ltd., 1902. Revised edition, New York, B. F. Buch & Company, 1905.

PIECE OF BLUE GROUND FROM DE BEERS MINE,
SHOWING DIAMOND EMBEDDED IN IT.

DRAWN FROM NATURE, FULL SIZE,



RELATIVE POSITION OF DE BEERS COMPANY'S MINES.

The amygdules are filled with granular and chalcedonic quartz. The malaphyre rests upon quartzite, which is 722 feet thick where De Beers mine rock shaft passes through it. The constituents of the quartzite are partly rounded or subangular grains of quartz, microcline and other plagioclastic feldspars and chert. The cement consists of shreds of sericite together with calcite in places. Some of the feldspars are replaced by calcite and a little pyrite. The quartzite was evidently derived from a granite by rapid erosion, for, if it had been by slow disintegration, the feldspars would be decomposed. The Kimberley mine rock shaft was sunk through about 400 feet of quartzite and 260 feet of mixed quartzite and shaly material, some pieces of which show organic matter. Underlying the quartzite is quartz porphyry, which has been proved to the depth of 2,600 feet.

Upon the information at hand it may be assumed that all diamonds found prior to the discovery of the Kimberley pipes, or craters, came from alluvial deposits.

In the case of the Kimberley mines, the diamond-bearing rock or blue ground has been forced up through the geological strata mentioned above. This rock was described by Professor Henry Carvill Lewis as "a phorphyritic volcanic peridotite of basaltic structure," which he named kimberlite*—a name now generally accepted by geologists.

In De Beers mine a dyke of igneous rock appeared and, owing to its taking a serpentine course across the mine, it received the local name of "snake." It stands like a vein, nearly vertical, varying in thickness from 2 to 7 feet. No diamonds have been found in it, yet investigations show that its composition is substantially the same as the surrounding diamond-bearing rock. The late Dr. Stelzner described the blue ground and snake as follows :—

> "The main body of the blue ground is entirely analogous to the snake rock, naturally more decomposed ; but in essential points the microscopic features of blue ground and snake (not taking into consideration the numerous little slate fragments in the blue ground) are in an extraordinary degree alike. It therefore impresses upon one's mind that the 'snake' is a younger eruption formation coming from the same volcanic source as the blue ground."†

The blue ground must be designated as a breccia. There is no doubt that it is of volcanic origin, and was forced up from below ; it consists of olivine with fragments of other rocks. The writer has lately had slides made of pieces of blue ground from the several mines. These show it to be very similar in all the five mines. It consists of a clastic mass of rounded and angular olivine which is

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*"The Matrix of the Diamond," Henry Carvill Lewis, M.A., F.G.S., Professor of Mineralogy in the Academy of Natural Sciences, Philadelphia, U.S.A., at meeting of the British Association at Manchester, August and September, 1887.

†Dr. A. W. Stelzner, Professor of Geology at the Freiberg, Saxony, Mining Academy, in a letter to the writer.

almost entirely converted to serpentine. This alteration appears to have taken place down to the lowest depths from which the samples were taken, *i.e.*, 2,520 feet. The following minerals are to be found in the blue ground : augite, biotite, bronzite, calcite, chlorite, chrom-iron, cyanite, garnet, hornblende, magnesite, magnetite, mica, olivine, perofskite, smaragdite, titanic iron (ilmenite or menaccanite), and zircon.* Corundum is said to have been found in Jagersfontein mine, in the Orange River Colony, and in the Frank Smith mine, situated about 50 miles west of Kimberley. Iron pyrites and barite are found in the deposit resulting from the washing of the blue ground. The pyrites come, for the most part, from the country rocks, which become more or less mixed with the blue ground during the process of mining. The barite is a secondary formation of small veins in the blue ground at its junction with the country rock. Beautiful crystals of doubly refracting or Iceland spar are occasionally found also near the boundary of the blue ground. The shale fragments which are contained in the blue ground are altered very little, in fact most of them are unaltered. The pieces of shale, which show any alteration, have probably been changed by recrystallization to minerals of a micaceous or calcareous character. There is not the slightest evidence that the carbon of the shale has crystallized to diamonds.*

As to the origin of the diamond-bearing pipes themselves, I have always held that they were filled by aqueous rather than igneous agencies, possibly by something of the nature of mud-volcanoes.

It is a noteworthy fact that all the craters are filled just even with, or slightly above the surface of the surrounding country. Would this have been the case if the pipes were of igneous origin ? I think not. It has been claimed that the surface of the country, as it existed when the craters were filled with the diamond-bearing breccia, was not the same as at present, but that it has been denuded or washed away. There is not the least particle of evidence to bear out such a contention. If the country rock and diamond-bearing ground had been washed away, then diamonds would have been found in the "wash" or in ravines and water-courses in the vicinity of the mines. Such is not the case ; no diamonds have been found in alluvial soil nearer than the Vaal river, some 20 miles distant, and these diamonds are totally different in character from the Kimberley stones. The Kimberley mines lie in basins from which no water flows into any stream, but runs into pans or vleis where it evaporates or is used for mining purposes.

In this connection it may be stated that Dutoitspan mine is situate within a few hundred feet of Du Toit's pan, a pond, which is fed by small water courses during the rainy season. The bottom of the pan was probably 30 feet lower than the edge of the mine, where the yellow diamond-bearing ground joined the basalt, yet it is a significant fact that no diamonds have been found in the pan.

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*Waldemar Lindgren, U.S. Geological Survey, in a letter to the writer, Dec., 1904.

Bultfontein mine is also quite as near this pan and lies at a considerable elevation above it.

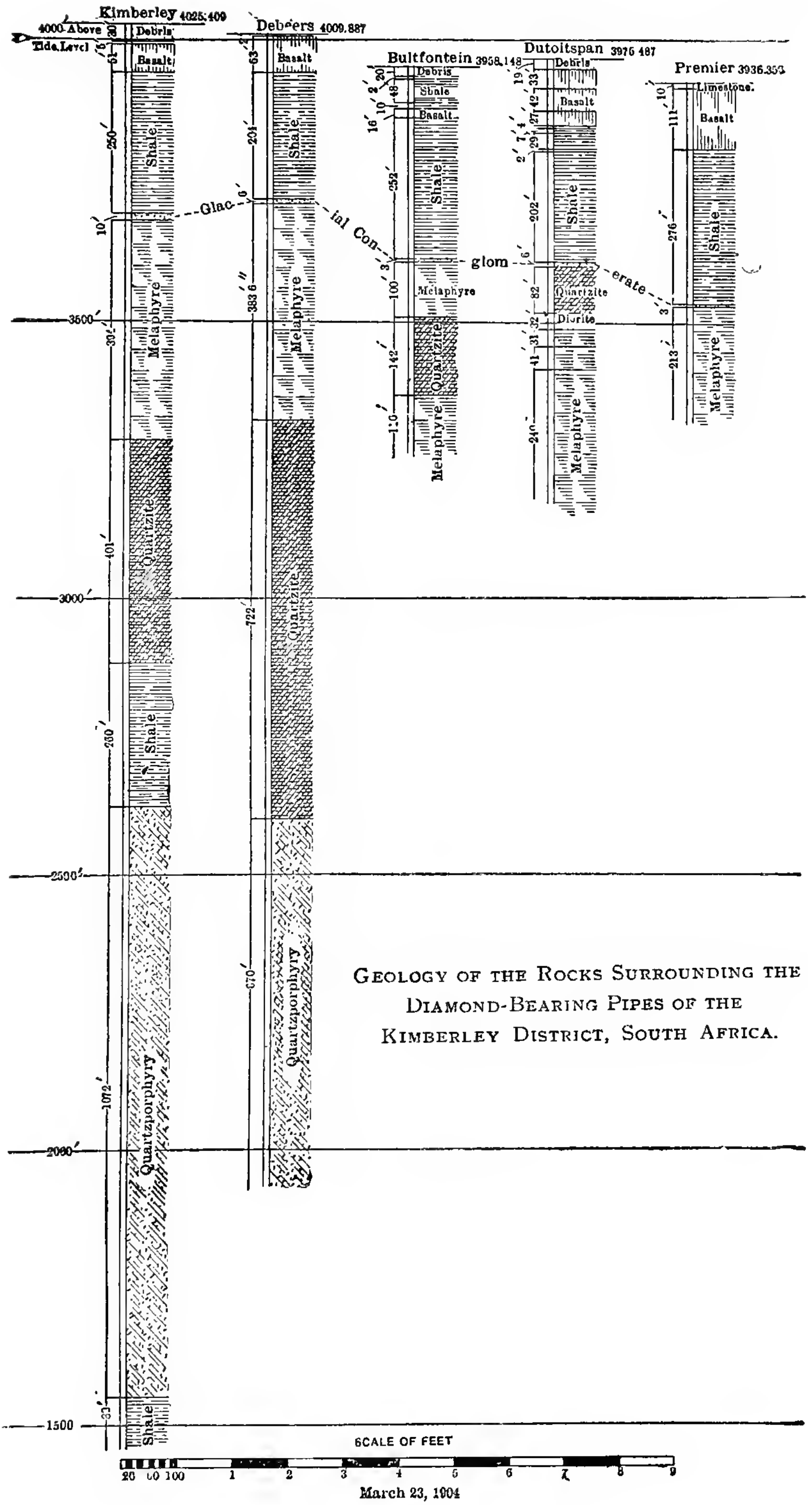
At Kimberley and De Beers mines the same conditions exist, but the drainage from these mines is to the north into Diebel's Vlei, which is one hundred or more feet below the mines and nearly 4 miles distant therefrom. No diamonds have been found between the mines and the vlei nor in the vlei itself, and I repeat that this is a significant fact. By what laws of nature would it be possible to obliterate a large section of these mines and leave no diamonds behind in these depressions. In case the depressions have been made since the formation of the pipes, would it not be reasonable to expect that the forces that made them would have washed a portion of the diamond pipes into them ?

I have given these facts at considerable length because my contention that these are the craters, and not simply the necks, of mud volcanoes has been questioned. It is contended that the craters have been washed away, but this is hardly borne out by local observations. The tops of these craters are bell-shaped as is the case of ordinary volcanoes. I cannot conceive how these craters could have been just filled to the level of the surface of the surrounding country except that the material which filled them came up as mud highly charged with gases which escaped in the air on nearing the surface and allowed the mass of mud to subside. There must have been some such process to incorporate the shales, which lie near the surface, so thoroughly with the eruptive mass.

If, as contended, a few thousand or even a few hundred feet of the tops of these mines have been washed away, where are the rich places which contain this marvellous store of diamond, richer than the soil along the banks of the Kistna and Godavari rivers, where the Golconda of tradition outstretched, and richer than the cascalho of Brazil ? A story is told of the climbing of Zulmat by the great Alexander, to the rim of an inaccessible valley, where, beneath sheer precipices, glistened a coverlet of the stones of fire. There was no way of winning the diamonds that glowed so temptingly except by flinging down masses of flesh and waiting for swooping eagles to bear the lumps up to their perches on the mountains with the precious stones sticking in the meat.*

Sindbad the sailor had this tale in mind in his second voyage. It will be remembered that he was stranded by shipwreck on a desert island and was carried away by the flight of a gigantic rukh to the top of a distant mountain. From this mountain he descended into a neighbouring "valley," exceeding great and wide and deep and bounded by vast mountains that spired high in the air. Walking along the wady, he found that "its soil was of diamond, the stone wherewith they pierce minerals and precious stones and porcelain and the onyx, for that it is a dense stone and a stubborn, whereon neither iron or hard head hath effect, neither

* "Oriental Accounts of Precious Minerals," Journal of Asiatic Society of Bengal, August, 1832.



GEOLOGY OF THE ROCKS SURROUNDING THE DIAMOND-BEARING PIPES OF THE KIMBERLEY DISTRICT, SOUTH AFRICA.

can we cut off aught therefrom, nor break it save by means of lead stone." The sailor soon bethought himself of the old story of the valley from which diamond-studded meat was "plucked by eagles." So he quickly filled his pockets and shawl girdle and turban with the choicest diamonds. Then he put a piece of raw meat on his breast and lay down on his back. Soon a big eagle swooped down into the valley, clutched the meat in his talons and flew up to a mountain above, "where, dropping the carcass, he fell to rending it," leaving the lucky sailor to scramble off with his booty.*

These amazing stories are less teeming with interest than they were in the days when they were first told. If from the mines of Kimberley huge masses of diamond-bearing earth have been washed away there must be a massing of these diamonds in the valleys of the Vaal and Orange rivers awaiting the coming of some lucky Aladdin which will make the discoveries of Alexander and Sindbad look insignificant. Personally, I do not believe that toilsome searches for these masses of precious stones from the craters of Kimberley will ever be rewarded.

I cannot conceive of any denudation of the tops of volcanic craters which would not have left behind some trace, even more than a trace, some concentration of diamonds and the heavy minerals which are associated with them. In the machines in use on the Diamond Fields we imitate nature in concentrating the heavy minerals. The light particles are washed away leaving the concentrates behind.

In the case of the Kimberley diamond mines there was no richer ground on surface than that found below it. In the Transvaal Premier mine the conditions seem to have been different. There a concentrating process seems to have gone on for ages. These concentrates have not been swept away into unknown quarters, but have simply sunk down as the upper part of the mine was disintegrated and the lighter material was washed away. It is true that a portion of this concentrated mass finally found its way into the alluvial deposits below, but the diamonds appear to be found at no considerable distance from their source.

The evidence of the movement of the diamond-bearing rock after solidifying is indicated by the slickensides and striated surfaces of the country-rocks at their junctions or contacts with the kimberlite. Large sheets of calcite are frequently found at the junction of these rocks, which have taken the form of the striæ. Beautiful calcite crystals and transparent pieces of doubly-refracting, or Iceland spar, are of frequent occurrence.

There is conclusive proof that the diamonds in the South African mines are not found in their original place of crystallisation, as, for example, the frequent occurrence of broken crystals, embedded in the hard kimberlite.

Concerning the discussion of the genesis of the diamond, Sir Isaac Newton's opinion was that it was of vegetable origin and

* Arabian Nights, Lady Burton's edition, Vol. III., pp. 476—482.

combustible; but it was not until 1694 that the combustibility of the diamond was actually proved by the famous burning-glass experiment of the academicians of Cimento.

Lavoisier, Guyton de Morveau, and others determined that the diamond was converted into carbonic dioxide by burning. The experiments of Sir Humphrey Davy, in 1816, showed that the diamond was almost pure carbon. These experiments have been confirmed by Dumas, Stas, Friedel, Roscoe and other eminent chemists, who have fixed with extreme precision the composition of the diamond to be pure carbon in crystalline form. The late Dr. W. Guybon Atherstone was one of the first scientists to deal with the occurrence and genesis of the diamond in the Kimberley mines. Being a resident of the Cape Colony he made frequent visits to the diamond fields and made personal investigations.*

Professor Lewis alleged that the diamond is the result of the intrusion of igneous rocks into and through the carbonaceous shales. He says:

> "The kimberlite is shared by no other terrestrial rock. In structure it resembles meteorites of similar composition. If the ground-mass of kimberlite were replaced by native iron it would be nearly allied in both structure and composition with meteorites known as chrondrites. . . . . . Perhaps the most interesting chemical observation concerning the blue ground was that made by Sir H. E. Roscoe. He found that on treating it with hot water an aromatic hydrocarbon could be extracted. By digesting the blue ground with ether, and allowing the solution to evaporate, this hydrocarbon was separated and found to be crystalline, strongly aromatic, volatile, burning with a smoky flame and melting at 50 ° C. . . . . That the rock was a true lava and not a mud or ash is indicated by the fact that the minerals and their associations are those characteristic of eruptive ultra-basic rocks."†

Professor Lewis advanced the theory that probably the diamonds came from the hydrocarbon which was contained in the fragments of carbonaceous shales distributed through the blue ground, but the inclusion of carbonaceous shales in the blue ground can hardly be reconciled with Professor Lewis's conclusion "that the rock was a true lava."

If the diamond is the result of the intrusion of igneous rocks into and through the carbonaceous shales, why do not all pipes composed of kimberlite contain diamonds? And why do diamonds exist in some mines, such as those in the Pretoria district, where no carbonaceous shales are to be found?

Professor Molengraaff,‡ formerly State Mineralogist to the South African Republic, discusses the genesis of the diamond, and says

*Geological Magazine, Vol. VI., p. 208, May, 1889.

†The Matrix of the Diamond. Professor Henry Carvill Lewis, p. 52.

‡ A Monograph on the Diamonds at Rietfontein, near Pretoria, in the Transvaal.

that the theory of the formation of diamonds during the ascension of the blue ground from carbon borrowed from the carbonaceous shales was, in his opinion, weak.

> "In the Pretorian beds, as well as in the formations underlying these, strata containing any notable quantities of carbon were nowhere to be found in the Transvaal; so that the conclusion might safely be drawn that the igneous blue ground, in forcing its way from great depths towards the place where it was found, could not borrow any carbon from the surrounding strata in order to convert it into diamonds."

In Bohemia a rock occurs which contains every mineral known in the blue ground of Kimberley, except diamonds. On my visit to the Mining Academy at Freiberg, Saxony, a few years ago, Dr. Stelzner, Professor of Geology, showed me two cases containing these minerals, and in every instance the Bohemian minerals corresponded with those from Kimberley, except that the case of Kimberley minerals contained a few small diamonds, which had been presented to the Academy.

It is reported by Mr. G. F. Kunz that diamonds have been found in Bohemia, but they did not occur in the rock mentioned above.

Both the aqueous and igneous theories of the origin of the kimberlite have had able supporters, among the former being Stanislas Meunier,* M. Chaper,† and, later, Professor Garnier and Sir William Crookes.‡ The igneous theory is strongly supported by Professors Lewis,§ Molengraaff|| and Stelzner.** My own opinion is that the aqueous theory is the less assailable.

Concerning the origin of the blue ground, assuming that it is not the original matrix of the diamond, I find the following weak points in the igneous theory.

1. As already observed, it is impossible to account by the igneous theory for the water-worn boulders found in the blue ground, and the presence of carbonaceous shale fragments.

2. The experiments of Herr W. Luzi,†† of Liepsic, in the production of artificial figures of corrosion upon the surfaces of rough diamonds, are most interesting in the light which they throw on the crystallisation and the probable matrix and genesis of the diamond. Until lately the only appearance of corrosion upon the surface of

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* "Composition et origine du sable diamantifère du Toits Pan, Afrique Australe"—Comptes rendus de l'Academie des Sciences de Paris, Vol. LXXXIV., No. 6, p. 250. "Examen mineralogique des roches qui accompagnet le diamant dans les mines du Cap de Bonne Experance"—Bulletins de l'Academie Royale de Belgique, 3d. series, Vol. III., No. 4.

† "Note sur la région diamantifère de l'Afrique Australe," Paris, 1880.

‡ Lecture before the Royal Institute of Great Britain, June 11th, 1897.

§ The matrix of the Diamond—Henry Carvill Lewis at a Meeting of the British Association at Manchester, August, 1887.

|| The Occurrence of Diamonds at Rietfontein, G. A. P. Molengraaff.

** A lecture by A. W. Stelzner before the Isis Society, in Dresden, Saxony, April 20th, 1893.

†† Artificial Figures of Corrosion on Rough Diamonds, Berichte der Deutschen Chemischen Gesdleschaft, 1892.

rough diamonds was the regular, triangular negative pyramids which were produced through heating the diamond in the open air or under the oxygen flame.

Herr Luzi discovered that the breccia (kimberlite) from the South African mines, when in a molten condition, possesses the property of absorbing the diamond or of changing its shape.

He describes his experiment as follows :—

> "A small quantity of blue ground was melted in a crucible placed in a Fourquinon-Leclerq furnace at a temperature of 1770 ° R., which was the highest temperature attainable. A diamond with perfectly smooth, natural faces was submerged in this molten mass. A further quantity of blue ground was added to the contents of the crucible until it was completely filled. A tightly-fitting cover was placed on the crucible, which was again exposed for thirty minutes to the greatest heat attainable. When the crucible was cooled the diamond was removed and found to be covered with irregular oval and half-round grooves of various depths. In one experiment the diamond was found to be deeply eaten away on one side."

Some of these partly-absorbed diamonds, upon which Herr Luzi experimented are deposited in the mineralogical museum of Leipsic University.

Owing to the cost of the material to be experimented upon, however, Herr Luzi was unable to determine positively what chemical action took place during the time the diamonds were heated in the complicated silica flux. The fact that diamonds can be absorbed by being placed in molten blue ground tends to prove that the blue ground was not thrust up through the earth's crust in a molten state.

If the diamond is unable to withstand the corroding influence of the silica magma at the comparatively low temperature given above how could it possibly have retained its forms of crystallisation and perfect faces at the temperature and pressure which must have existed under the igneous theory ?

3. Some years ago a diamond weighing 28·5 carats, found at Kimberley, attracted the attention of the valuator. Its external surface was smooth and crystallised, showing no other mineral except the diamond itself, but the interior was white and not transparent. Noticing this peculiar appearance the valuator broke the stone in order to satisfy his curiosity, and found that a small, perfect octahedral diamond was enclosed in the centre of the larger stone. Nor was this all. There were flakes of a white mineral, not diamond, attached to the fragments of the broken diamond. In appearance the flakes were white, translucent and crystalline, and about as hard as steel. When heated in a closed tube moisture was given off. It fused readily on platinum wire to a white bead. A few grains of this white mineral were collected, and by analysis it proved to be apophyllite, a silicate of lime and potash with 16 per cent. of water.

If a mineral which is fusible at the ordinary temperature obtained with a blow-pipe, and which contains 16 per cent. of water, was formed at the same time that the diamond crystallised, it is certain that this did not take place under an enormously high temperature. How, then, one may ask, did the apophyllite become a part of this diamond ?

Herr von Tschudi* describes a beautiful crystallised Brazilian diamond in the centre of which was a leaf of gold. He obtained the information from Dr. Mills Franco, who claimed that there was no doubt or deception as to the identification of the gold.

Occurrences of this nature tend to veil in additional mystery the genesis of the diamond.

Professor T. G. Bonney,† at a meeting of the Royal Society, presented the following conclusions in reference to the origin of the diamond :—

> "The blue ground is not the birthplace, either of the diamond or of the garnets, pyroxenes, olivine and other minerals —more or less fragmental—which it incorporates. The diamond is a constituent of the eclogite, just as much as a zircon may be a constituent of a granite or a syenite." . . . "I had always expected a peridotite (as supposed by Professor Lewis), if not a material yet more basic, would prove to be the birthplace of the diamond.
>
> "Can it possibly be a derivative mineral, even in the eclogite ? Had it crystallised out of a more basic magma, which, however, was still molten when one acid more was injected, and the mixture became such as to form eclogite ? But I content myself with indicating a difficulty and suggesting a possibility ; the fact itself is indisputable : that the diamond occurs, though rather sporadically, as a constituent of an eclogite, which rock, according to the ordinary rules of inference, would be regarded as its birthplace."

Professor Bonney's statement that diamonds occur in the eclogite of the Newlands mine caused me to examine the eclogite (?) which is found in all the mines at Kimberley, and has always been treated as waste rock and thrown away. There are tons of it lying about the Kimberley mines. I have examined hundreds of pieces of this rock, but never found a diamond ; nor have I ever heard of a diamond being found in it by any one during the many years that these fields have been worked. I caused about twenty tons to be collected and sent to a test-plant, where it was crushed and afterwards jigged ; but it contained no diamonds.

Mr. Waldemar Lindgren, who is connected with the United States Geological Survey, has had an opportunity of studying the blue ground and the minerals contained therein from samples

* Travels in South America, by J. J. von Tschudi.

† The Parent Rock of the Diamond in South African, Professor T. G. Bonney. Proceedings of the Royal Soc., Vol. LXV., July 27th, 1899.

supplied by the writer from which forty-five slides were made. His conclusions are as follows :—

> " In looking over the literature (on diamonds), especially the papers by Professors A. W. Stelzner and T. G. Bonney, it seems to me that the connection of the diamond with the garnet in the peridotite and pyroxenite has been satisfactorily proved. It is not possible to regard it as formed in the 'blue ground.' On the contrary it was evidently contained in the peridotite magma and crystallised with it."

A specimen of the rock, which I presume to be the same as the eclogite spoken of by Professor Bonney, taken from Dutoitspan mine, was handed to Dr. G. F. Becker, who had a slide made from it. He determines the rock to be lherzolite and says : " This composition shows that the rock is extremely analogous to kimberlite, in fact probably a sub-variety of it. Zirkel considers kimberlite as closely allied to lherzolite, while Rosenbush appears uncertain how to classify it." Dr. Becker is still of the opinion that diamonds ought to be found in the lherzolite in spite of the result of the test of twenty tons.

Quite a number of specimens of diamonds and garnets cemented together have been found, but in most specimens which have come under my observation the diamond has grown into the garnet. A diamond was found (January 9th, 1904) in Wesselton mine, Kimberley, which had a small garnet embedded in it. The diamond weighed 114 carats, and the garnet was estimated to weigh about half a carat. It appeared to fill the hole in which it was embedded. The diamond was of cubic crystallisation, with nearly half of the cube wanting. The part of the diamond in which the garnet was buried had numerous depressions similar to the one containing the garnet, and one is led to think that these depressions were also once filled with small garnets, or in other words the diamond crystallised upon a nest of garnets. It was of a peculiar plumbago colour and semi-transparent. All of the diamonds crystallised in cubic form which have been found of late in Wesselton mine were of this peculiar colour. Specimens have also been found where the diamond was embedded in olivine.

Sir William Crookes and others have mentioned diamonds which burst or explode on being brought to the surface ; and Sir William says it has been " conclusively proved that the diamond's genesis must have taken place at great depths under enormous pressure. The explosion of large diamonds on coming to the surface shows extreme tension."

Professor Lewis says that Kimberley diamonds have been found sometimes to have optical anomalies due to strain. Fizzan thought this strain to have been caused by the unequal distribution of heat during cooling ; but Jannettaz* holds that the strain is due to compressed gas in the interior of the crystal.

* Bulletin de la Société Minerale de France, II., 1879, p. 124.

I have found that the light-brown, smoky diamonds are the ones which crack on being brought to the surface; but even these remain intact if kept in a moist place. In the days of open-cut working, when a smoky or light-brown diamond was found, the digger placed it in his mouth, where he kept it until he offered it for sale. The buyer placed it in a raw potato, in which it was shipped to Europe. The temperature of the ground in which the stone was found would, as a rule, not exceed 70° F. The temperature of the diamond would be raised to 98° F. while in the digger's mouth. If, however, the stone was kept in a dry place, even at a lower temperature, it would crack in all directions. One might argue from this that it was not the expansion of gases by heat alone which caused the fractures. If these fractures were due to compressed gas, as contended by Jannettaz, one might expect this cracking to have occurred while the diamond and its contained gas were exposed to the enormous heat to which, according to the igneous theory, diamonds must have been subjected.

I had been led to believe that only light-brown or smoky stones cracked on being exposed to dry air, but I have lately been informed by one of the old diamond miners that he had seen white stones which showed the same phenomenon.

Sir William Crookes says that the ash left after burning a diamond invariably contains iron as its chief constituent, and the most common colours of diamonds, when most perfectly pellucid, shows various shades of brown and yellow from the palest "off-colour" to almost black. These variations, he declares, accord with the theory that the diamond has separated from molten iron.

I have made exhaustive tests in order to ascertain whether diamonds contain iron, oxidised or metallic. The experiments were made upon a magnetic separating-machine, the field-magnets of which attracted any mineral containing iron or iron oxides, except iron pyrites. Although some of these diamonds had the appearance of being coated with iron in some form, and others were coloured dark brown and deep yellow, they were in no way attracted by the magnet, even when excited by a strong electric current. These experiments do not, perhaps, disprove the existence of iron in the diamond, but they do establish the fact that the quantity is infinitesimally small. Further experiments in this direction ought to be made by those who have better facilities for such work than are at our disposal here in Kimberley. The experiments of Messrs. Hannay, Moissan, Friedel, Sir William Crookes and others all show that microscopical diamonds can be produced artificially; but they throw very little light upon the question how the diamonds in the South African craters crystallised.

From what is known of the theory of crystallisation, one is inclined to the old Indian idea that diamonds grow like onions, though much less quickly. It is hardly conceivable that diamonds, such as the Koh-i-nûr, the Great Mogul, the Excelsior (a Jagersfontein, South African stone of 971 carats), and the two largest De Beers

AUTHOR'S COLLECTION OF DIAMONDS.

DRAWN FROM NATURE—MAGNIFIED BY ONE DIAMETER.

diamonds (respectively of 503 and 428·5 carats) were formed, as the microscopical diamonds have been, in a moment of time during the sudden cooling of molten iron.

Is it not more reasonable to suppose that these enormous crystals grew little by little, and that nature has followed the same laws of crystallisation in the diamond as in other minerals ?

SECTION VII.—ECONOMIC.

1. DISEASES OF STOCK IN SOUTH AFRICA.

By D. Hutcheon, M.R.C.V.S., Chief Veterinary Surgeon, Cape Colony.

South Africa has obtained an unenviable reputation regarding the number and virulence of the diseases which affect its domestic animals.

It is a generally accepted opinion that the farm and domestic animals in South Africa are subject to more diseases, and that these present a more obscure and fatal character than the diseases affecting the farm and domestic animals in any other part of the world. Now, although that picture is considerably overdrawn, it must be admitted that during the last half century one animal plague after another, has swept over large portions of the South African Colonies and States, causing serious losses, and great disappointment to the stock owners of the country. It has to be noted, however, that with the exception of "Horse-sickness" and one or two diseases which are closely allied to it, which appear to be indigenous to South Africa, the large majority of the epizootic diseases which affect farm stock have been introduced, either from Europe, or from the East Coast extending towards the equator.

Large herds of cattle were found in possession of the Hottentots at the Cape at the time of its discovery by the Portuguese, and we do not read of any special disease having appeared amongst this class of stock during the eighteenth and first half of the nineteenth centuries.

The Contagious Pleuro-Pneumonia of Cattle.

This was first introduced into Cape Colony in 1854, by some bulls which were imported from Holland and landed at Mossel Bay. Since that date it has spread all over South Africa, and has been the cause of serious losses annually.

Inoculation for the prevention of this disease—first discovered by Dr. Willems, of Hasselt, Belgium—has been generally adopted by the European farmers in all the Colonies and States, and with more or less success, depending on the care and skill of the operators. But the natives, within their own territories, rely principally upon the alleged curative action of certain plants, and consequently lose large numbers of their cattle annually.

The Contagious Pleuro-pneumonia of cattle will not be eradicated from the herds of South Africa until the respective Governments agree upon a uniform policy of the strict isolation of infected herds, and slaughtering all affected animals.

Infectious Pleuro-Pneumonia in Goats.

This virulent infectious disease was introduced into this Colony by a shipment of Angora Goats which arrived at Port Elizabeth from Asia Minor about the middle of December, 1880. One consignment of these goats was taken to Mount Stewart, and shortly after their arrival the disease appeared amongst a flock of 460 ewes belonging to Mr. Cawood, amongst which the imported rams had mixed. The disease spread rapidly until about 200 of the flock had died; the remainder were then destroyed and their carcases buried. This action was effective in arresting the further spread of the disease at that centre.

Another consignment of this shipment of goats was sent to Somerset East, and subsequently sold there. Mr. Niekerk, of Brakfontein, Bedford District, purchased one ram. This ram became sick after his arrival at the farm and recovered, but the disease spread, first to Mr. Niekerk's own Angora flocks, thence to the flocks on adjoining farms, rapidly increasing its radius of infection until it carried off about 13,000 large goats, and caused the loss of over 20,000 kids, the average mortality being 65 per cent.

The author devised a system of inoculation, which was effective in preventing the disease, or reducing the death-rate to a minimum, if applied before any infection had reached the flock. If the infection appeared in a flock some time subsequent to the inoculation, the re-inoculation of the flock, and the slaughter of those affected, arrested the disease at once, and left no infection behind.

In 19 uninoculated flocks containing 7,500 goats, 5,100 died, or a mortality of 68 per cent.

In 12 flocks containing 12,550 goats which were inoculated after the disease appeared in the flock, 4,380 died; a mortality of 31 per cent.

In 35 flocks containing 21,500 goats, which were inoculated before any visible signs of disease were manifest, 2,860 died; a mortality of 13½ per cent.

There were 18 flocks containing 9,950 goats, which were free from disease when inoculated, and remained free.

Nature of the Disease.—It may be described as an infectious febrile disease, characterised by a special form of Pleuro-pneumonia, which terminates in consolidation of the whole of one lung, or portions of both lungs, an effusion of a serous fluid into the pleural cavity, and adhesions of the pleural surfaces. The period of incubation is from seven to ten days, and the length of the fever about twelve days.

The disease makes its first appearance in the lungs as a number of small nodules about the size of a pin head; they are of a pale yellow colour, and firm consistency when pressed between the fingers. Surrounding these nodules, in a spherical form, is a congested ring of a bluish-purple colour, varying in diameter from

$\frac{1}{8}$ to $\frac{1}{2}$ inch, corresponding to the size of the nodule. These nodules appear irregularly, sometimes in one lung only, in other cases they are distributed irregularly in both. These nodules enlarge in spherical form, giving the lung at a certain stage a distinctly globulous appearance. These globular portions gradually coalesce, when the whole diseased portion becomes solid; a cut section presenting an appearance similar to that of a granular liver. There is no perceptible enlargement of the interlobular tissue, the air cells and smaller bronchii become filled with cellular elements, saturated with a serous fluid. As the disease advances, the affected portions become drier and firmer in consistency, and present a dirty yellow colour on section. At the same time a quantity of serous fluid becomes effused into the pleural cavity, and fibrous adhesions appear between the pulmonary and costal portions of the pleura. The pericardium is usually filled with fluid, and both the pericardial and thoracic fluids coagulate after death. The pathological lesions are confined to the thoracic organs.

Preventive Inoculation.—The clear serous fluid found in the thorax and that expressed from the diseased lungs, is strained and used as fresh as possible. When it has to be kept for twenty-four hours or more before being used, a little glycerine is added. About 5 minims of the virus was injected hypodermically on the under surface of the tail. If the goats were still exposed to infection, a second injection of 8 minims was given after a month.

The disease was eradicated from the Angora flocks of the Colony in February, 1882, and has not re-appeared. The measures adopted were:—The quarantine of infected flocks, the inoculation of healthy flocks surrounding infected areas, the slaughter of affected goats, and when the disease was well under control authority was obtained to slaughter, with compensation, any flocks which became affected, that had not been previously inoculated.

Rinderpest.

From ancient literature on the subject, this Bovine Plague must have existed in the steppes of Oriental Europe and of Central Asia since the most remote periods, and from these countries it has evidently spread by wars and the migration of people to almost every country in Europe.

Origin of the Disease in Central Africa.—Sir John Kirk, in Nature, June, 1896, says:—"There can be little doubt that the present epidemic known under the common name of Rinderpest, is the same as that with which we have been familiar in Central Africa for the past six years, commencing, as far as we know, in Somaliland in 1889, where the disease killed off a large part of the cattle.

It passed through Masailand in the autumn of 1892. It was there that Sir Frederick Lugard, then an officer of the Imperial British East African Company, first came in contact with it."

Sir Frederick considers that the disease started on the East Coast opposite Aden, and thence to have spread inland.

From Somaliland it spread in 1890 to Uganda, and Kasalli in 1891. Passing southward it reached the north of Ngara, July, 1892, and in August of the same year, Lake Nyassa.

The Imperial German Consul writing under date the 7th February, 1893, states:—"The Governor of German East Africa reported on the 9th December last that great havoc had been done of late by cattle disease through the country generally. The disease was first officially reported at Bulawayo, March 3rd, 1896, but a report reached Mafeking as early as February 19th, that cattle south of the Zambesi were rapidly dying from some mysterious disease, doubtless Rinderpest."

From Bulawayo the disease was carried rapidly southward by the transport wagons returning to Mafeking.

An effort was made to stop these, quarantining the oxen, and killing the affected spans. But the native transport riders left their wagons and drove their oxen through the cordon in all directions southward. By this means the disease was carried to Kopani's Stadt in the Transvaal on the east, and to Mosita Reserve in the Mafeking district. In less than a month the disease had travelled over 500 miles. It got into the Mosita Native Reserve early in April, the Setlagoli Reserve in May. It was reported in the Vryburg district early in July. It appeared in the Taungs Reserve on September 1st, and on the same date it was reported at Daniel's Kuil in the Barkly West district. On the 1st of October it appeared at Warrenton in the Kimberley district. The policy of slaughtering the infected herds and stopping all movements of cattle was carried out at first. This policy was abandoned in Bechuanaland on October 12th, but it was maintained north of the Orange River until the end of March, 1897, when Dr. Koch's method of bile inoculation, was generally adopted throughout the whole of South Africa—the disease following in its train.

This first invasion of Rinderpest died out in the British Colonies and the Dutch Republics about the end of June, 1899. But it still existed in German South-West Africa, north of Windhoek.

In May, 1901, the disease re-appeared at Ladybrand in the Orange River Colony, and at Maseru in Basutoland. The general opinion is that the infection was brought from German South-West Africa. From Basutoland and the Orange River Colony it spread to the Transvaal, Natal, Zululand, the British Protectorate, Bechuanaland, and the frontier districts of the Cape Colony.

Effective measures could not be taken to suppress the disease until October, 1902, due to the forced movements of cattle during the war. At the above date the disease existed in twenty-two districts of the Cape Colony, and the number of separate infected centres were seventy-seven, involving 27,235 cattle.

The disease was entirely suppressed within the Cape Colony in April, 1903. Our complete success was almost wholly due to the use of large doses of strong Serum obtained from highly fortified recovered cattle. The disease lingered several months longer in the other Colonies, especially in Zululand and the adjoining districts of Natal. But with the exception of German South-West Africa, where the war has prevented the authorities from suppressing it, the disease is not known to exist in any of the Colonies of South Africa.

Inoculation against Rinderpest.—The principal methods of inoculation against Rinderpest practised in South Africa are Bile and Serum.

The former is used both fresh and glycerinated, and the latter in the form of preserved Serum and as blood freshly drawn from a recovered animal.

Pure Fresh Bile (*Koch's Method*).—Using 10 c.c. of selected Biles from animals which have succumbed to Rinderpest or killed in the last stages of the disease and injecting it under the skin.

Edington's method consists of adding one part of glycerine to two of the Fresh Bile; stirring the mixture, and allowing it to stand for eight days, then using a dose of 15 to 25 c.c. subcutaneous, and after an interval of ten days, giving an inoculation of 1 c.c. of virulent Rinderpest blood.

Serum and Defibrinated Blood.—Behring's important discovery that if the toxines of a pathogenic organism are injected in proper quantities for a sufficient length of time into the body of one of the higher animals, the Blood Serum of this animal acquires sufficient specific antitoxic properties, but they do not neutralise or render harmless the toxines of any other species of micro-organism was generally known at the date of the outbreak of Rinderpest in South Africa.

Koch, in the early stages of his experiments at Kimberley in January, 1897, found that Serum obtained from cattle which had recovered from Rinderpest, when injected into susceptible animals, gave them an immunity against the disease, for a limited period, when injected in large doses; but at that time Koch discovered the efficacy of the Bile obtained from sick animals, which he considered was safer and more effective than Serum.

It was Messrs. Watkins-Pitchford and Theiler, Chief Veterinary Surgeons of Natal and the Transvaal respectively, who were the first in South Africa to aim at confering an active immunity to cattle by the Serum method of treatment, but their experiments were interrupted.

Later Dr. Danysz and Bordet, of the Institute Pasteur, Paris, commenced work at Waterfall in the Transvaal, and directed their attention to the elaboration of the Serum method. They employed defibrinated blood obtained from recovered animals which, after recovery, had received large doses of virulent Rinderpest blood at periodic intervals. The inoculated cattle were then mixed with infected animals, from which they contracted a modified form of the disease under the resisting action of the Serum. As a curative remedy, large doses of freshly drawn blood were injected into the jugular vein of the sick animals.

Drs. Turner and Kolle devised what is known as the "Simultaneous Method" of inoculation—that is to inject 1 c.c. of virulent blood on the one side of the animal, and a regulated dose of standardized Serum on the other. The amount of the Serum depended on its ascertained strength, which was previously tested, and the size of the animal. This is the simplest and one of the most effective methods of conferring an active immunity on herds of cattle where the disease is prevalent. But when the outbreaks of Rinderpest become sporadic in character, as they did during its second invasion of the Colony, nothing succeeds so well as the injection of large doses of strong Serum alone to the whole of the infected herds and all likely to come in contact with these. It arrests the spread of the disease at once, with little loss to the owner, and it leaves no infection behind.

Redwater, Texas Fever, or Bovine Piroplasmosis.

The causal organism of Texas Fever was first discovered by Dr. Theobald Smith, Pathologist to the United States Bureau of Animal Industry, in 1889, and during the following year his collaborator, Mr. F. L. Kilborne, discovered that the cattle tick—*Boophilus bovis, vel Rhipicephalus annulatus*—was the medium of transmitting the infective organism. This tick is closely allied to our common Blue Tick (*Rhipicephalus decoloratus*), which Dr. Koch demonstrated was the tick which transmitted the Redwater in German East Africa. In December, 1896, at Kimberley, Koch recognised the identity of Texas Fever and South African Redwater, on examining the first blood which he obtained for inoculation purposes from Taungs, Bechuanaland.

In their first report, which is a classic on the subject, Smith and Kilborne describe the disease by its previously-recognised name—Texas Fever—and Smith named the causal organism *Pyrosoma bigeminum*, from its pyriform shape and its usual occurrence in pairs within the red blood corpuscles.*

Since Smith's discovery of the causal organism of Texas Fever, this organism has been found in the blood of cattle affected with the same disease, but described under different names, in several countries of the world.

"At the suggestion of Lignieres, the term 'piroplasmosis' was proposed as a suitable term for all diseases due to a piroplasma; accordingly Texas fever is called Bovine piroplasmosis."—(Theiler).

Redwater was first discovered in British South Africa in 1870, when it appeared among some cattle near the mouth of the Tugela, in Natal. The disease was evidently carried by cattle from Zululand and Swaziland, as the native servants from these territories recognised the disease as one which they had previously seen among their own peoples' cattle, and Dr. Koch, in his official report from Dar-es-Salaam, dated 15th November, 1897,† states, "that from

* Investigation into the Nature, Causation, and Prevention of Texas Fever, Bulletin No. 1., Government Printing Office, Washington.

† Vide Agricultural Journal, Vol. XIV., p. 658.

information obtained in these territories it is evident that Texas fever (Redwater) had for a long time been endemic on the East African Coast, and the Island of Mafia. Presumably the region where it is endemic includes other East African cattle-rearing islands, and stretches both north and south across the German Protectorate."

Redwater caused very serious losses amongst cattle in Natal during the early years of its invasion of that Colony; similar very heavy losses followed in its train as it invaded the adjoining States of the Transvaal and Orange Free State. In 1883 it spread through the Transkeian Territories and made its first appearance in the Kaffrarian districts of the Cape Colony.

In the year 1885 it was estimated that over 100,000 cattle died in Griqualand East and the Transkeian Territories alone. It has since spread as far south as the districts of Mossel Bay and Oudtshoorn, and inland as far as Queenstown, Stockenstrom, Bedford, etc., and is occasionally met with in Griqualand West and Bechuanaland in the Cape Colony.

Preventive Inoculation.—The possible success of preventive inoculation was clearly foreshadowed in the exhaustive reports of Smith and Kilborne already referred to. They proved that the tick was the medium of communicating the disease in Nature, and that it could also be communicated to a clean animal by inoculation with blood obtained from a sick animal.

Immunity was, therefore, sought to be established first, by placing a limited number of infected larval ticks on a clean animal; then, by exposing susceptible cattle to natural tick infection for a limited time. This led to inoculation with blood obtained from a recovered animal, first tentatively by the Officers of the Bureau of Animal Industry, and subsequently by other State veterinarians. In 1896 the Queensland Government took this subject up with great enthusiasm. It would appear that Mr. A. Barnes, Veterinary Surgeon of the Queensland Government, was the first to tentatively try the effect of recovered blood as an inoculating medium there. But it was Mr. Pound, Director of the Queensland Stock Institute, and Dr. Hunt, who by their carefully-conducted experiments first established the value of preventive inoculation with recovered blood for Texas fever in Queensland.

Mr. Pound prefers obtaining blood from a young animal which has recovered from a severe attack of fever that has been *artificially* produced, rather than from one which has contracted the disease naturally.

Dr. Edington recommends taking a recovered, or naturally salted animal, from an infected area; injecting it with a dose of virulent blood, and twenty-eight days after, if no great degree of fever has been produced, this animal's blood may be used for inoculation.

Our experience is that the blood of recovered animals, even when obtained from the same infected veld, varies considerably. In some cases the blood gives little or no reaction when inoculated into susceptible animals, while in other cases the fever re-action is so severe that a heavy mortality follows. The safest plan is, therefore, to test the recovered animal's blood first on a limited number of cattle before using it on large herds.

AFRICAN COAST FEVER (PIROPLASMA PARVUM).

This disease was first discovered by Dr. Koch in German East Africa in 1897, and in his official report from Dar-es-Salaam he described the disease as Texas Fever, and the causal organism found in the blood corpuscles as a form of pyrosoma bigeminum.

In 1901 it appeared, in combination with Redwater, amongst a shipment of cattle from New South Wales, which were landed at Beira. There is some doubt expressed whether they were the first cattle to introduce the disease into Rhodesia or not. Mr. Jarvis, Veterinary Surgeon to the Rhodesian Government at Umtali, is of opinion that a shipment of cattle was imported from German East Africa direct, previous to the arrival of these cattle from New South Wales, and that these latter died.

It is generally admitted by Messrs. Gray, Jarvis and the other veterinary surgeons who were actively engaged in attending to these imported cattle, that the most susceptible cattle which fell victims to the disease shortly after their arrival, presented all the prominent clinical and *post mortem* appearances of Redwater; but as the disease progressed in the herd, the symptoms manifested, and the *post mortem* lesions observed, deviated considerably from those met with in the normal type of Redwater. These atypical cases became more and more numerous during the following season, 1902, when it spread from Umtali to several other centres in Southern Rhodesia.

It was still associated with Redwater, however, and those who were engaged in its investigation at the time, like Dr. Koch, when he first met with the disease at Dar-es-Salaam, although they clearly recognised and described the small and characteristic organisms of African Coast Fever, did not consider these special and distinct parasites, but regarded them as different forms of the *P. bigeminum.*

When Dr. Koch came to investigate this disease at Bulawayo, in the beginning of 1903, it is very evident that he met with the disease in an uncomplicated form, as he states in his first report, that, "in the blood of animals examined by us we only found the small parasites characteristic of the disease." In his second report he qualifies that statement and admits that in ten out of ninety-one sick animals, he found the large pyriform organism, and in six out of these latter cases he observed blood-coloured urine. These cases he considered, were animals salted to ordinary Redwater, which again developed that disease as a result of the high temperature produced by an attack of African Coast Fever.

As a result of his experiments and observations, Dr. Koch showed that African Coast Fever differs from Texas Fever in the following particulars :—(*a*) the blood parasites are of different shape, and considerably smaller ; (*b*) although the blood parasites are more numerous in African Coast Fever than in Texas Fever, there is not the same destruction of the blood corpuscles, and consequently hæmoglobinuria is rarely observed ; (*c*) a strong immunity to Texas Fever gives an animal no immunity to African Coast Fever ; (*d*) Texas Fever is communicable to a susceptible animal by inoculation with the blood of an affected or recovered animal, but African Coast Fever is not. (The fact that Messrs. Gray and Robertson obtained positive results from inoculation clearly shows that the cases which they had to deal with were combined with Texas Fever or Redwater.)

" At the present time African Coast Fever exists only in areas infected " (more or less) " with ordinary Redwater."—(Theiler). Further, it has since been found, although not recognised by Koch, that while the blood of cattle immune to Redwater is still infective, the blood of cattle immune to African Coast Fever is not infective. (*e*) The local lesions in certain organs are quite different in African Coast Fever from those seen in Redwater. For example, the enfarcts in the kidneys, lungs and liver, the swollen and haemorrhagic condition of the different groups of lymphatic glands, and the appearance of local oedema especially in the lungs from which the peculiar frothy effusion, occasionally observed, arises, are sufficient proof that African Coast Fever, although allied to Texas Fever and belonging to the same class of diseases, is still a distinctly different disease.

Transmission of African Coast Fever.—This fever can be transmitted by the " Brown Tick," *Rhipicephalus appendiculatus*, either by a nymph which fed as a larva on a sick animal, or by an adult which fed on a sick animal as a nymph ; the infection does not pass through the egg. It may also be transmitted by the *R. simus*.

Can Animals other than Bovines carry the Infection.—Messrs. Gray and Stockman and Dr. Thieler are confident that bovines alone contract the disease, and convey the infection. The tick has to acquire the infection by feeding on a sick beast, either as a larva or a nymph. If the tick contracts the infection as a larva it communicates it in its nymphal stage ; and whether the animal that it bites is susceptible of the disease or not, the tick discharges its poison, and loses its power of conveying further infection, and it does not remain long enough on the animal that it infects to get re-infected.

Another important fact is that recovered cattle are incapable of conveying infection to the ticks, hence, although recovered cattle are left on an infected farm, the infection dies out as completely as if the farm were cleared of cattle. within a period of fifteen months.

Piroplasmosis in the Dog.

This disease has been recognised in many countries of the world. The first authorities to describe the causal parasite were Galli, Valerio and Piana, who in 1895 demonstrated the piroplasma in the blood of a dog in Milan, and gave a minute description of it and the clinical history of the disease. He named the parasite *Pyrosoma bigeminum var. canis*. Dr. Koch alludes to malarial parasites in the blood of dogs at Dar-es-Salaam. Hutcheon first met with the disease at Port Elizabeth in 1885, and described it in 1887. In 1893 he drew attention to the close resemblance between the disease and Redwater in cattle. Veterinary Surgeon Spreull proved its inoculability in 1899, and Dr. Carrington Purvis the same year demonstrated the piroplasma in the blood sent to him for microscopic examination.

Lounsbury and Robertson in 1901, working conjointly, confirmed the fact that the disease was communicated by direct inoculation of virulent blood, and through the agency of the dog tick *Haemaphysalis leachii* (Audouin), and described in detail and at length, the causal parasite, the clinical symptoms, *post mortem* appearances, and microscopical characteristic of the blood and tissues from a great number of cases of the disease. They also proved that the blood of a dog which had recovered from an attack of the disease, (and had been kept out of the reach of second re-infection by ticks, etc.) can by direct inoculation, or through the medium of ticks, produce the disease after an interval of nearly two years.

Mr. Lounsbury by a long series of carefully-conducted experiments, satisfactorily demonstrated that the common dog tick at the Cape, *Haemaphysalis leachi* (Audouin), transmits the infection of malignant jaundice through its progeny, and that such progeny normally remains incapable of transmitting the infection it inherits until it attains the adult stage." Mr. Lounsbury remarks :—"That the infection passes through the egg stage is a fact not unparalleled and therefore not surprising, but that it is harboured through two feeding stages without being transmitted is at present unique."

Veterinary Surgeons Bowhill and M. Le Doux, in 1904, describe an endoglobular form of the parasite, the Piroplasma, which form possesses " flagella like processes with two bulbs on the flagellum, and some with only one at the end."—" Numerous free parasites were also present in the blood, and in a few instances we thought we observed flagellate bodies entering infected corpuscles."

Diseases Produced by Trypanosomata.

The genus of Trypanosoms is characterised by the possession of a longitudinal undulating membrane, the thickened border of which takes its origin posteriorly from a centissome and terminates anteriorly in a free flagellum.

The Trypanosomidae occur in amphibia, reptiles, birds and mammals, and depend for their propagation and spread upon an intermediary host or bearer—a Blood-sucking Fly.

The principal Trypanosomal diseases in Africa are :—

The *Sleeping Sickness* of Uganda, affecting human beings, caused by the *T. Gambiense* and *T. Ugandense,* and carried by the *Glossina palpalis.*

The *TseTse,* or Fly Disease, affecting horses, mules, donkeys, cattle and dogs, caused by the *T. Brucei* and carried by the *Glossina morsitans.*

Transvaal Gallziekte, or Gall Sickness, affecting cattle, caused by the *T. Theilerii,* and carried by the *Hippobosca rufipes.*

Up to the present, none of the above diseases have been met with in the Cape Colony.

African Horse-Sickness.

This remarkable equine disease, known locally as Horse-sickness, has been more or less prevalent in South Africa for nearly two centuries. It appeared at the Cape in 1719, fifty years after the introduction of horses into Cape Colony by the Dutch East India Company. The fact that there were no horses in South Africa at the date of its first occupation by Europeans, although they were plentiful in Northern Africa from the dawn of history, makes it probable that their absence was mainly, if not entirely, due to the existence of this disease.

The infective agent is harboured by the other species of the genus *Equus,* which roamed in large troops all over South Africa, and are known to possess a strong resistence to Horse-sickness.

Horse-sickness occurs as an enzootic, or seasonal disease, in certain areas of South Africa, but at intervals of more or less duration, it assumes an epizootic character, and passes like a wave over the greater portion of one or more of the Colonies, carrying off a large percentage of the horses and mules.

The seasons in which these epizootics usually occur are characterised by early and abundant rains, followed by heat and unusually heavy dews. It was these conditions that gave rise to the popular opinion that these heavy dews, which fell during the night —the period in which the disease is contracted—had something directly to do with its origin. This view was further strengthened by the fact that, when horses were taken from the valleys and plains, and placed on high table lands, during the summer and autumn, and not returned until the first frost fell, they escaped infection. It was further observed that it was the local elevation and not the absolute height of the table land above sea-level which conferred the immunity.

Proper stabling was also believed to give protection when care was exercised to protect the food and water from the night air.

The Nature of Horse-sickness.—This disease was considered by several military and civil veterinary surgeons who studied the disease in Natal, to be closely related to Anthrax, but to Dr. Edington belongs the credit of being the first to show that Horse-sickness is a disease *sui generis ;* that it has a constant period of incubation, and that it may with great certainty be transmitted to horses by subcutaneous inoculation with the blood of an animal dead of the disease.*

The hypothetical organism of Horse-sickness has not been discovered, and Professor McFadyean showed in 1902 that the contagium passed through a Berkfeld filter.

It has, however, been generally recognised as a disease peculiar to the genus *Equus*, but Dr. Edington, in his more recent reports, states that "both bovine and caprine animals, obtained from the Karoo, could be infected, though with some difficulty"; he therefore proposes to group Horse-sickness, Heartwater and Veld-sickness (Coast Gallsickness) under the generic name of "South African Fever," having Equine, Bovine and Caprine varieties.

In 1900 Mr. Watkins-Pitchford, F.R.C.V.S., Natal, published in the Agricultural Journal of that Colony, a short series of articles embodying his views on the etiology or cause of this disease, and stating the various factors which had led him to incline to the theory of the disease being one which was due to the agency of nocturnal insects, probably some species of Mosquito.

During his recent work, Mr. Watkins-Pitchford states that he has been able to observe that horses carefully protected from possibility of attack from other insects can be subjected to the bites of a species of Mosquito (Anopheles) without any appreciable after-effect, but when steps have been taken to infect these mosquitos (by previous feeding upon an animal suffering from Horse-sickness) a disease indistinguishable from a mild attack of Horse-sickness is produced, when the insects are allowed access to a horse in a normal condition.

Dr. Arnold Theiler, in his yearly Report, 1903, claims to have found a system of preventive inoculation whereby mules (which are not so susceptible to the disease as horses) can be rendered immune against an attack of Horse-sickness.

Dr. Edington, in a recent report, states that he has devised a Vaccine for the inoculation of mules, which is being issued, and is acting satisfactorily; while that for horses will be issued as soon as the present season of sickness has ceased.

The method of preventive inoculation recommended by Dr. Koch for the establishment of artificial immunity against Horse-sickness, as the result of his experimental work in Rhodesia, is summed up briefly as follows:—

Step I.—0.01 c.c. of Virus injected subcutaneously in the neck, at an interval of four days; 100 c.c. of standardised strong Serum is injected subcutaneously, a hand's breadth below the site of the Virus injection, at 12 days interval.

Step II.—0.05 Virus. 4 days interval.
50 c.c. of Serum. 12 days interval.

Step III.—0.2 c.c. Virus. 4 days interval.
50 c.c. Serum. 12 days interval.

* Vide Dr. Edington's Report, 1895.

Step IV.—0.5 c.c. Virus. 12 days interval.
Step V.—1 c.c. Virus. 12 days interval.
Step VI.—2 c.c. Virus. 12 days interval.
Step VII.—5 c.c. Virus. 12 days interval.

Dr. Koch adds that the doses of Virus and Serum must be regulated according to the relative strength of the Virus and Serum employed, which must be tested in every case by previous experiments.

Preparation of Serum.—In fortifying salted horses, Dr. Koch preferred the intravenous injection of 1,000 c.c. of virulent Horse-sickness blood, to the subcutaneous method with 2,000 c.c.

For intravenous injection the blood must be carefully defibrinated, filtered through muslin, and injected while warm, or if allowed to cool, it must be raised again to a temperature of 25° Cent. in a water bath. The blood should then be introduced directly into the jugular vein with a large Canula, by gravity alone, etc.*

EQUINE PIROPLASMOSIS OR BILIARY FEVER.

It is impossible to say whether this disease is indigenous to South Africa, or whether it has been imported from some other country, or extended south from the eastern coast districts, like African Coast Fever, Redwater and Heartwater, as we do not know anything relating to its origin, or the medium of its transmission.

Veterinary Surgeon Bowhill gives the following description of its—

History and Geographical Distribution.†—Equine piroplasmosis, commonly known throughout South Africa as Biliary Fever, was first observed in Natal in 1883 by Wiltshire, who named the malady Anthrax Fever.

Subsequently, the author described it in the Cape Colony as Biliary Fever in the horse. He also states that it is most prevalent along the coast belt, and is fully as common among stable-fed horses as those which have never been inside a stable. It may occur at any season of the year, but is most prevalent during summer and autumn.

Gugliemi (1899) described the disease in Italy as Horse Malaria, and was the first to discover endoglobular parasites in the blood of the infected animals.

Rickman (1902) described endoglobular parasites in the blood of horses that succumbed to Horse-sickness, and concluded that Horse-sickness was similar to pernicious malaria in man.

Robertson, in the Report of the Chief Veterinary Surgeon for 1901, describes the parasites in detail, and failed to transmit the disease by direct inoculation.

Bowhill (1904) observed *P. Equi* in a horse that died of naturally acquired Horse-sickness at Grahamstown.

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* Vide Cape Agricultural Journal, Vol. xxiv. pp. 505 & 663.
† Journal of Hygiene, Vol. v. No. 1, January, 1905.

Koch (1904) met with this disease during his Horse-sickness work in Rhodesia. One of his young animals developed a fatal attack of Biliary Fever after inoculation with blood from a salted horse.

Theiler (1902) describes the disease as Equine Malaria.

Edington (1901) considers the disease as a Malarial form of Horse-sickness.

Zieman (1902) has described equine piroplasmosis as occurring in Germany, and states that a similar disease prevails in Venezuela.

Theiler, in his annual report for 1903–1904, states that he succeeded in transmitting the disease to a recently imported horse by direct inoculation, using the blood of a horse which recovered from an attack of the disease two years previously. The inoculated animal succumbed on the 16th day, with all the clinical symptoms and *post mortem* appearances of Biliary Fever, and with typical Piroplasma in the blood. The period of incubation was eight days. In Dr. Koch's case the temperature rose on the 9th day.

The Parasite which causes piroplasmosis of the horse, mule and donkey belongs to the Haemocytozoa or endoglobular haematozoa. In an outbreak of piroplasmosis which appeared amongst some troops of donkeys in the Transvaal, the parasite was discovered by Theiler, who states that it is very closely related to, if not identical with the piroplasma found in Biliary Fever of the horse and mule.

Agent of Transmission.—Most observers, judging from analogy, are of opinion that a tick is the transmitter of the disease. I entertain strong doubts on that point, because I have seen numbers of severe attacks, sometimes ending fatally in imported stud and racehorses, which were kept in good clean stables and well groomed, at least twice a day, and no tick allowed to rest on them.

Heartwater in Sheep, Goats and Cattle.

This is a specific fever which affects sheep, goats and cattle along the eastern districts of the Cape Colony, the Transkeian Territories, Natal, Zululand, and a large area in the Transvaal. It most probably exists along the greater portion of the north-east coast districts of South Africa, as it is believed to have come originally from that region.

Heartwater was recognised as a special disease of sheep and goats in the coast districts of the Eastern Province of the Cape Colony forty years ago. But in 1898 Dr. Edington demonstrated that it could be communicated to cattle by inoculation, and since then it has been observed that cattle, more especially young cattle, contract the disease on the veld.

It is not infectious, but is communicable by inoculation with the blood, spleen pulp, and thoracic fluid, obtained from an affected or recovering animal.

Mr. Lounsbury has demonstrated that the medium of communicating the infection in Nature is the "Bont tick"—

Amblyomma hebraeum, Koch, which has previously fed on an affected animal, one tick being sufficient to communicate a virulent attack.

The hypothetical infective organism has not been discovered, but Mr. Robertson has shown that the infective agent does not pass through a Chamberlain or Berkfeld filter. The incubation periods are :—After inoculation, from 8 to 10 or more days ; after successful tick infestation, from 11 to 15 days. The fever period usually lasts from 6 to 10 days, but death may occur within 48 hours.

Post-mortem Lesions.—There is usually slight enlargement of the spleen and congestion of the liver. The mucous membrane of the fourth stomach—abomasum—and portions of the small intestines are highly congested. In cattle there is acute gastro-enteritis, but the characteristic lesion is an effusion of a clear buff-coloured sero-albuminous fluid into the thoracic cavity and pericardial sac, which coagulates into a firm jelly on exposure to the atmosphere. Hence its popular name, "Heartwater."

Preventive Inoculation.—A long series of experiments have been conducted by Dr. Edington and the officers of the Veterinary Staff of the Cape Colony with the object of discovering a safe and effective method of preventive inoculation. And strong hopes are entertained that by giving two or more graduated inoculations of virulent blood hypodermically, at intervals of 30 days, that the greater portion of the animals so treated will resist the ordinary tick infection on the veld.

Medical treatment has not proved a success, although a large number of remedies have been tried.

Malarial Catarrhal Fever of Sheep.

This is a specific disease which affects sheep over a large area of South Africa. It is characterised by high fever, a catarrhal inflammation of the mucous membranes lining the lips, tongue, mouth, fauces and upper air passages, accompanied, in the majority of cases, by inflammation of the coronary band and laminae of the feet, and followed in severe cases by suppuration and shedding of the hoofs. In other cases there is extensive exfoliation of the epidermis and shedding of the fleece. It is non-infectious, but readily communicable by inoculation with a small dose of blood from an affected animal either sub-cutaneously or intravenously.

It visibly affects sheep only, but a slight fever re-action can be communicated to goats, rabbits, cattle, and probably to other animals by the intravenous injection of large doses of virulent blood, and blood drawn from these animals during the fever re-action, if injected into sheep will communicate a severe form of the disease to them. (Spreull).

It is not communicable to the horse. (Mr. Robertson.)

The period of incubation is from two to four days, rarely five. The temperature is high, reaching from 104° to 107° Fah. The fever period extends from five to seven days. In young animals in poor condition, the disease is very severe and runs its course very rapidly. In cases of recovery the course of the disease is about twenty-one days (Spreull.)

The blood of an infected sheep is virulent during the whole course of the fever, and for a number of days after recovery, in some cases up to fifty. (Ibed.)

Etiology.—This "Ovine Malaria" was until recently believed to be due to a small intra-corpuscular organism, similar to the plasmodium found in the red corpuscles of a horse suffering from Equine Malaria. But in conducting certain experiments relating to this disease at Cape Town, Mr. Robertson failed to find the intra-corpuscular organism in artificially produced cases, which he had previously seen in the blood of sheep on the East Coast districts affected with malaria. He then demonstrated that the contagium was capable of passing through a tested Berkfeld filter. In this respect, as well as in the conditions under which it arises, "Ovine Malaria" closely resembles Horse-sickness.

Preventive Inoculation.—Mr. Spreull has discovered that by mixing 2 c.c. of virulent blood, and a regulated dose 3 to 6 c.c. of standardised fortified Serum, and injecting them together, that a modified fever is produced, which confers an immunity sufficient to resist veld infection.

Geel Dikkop, or Yellow Thick Head.

This is a peculiar disease affecting sheep and goats, but more particularly the former. It is most prevalent in the Karoo districts, but it is met with in mixed veld, and even in pure grass veld.

It is characterised by an effusion of a clear yellow serous fluid into the subcutaneous cellular tissue of the head, throat, cheeks and ears, hence its local name of "Yellow Thick Head." There is a rise of temperature from 103° to 105° Fah. The fat and tissue of the body present a jaundiced appearance; the liver also presents a saffron colour, and the gall bladder and bile ducts are usually distended with bile of a similar colour often mixed with mucous. There is also a catarrhal condition of the small intestines and of the cystic duct, "and in numerous cases an absence of bile in the small intestines." (Dixon.)

Cause.—This disease has been attributed to several causes, but the general opinion entertained by the farmers is that it is due to a small plant called the "Dubbeltje Doorn."—*Tribulus Terrestrus Lin.*—which springs up luxuriantly after rain, the time when the disease becomes most prevalent.

Numerous feeding experiments have failed, however, to confirm that opinion. And it is observed that the disease will suddenly cease, although this plant is still abundant. Further, it occurs where the plant does not grow. There has, therefore, been a growing conviction that this disease is due to some specific infective agent.

It occurs at the same period of the year, and under conditions similar to those which give rise to Horse sickness and Ovine Malaria. But it is not inoculable like these two diseases.

Anthrax.

Charbon (*France*), *Miltzbrand* (*German*), *Meltziekte* (*Dutch*).

Sporadic outbreaks of this disease are met with in numerous districts of South Africa, and there are some limited areas where the disease occurs with more or less virulence as an annual visitor, while on individual farms, the losses during some seasons are so heavy, that it is found necessary to resort to preventive vaccination or inoculation, employing as a vaccine the double inoculation of attenuated cultures prepared and despatched by the Laboratories of the Institute du Pasteur.

In Griqualand West, in parts of which the disease is very prevalent, a large proportion of the cases which occur in horses take on the external form, characterised by circumscribed swellings due to cutaneous infection most probably by the *Hippobosca rufipes.*

These cases are amenable to prompt treatment, a considerable percentage recovering.

Black Quarter or Quarter Evil.

Charbon Symptomatique (*France*), *Rauschbrand* (*German*) *Sponsziekte* (*Dutch*).

This disease has been known from the time of the early settlers, and behaves much as it does in Europe.

Preventive inoculation for this disease has proved very successful (Arloing, Cornevin, and Thomas method) and is becoming more general every year.

Glanders.

Jetajé (*French*), *Rotz* (*German*), *Droes* (*Dutch*).

Glanders appears to have been introduced into the Cape at an early period of the Dutch occupation, but, except in the principal towns, a large proportion of farmers had no experience of it until after the sale and distribution of the military horses at the close of the recent war, when it was spread all over the country; at present the disease is rapidly being subdued by slaughter of visibly-affected animals, and the application of the Mallein test to suspected animals, with their future quarantine if the reaction is suspicious.

Strangles.

Gourme (*French*), *Druse* (*German*) or *Infectious Reno Adenitis* is called by the Dutch Nieuwziekte or New Sickness, which indicates that it was introduced at a recent date, most probably during the last generation. It is very evident that it spread rapidly over the whole country, for almost every horse owner appears to be familiar with it. as every case of any disease in which there is a discharge from the nostrils in a horse is described as Nieuwziekte.

Epizootic or Suppurative Lymphangitis.

This disease was known to exist amongst the horses in some of the Eastern Coast districts of the Cape Colony for over twenty years, and was known as Tick Farcy.

A great influx of the disease appeared with the commencement of hostilities, and "there can be no doubt that it *was* introduced by animals imported during the war, though no cases appear to have been observed prior to 1901. In 1902 it became a scourge, and has so remained.—(Lieut.-Colonel F. Smith.)

It has been spread over the greater part of South Africa by the dispersion of the cast military horses. It has since been proclaimed an infectious disease, and treated as such in all the British South African Colonies.

Its etiology and treatment, both preventive and curative, are now well known, and consist of isolation of the affected animals, the surgical removal of the affected parts, and complete destruction of all diseased products by caustics or cautery, accompanied by the thorough disinfection of the stable, its furniture and utensils.

Tuberculosis.

At what date this disease first made its appearance in the country we have no definite records to go upon.

It is customary to regard native and indigenous cattle as comparatively free from this affection, but I have seen numerous cases of advanecd Tuberculosis in Western Province bred and reared cattle, more particularly amongst the Friesland breed.

At present all over-seas cattle have to be provided with a certificate from a properly-qualified veterinary surgeon, certifying that they have been submitted to the tuberculin test and failed to react, in default of which they are landed in quarantine, submitted to the tuberculin test by a Government Veterinary Surgeon, and if they react, slaughtered. By these means we hope to at least minimise the chances of further infecting the cattle of the Colony with Tuberculosis.

Epizootic Aphtha, or Foot and Mouth Disease.

This well-known disease has had a wide distribution. There are few countries in which it has not appeared. It has been introduced into South Africa on several occasions, at long intervals. It, however, assumes a much milder type in this country than in Europe, and the losses arising from it are comparatively small, except during the prevalence of a drought, when the mortality among sheep has sometimes been heavy.

Specific Ophthalmia of the Horse.

Specific Ophthalmia or recurrent inflammation of the interior of the eye of the horse—a disease which arises without discernible cause—was comparatively rare in South Africa until the war. Lieut.-Colonel F. Smith states that "this disease appears to have been introduced during the war with horses from America. It was not seen during the early days of the Campaign, and did not attract serious attention until 1902. In its symptoms and results it does not differ from the disease as observed in Europe; all the tissues of the eye, excepting the sclerotic, are involved, leading to gradual disorganisation in the course of one or more attacks." It is peculiar to the horse, and there is a growing conviction that it is due to some specific microbe. "It cannot, however, be conveyed by any known method of inoculation." "Its recurrent character is its destructive feature, and this is unaffected by treatment."—(F. Smith.)

Ulcerative Keratitis.

This is acute inflammation of the eyeball or cornea of ruminants, and is extremely common in certain parts of Cape Colony at certain seasons of the year, chiefly during the summer months, when it frequently assumes an epizootic form, affecting a large proportion of the herds and flocks. The inflammation is confined to the cornea, the conjunctive lining the eyelids being rarely affected at the commencement of the attack.

Symptoms.—The cornea becomes cloudy and opaque followed by a circumscribed swelling, which increases in size and acquires a pale yellow colour. An abscess forms, which bursts and discharges its contents. It is marvellous how such cases recover, leaving only a small cicatrix.

The cause is not definitely known. The disease is extremely contagious, and may be introduced into a clean herd by an affected animal. As it occurs during the summer months only, it may be that the pollen of certain plants enters the eye, and injures the epithelium of the cornea. The micro-organisms may enter the cornea with the seed or afterwards.

The treatment is local, consisting of soothing and antiseptic applications, and when granulations appear the use of Calomel, or applications of Lunar Caustic, are to be recommended.

Parasites in the Eyes of Cattle.

The presence of worms in the eyes of cattle is frequently met with in Cape Colony, more particularly in the Eastern districts.

Calves are the most common victims.

There are two varieties of the worms. One, the *Filaria lacrymalis*, is found under the *membrana nictitans* at the inner angle of the eye, and is very common. The other variety, *Filaria oculi*, occupies the anterior chamber of the eye, immediately behind the cornea in the aqueous humour. This parasite is comparatively rare.

The treatment for the first parasite is washing them out with a solution of salt or weak tobacco water; the second can be removed by an operation.

Chronic Catarrhal Pneumonia (Jagziekte).

This is a special and peculiar form of inflammation of the lungs, which affects sheep over a large area of the Cape Colony, more particularly in the higher and colder districts. It bears a close resemblance to catarrhal pneumonia, with a natural tendency to terminate in interstitial pneumonia. There is no tendency to breaking down of the lung tissue or the formation of abscesses;

the smaller bronchiæ become filled with catarrhal products, at the same time there is an exudation of inflammatory lymph into the lung tissue, until in advanced cases, a cut section of the lung presents a semi-solid appearance, of a pinkish yellow colour, and an oily soapy feel. In still more advanced cases, the diseased portion of the lung becomes drier, and the interlobular tissue hard and resisting.

There is no tendency to recovery, even when the affected sheep is placed in a comfortable house and carefully nursed. Under such conditions, however, the progress of the disease is slow, and differs considerably in character from those cases which are exposed to the vicissitudes of the weather. The smaller bronchiæ and air-cells do not become filled with catarrhal products to any appreciable extent, but they become gradually closed up by the thickening of the lung tissue, which becomes leathery and inelastic. The animal dies of asphyxia.

Symptoms.—There is no constitutional disturbance observable in the early stages of the disease, except an occasional cough, which becomes more frequent, and the breathing more rapid, as the disease advances, until, in the latter stages, the poor beast stands with its ribs fixed, and flanks heaving, panting for breath, hence the Dutch name "*Jagziekte*" or driving sickness.

There is strong evidence that, under the climatic conditions in which it arises, it is infectious, but all artificial attempts to communicate the disease by cohabitation, or by inoculation, with the blood or inflammatory products, have failed.

Paralysis in Sheep caused by the Tick—Ixodes Pilosus

This tick paralysis is met with over a large area of the Cape Colony, and has been recognised by the sheep farmers for many years, and unanimously attributed by them to certain tick, which has been identified by Mr. Lounsbury as the *Ixodes pilosus.*

This paralysis is most prevalent during the cold winter months of May, June and July. It is met with most in the kloofs and valleys where the grass and other vegetation are longest. One tick appears capable of producing the paralysis, and a large number does not appear to intensify the attack. The tick attaches itself principally on the inside of the thighs, behind the elbows, and between the branches of the lower jaw. The tick is evidently the passive bearer of the infection only, as all ticks are not infective. Large numbers of the same species of tick may be found on sheep in flocks on adjoining farms where the disease dees not exist at the time.

In support of the opinion that the tick is the originating cause of the paralysis, if the affected flock is dipped in Cooper's sheep dip, which is an arsenical compound, the disease ceases almost immediately, and does not re-appear for some time, but the internal administration of the dip exercises no preventive effect. In like manner if the ticks are all removed from an affected sheep it makes a rapid recovery, whereas if the ticks are left on, the recovery is uncertain and very much retarded. Mr. Spreull failed to communicate the disease to healthy sheep by inoculation, nor has any definite micro-organism been found in the blood. It is not known whether one attack confers immunity, but young sheep are more susceptible than older ones. There is no perceptible rise of *temperature during the attack*, and the period of incubation is not known. The course of the disease is rapid ; from the time that the sheep is first observed to be affected, until it becomes paralysed, may be only six hours. When complete paralysis is established, the sheep will remain quiet, as if asleep for from twenty-four to forty-eight hours, after which the majority will recover, even if the ticks are not removed, if the sheep are placed in a shed and left undisturbed. But if no particular care is taken of them, a great proportion will die.

No definite or characteristic *post-mortem lesions* have been observed.

Acute Rheumatism—"Stijfziekte in Sheep."

This is an affection of the limbs which is very prevalent amongst sheep in the high and cold districts of the Cape Colony, during the winter months. It is characterised by acute inflammation of the sheaths of the tendons and capsular ligaments of the joints of all four limbs.

Cause.—It is attributed to the sheep having to walk long distances to the homestead in the evening, as the farms are large in the districts where it is most prevalent. The sheep arrive at the homestead warm, drink at the dam, and then lie down either in or around the kraal. At this time, about sunset, the temperature usually falls suddenly from 30° to 50° Fahr. every evening, for a great portion of the winter months. When the flock is examined the following morning, a considerable percentage will be found more or less stiff and lame, and the more acute cases unable to stand. The sheaths of the tendons are found tense and painful. If these are opened, the synovial fluid appears like a clear pale yellow jelly. In these very acute cases the sheep are unable to stand, and often die from the accompanying fever.

Prevention.—If farms were fenced, and water and shelter provided, at convenient centres, the driving home would be avoided.

Internal Animal Parasites.

Apart from the specific diseases which affect the different classes of domestic animals in this country, a very heavy loss is experienced annually from the prevalence of internal animal parasites. Every class of stock is more or less affected, but the principal losses occur amongst sheep, goats and ostriches ; it is almost the only cause of loss amongst the latter class of stock.

Ostriches become early infested from being hatched and reared on tainted ground. If the chicks could be reared on clean ground, and well cared for until they are a year old, the losses amongst this class of stock would be exceedingly small, as full grown ostriches do not appear to suffer from any special disease. if the food supply is sufficient, and suitable in quality.

The drinking water of stock, which consists mainly of rain water which has drained into dams from the surface of the tainted pasture, and the further contamination which takes place when the stock come to drink at these dams, is doubtless responsible for a great deal of this prevalence of parasitic diseases. I am of opinion that underground water should be provided, as far as possible, for stock, using the water obtained from surface drainage for irrigation. At any rate, where dams are used they should be fenced in, and the water led out into troughs for the stock to prevent pollution.

Poultry Diseases.

Poultry are comparatively easy to rear in the mild climate of South Africa, if infectious diseases are rigidly guarded against. But very severe losses occur if any of these diseases are temporized with and allowed to contaminate the fowl run.

Care is also required to keep poultry free from external and internal parasites, to which they are very subject. But one of the principal considerations is to keep the houses and runs clean, and completely free from putrid pools, open drains, or dirty puddles of any kind.

Apart from infectious diseases to which poultry are very liable in this country, such as Chicken Cholera, Septic Enteritis, Diphtheretic Roup, etc., Septicaemia, or Septic Intoxication, is the principal cause of the heavy mortality which occurs amongst poultry, and this is invariably due to want of care in keeping the runs clean and dry, and their food and water free from contamination.

Even for ducks, unless there is a running stream for them to swim in, where the water is always fresh and clean, no artificial pond should be provided; it is difficult to keep clean, and is rarely effected. It is much better to confine them to a regular supply of clean water to drink, renewed several times a day.

Dietetic Diseases.

Gallsickness, Bushsickness, Veldsickness, etc.

The disorders of the digestive organs of ruminants, commonly called by the farmers Gallsickness, Black-gallsickness, Bushsickness and Veldsickness, are very numerous, and very difficult to differentiate. The more common forms of digestive disorders, such as indigestion, congestion of the liver, gastro-intestinal irritation, and impaction of the stomachs and constipation of the bowels, occur all over the country in stall-fed, as well as in veld-fed animals, and are generally attributed to changes in the vegetation, overfeeding, and similar errors of diet. The treatment of this class of cases is comparatively simple when it is carried out early, and consists mainly in the administration of suitable purgatives. But in addition to these common disorders of the digestive organs, stock of all kinds are very liable to eat noxious and irritating plants, more especially when these are young and springing up with the fresh vegetation, and also when more wholesome food is scarce.

In a country in which the pasturage for farm stock consists almost wholly of the natural vegetation, it is only to be expected that, with the rich and varied flora which South Africa possesses, a great many plants which are liable to be eaten by animals, would be found to be inimical to health, while several others would prove directly poisonous.

There is a popular opinion that animals are gifted with certain instinctive perceptions which enable them to select the safe and nourishing plants, and avoid those that are dangerous. But this perceptive faculty must be largely due to hereditary and acquired experience. Because, it is an unfortunate fact, that, when travelling with stock through different districts of the country, or introducing stock for the first time into some locality which is entirely new to them, we find that a large number become ill and die, through eating some plant or plants that they were unaccustomed to. Take the several species of *Moraeæ* or "Cape Tulp" as an example. Stock that are bred and reared on farms where it grows luxuriantly, rarely eat it, or if they do, it must be in very small quantities, as they rarely suffer from its effects. But if you remove stock from veld which is free from it, to veld on which it is abundant, it is almost the first vegetation which they go for, the mortality being greatest within the first day or two.

It does happen, however, that stock that are accustomed to graze on veld where some of these noxious and irritating plants grow, are often tempted to eat them, (*a*) during a severe drought, when the other vegetation is scarce; and (*b*) when these plants come up green and fresh with the early vegetation that springs up after rain. A number of these noxious plants have already been convicted, by feeding experiments, of being the originating cause of some of those serious diseases of the digestive organs. But there are many more which require to be investigated.

The rapidly fatal effect which the different species of "Cape Tulp," *Moraea polystachya*, *M. polyanthos*, *M. collina* and *M. tenius*, have upon ruminants, more particularly cattle, has been known to transport riders for many years, and their opinion has been confirmed by feeding experiments, conducted by the Cape Veterinary Department.

When eaten in sufficient quantity, these species of *Moraeæ* produce acute gastro-enteritis, accompanied by great nervous prostration, the affected animals usually dying in a state of collapse.

If the animal lives for a day or two the inflammation usually involves the cystic and hepatic ducts of the liver. This gives rise to the secretion of a large admixture of mucous and other cellular elements along with the bile, which causes the latter often to present the appearance and consistency of Stockholm tar, which has given rise to the name "Black-gallsickness." But the colour of the bile may vary from a dark green to a dirty yellow.

"Slangkop," Ornithoglossum glaucum Sallisb.—This is another bulbous plant which is found over a large area of South Africa. When eaten by stock, it produces similar effects to those produced by "Tulp," more especially on sheep who eat it readily when young.

*Chailletia cymosa. Hk.**—This plant is a native of the Transvaal, and when eaten by cattle it produces its fatal effects very rapidly. Veterinary Lieut. Sawyer says :—

"In the majority of cases progress is rapid, often the first thing noticed is the animal halts, trembles for a few seconds and drops dead. In cases less severe the animal is tympanitic, lies down, groans with pain ; there is a green discharge from both nostrils, and symptoms of gastro-enteritis are present. On the veld the herd may be grazing, and all apparently well, when one or more will suddenly fall and die."

The *post mortem* appearances are :—The mucous membrane of all stomachs intensely inflamed ; there is also a catarrhal inflammatory condition of the intestines ; the other organs appear healthy. It is evident that the poison is absorbed during the primary process of digestion, as in some cases, the animal dies from coma, before the local lesions are sufficiently developed to cause death.

Nicotiana glauca or Wild Tobacco.—This plant is fatal to ostriches of all ages, both in the green and dry condition, but they are more liable to eat it when it is cut. Cattle are also reported to have died after eating a small quantity, but it is exceptional for them to eat it. It first causes excitement, then contraction of the voluntary muscles, followed by stupor and death by coma.

Stramonium or Stinkblaar.—The seeds and young growing plants of stramonium are very poisonous to young ostriches. Cattle also die after eating a certain quantity of the leaves or swallowing the seeds. There is first a delirious excitement, followed by a want of co-ordination of the muscles of locomotion, and death by coma.

Oleander.—Numerous instances are recorded of the poisoning of stock, principally horses and cattle, by eating the leaves of that well-known garden shrub *Nerium Oleander L.* Professor MacOwan says :—

"The active principal in the leaves resembles that of Digitalis, and re-acts directly upon the heart, stopping its action at the moment of expansion."

A very small quantity is sufficient to cause death. The symptoms exhibited by one horse twelve hours after having eaten a small quantity were :—He appeared dull and depressed, began to breathe heavily and his extremities became icy cold ; he suddenly dropped, and died without a struggle.

"Chincher-and-Ching" or "Chinkerinchee," Ornithogalum thyrsoides Jacq.—This well-known and popular flowering plant grows abundantly in moist lands and vleis over a large area of the Western district of Cape Colony.

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* Vide Cape Agricultural Journal, Vol. xix. p. 827.

It is very liable to get mixed with the oat-hay and other fodder which grows on such places, and when eaten by horses, along with the forage, it causes acute gastro-intestinal irritation and inflammation, accompanied by violent purging and great nervous depression. The animal becomes dull, stupid and insensible to outward influences, terminating in partial paralysis. A very few of the dried flower heads are sufficient to produce fatal results in from forty-eight to sixty hours.

Cynoctomum Capense or " Klimop."—This creeper grows plentifully in the Caledon and other of the South-Western districts of Cape Colony.

" It belongs to the family of the Asclepiadeae L.V. 2, which are all of a more or less poisonous nature."—(Professor MacOwan)

Cattle and sheep eat the plant readily when fed to them, and manifest the symptoms of nervous disturbance in from fifteen to thirty hours after. The losses of stock arising from eating this plant are often serious. The farmers call the complaint " Krampziekte." The first symptom is irregular movement, the animal is unable to stand quietly or to walk straight, but staggers like a drunken person. As the effects increase the animal falls down repeatedly, and on rising stands with hind legs spread out, or fore legs crossed. It frequently strikes the air with the latter convulsively. The cramps may appear first in the forelegs, or first in the hind legs, but the whole muscular system soon becomes affected, and the animal becomes completely paralysed.

The rapidity with which the symptoms develop, and their duration, depend upon the quantity of the plant eaten. In very severe cases, the animal suffers from violent tetanic spasms of almost the whole of the voluntary muscles of the body. Sheep suffer most severely from this form. The pulse increases to 110 and the breathing from 120 to 150 per minute. The temperature remains normal, although a slight rise is sometimes observed immediately before death.—(Henning.)

Horses do not eat the plant readily, but will do so when starved, and the plant is cut up and mixed with bran or other food. The first symptoms observed are those of abdominal pain, lying down and rolling, and exhibiting some difficulty in getting up. When standing the animal becomes restless, paws with its fore feet, and continuously twitches the muscles of the hind quarters. In one case observed one hind leg was trailed on the ground, and there was a loss of co-ordination of the hind limbs generally. The eyes were fixed and dull, and the animal appeared stupid. No fæces or urine passed, and food and water refused during first and second days' illness. The third day he fell down and had great difficulty in getting up. Same symptoms continued until fourth day, when he got one drachm of Calomel and five drachms of Aloes, and enemas of soap and water. On the following, fifth day, the bowels were acting freely, and the animal bright, eating freely, urinated and drank some water ; on the sixth day he was quite recovered.—(W. Robertson.)

Treatment.—The general treatment is to administer an active purgative immediately, combined with repeated doses of Chloral-hydrate or similar anodyne.

Vomeerziekte or Vomit Sickness of Sheep.

This peculiar disease is due to functional derangement of the stomach or of the nervous centre which regulates the spasmodic movements involved in the act of vomition. It is more or less prevalent in the western and north-western Karroo districts.

Cause.—It is generally attributed by the farmers to the action of the plant known as the "Vomeerboschje" (*Geigeria passerinoides*. This opinion has not been verified by feeding experiments. Quantities of the plant have been fed to heep with negative results.

The immediate cause of death, in the majority of cases, is Broncho-pneumonia, due to a certain portion of the vomit entering the larynx. The sheep, when vomiting and coughing, make an effort, at the same time, to re-swallow the vomit, and some of it enters the larynx.

The symptoms are greatly aggravated by driving the sick sheep, or allowing it to follow the flock.

Post Mortem.—There does not appear to be sufficient local congestion or inflammation of the mucous membrane of any of the stomachs, to account for the distressing symptoms.

Treatment.—This consists of rest, the administration of a sedative in combination with an alkali, followed by a dose of purgative medicine.

Paralysis of the Muscles of the Cheeks and Lips of Sheep. (Mest-bek.)

This is another peculiar affection which is met with in the same Karroo districts. It is paralysis of certain muscles of the face and cheeks which gives rise to a trickling of food from the mouth during mastication and rumination, principally during the latter.

If the muscles of one side only are affected, the food dribbles from that side. If the muscles of both sides are affected, the lips hang and the food dribbles from the front of the mouth.

Cause.—It is evidently due to the physiological action of some plant or plants which are eaten by the sheep at certain stages of their growth.

No anatomical lesion has been discovered, and the sheep recover if removed from the veld to a plot of lucerne, or fed artificially.

Melica dendroides or Dronk-Grass.—This grass is found in many parts of the Cape Colony. Cattle eat it readily, and very soon become giddy, semi-delirious, and lose control of the muscles of locomotion. If they are allowed to rest the symptoms gradually wear off. Experienced transport riders usually give the affected animals a large dose of brandy, which is said to relieve the symptoms at once. There are two or more varieties of this species which are said to produce similar effects.

GEILZIEKTE OR FULL-SICKNESS OF SHEEP.

This is an obscure disease which is observed over the whole of South Africa, principally in sheep. It is characterised by its sudden onset and rapid course. There is acute disturbance of the brain and nervous system; congestion of the venous circulation; and a tendency to the formation of gas in the rumen, followed by rapid *post mortem* decomposition.

Cause.—Several opinions are entertained with respect to the nature and cause of "Geilziekte," but the one most generally accepted is, that it is due to the direct action of a chemical poison which is produced in certain succulent plants by the action of the scorching heat of the sun. It is held that the succulent grass which springs up after a rain is quite wholesome, if it is eaten while it is green and fresh, but if it gets wilted and blanched by the scorching rays of the sun, it becomes poisonous and sheep eating it may die within a few hours from "Geilziekte."

Post mortem Appearances.—These are acute distention of the abdominal organs with gas, and a dark congested appearance of the whole of the tissues of the body, followed by rapid decomposition.

Preventive Measures.—These are removal of the flock to a change of pasture, if practicable, or dosing the whole flock with "Cooper's" sheep dipping powder, which is a compound of arsenic. It is very difficult to explain how this mixture acts, but it has thoroughly established its merits as a preventive amongst the sheep farmers.

In connection with Geilziekte, it is interesting to find that the recent researches by W. H. Dunstan and T. A. Henry, Imperial Institute Technical Reports, 1903, Part II., page 121, show that prussic acid is formed in "Kafir Corn"—*Sorghum vulgare*—in the early stages of its growth, but that the quantity becomes lessened as maturity approaches, until, with the ripening of the seed, it disappears entirely.

The authors state that:—"The symptoms of hoven" are not unlike those of prussic acid poisoning, and it is possible that the various leguminous fodders which are known to be particularly liable to produce these effects, may, at any rate in some cases prove like *Lotus arabicus* and *Sorghum vulgare* to furnish prussic acid." In support of this opinion, it is a curious fact that many of these diseases of stock which are attributed to the eating of poisonous plants suddenly cease, although there is no perceptible alteration in the vegetation, except that the plants comprising it are arriving at a more mature condition.

CEREBRO-SPINAL MENINGITIS OR "NENTA" IN GOATS.

This disease affects goats over a large area of the Karroo districts of the Cape Colony. It is characterised by congestion of the membranes of the brain and spinal cord, principally the latter, accompanied by irritability of the motor nerves, which is greatly increased by active movement of the muscles of locomotion.

Post mortem Appearances.—These are congestion of the membranes of the brain and spinal cord, accompanied by an effusion of a clear serous fluid into the sub-arachnoid space—most abundant about the base of the brain and under the medulla. In individual cases the cerebro-spinal membranes are highly congested throughout their whole extent, accompanied by complete paralysis.

Etiology.—It is evidently due to a certain plant or plants which the goats eat, and feeding experiments clearly point to the *Cotyledon nentricosa Burm.*, as being one which is capable of producing all the symptoms and *post mortem* lesions characteristic of this disease. Other plants are, however, suspected by some.

Symptoms.—In the early stages of the disease, the goat while at rest, or grazing leisurely, will scarcely indicate by its appearance, that there is anything seriously amiss with it, but upon being driven, it walks with its back slightly arched, the tail is held out straight in an upward direction with a quivering movement. These sypmtoms become aggravated as the goat proceeds, the head commences to dangle, and the muscles of the body to tremble. The goat walks with difficulty, and gives indications of great distress. The muscles of the limbs become painfully cramped, and the poor animal suddenly drops down completely exhausted. If allowed to rest for a few minutes, it will get up again, apparently refreshed, and will walk for another short distance, but only to repeat the same distressing symptoms. The appetite is not seriously affected until the animal becomes semi-comatose.

Treatment.—Remove affected goats from the flock at once, place them in a cool shaded place where they can have free access to water, and allow them complete rest. Give an active purgative followed by 1 drachm doses of chloral hydrate, repeated as may be required.

Cirrhosis of the Liver in Horses and Cattle.

Chronic inflammation and induration of the liver is very prevalent amongst horses which graze on the veld, more especially in the high sour grass veld districts of the country. It is rarely met with amongst horses that are exclusively stable-fed. It is much more prevalent on certain farms than others, even within the same district, and even on the same farm, it is observed that it is only when the horses are permitted to graze on certain portions of it that they contract this complaint.

This pointed to something in the veld, but its real cause remained obscure until recently, when our attention was directed to a similar disease amongst cattle in the Molteno district of Cape Colony. This led to Veterinary Surgeon Chase being stationed there to conduct an enquiry into its etiology. Just at this time our attention was directed to the recent reports of Mr. Gilruth, Principal Veterinary Surgeon to the New Zealand Government, in which is discussed a similar disease of cattle and horses attributed by the writer to the ingestion of "Ragwort" *Senecio jacobæa*. Acting upon this information, Mr. Chase had a careful search made over the veld of the affected farms for plants closely resembling *S. Jacobæa.* Two specimens were collected and submitted to Dr. MacOwan, Government Botanist, for identification, and he described them as *S. Burchellii* and *S. Isatidens.* Mr. Chase commenced feeding experiments with both these species at once, with the result that he clearly showed that, by feeding a quantity of the *S. Burchellii* to cattle they died, exhibiting all the characteristic symptoms manifested by those cattle which contracted the disease on the veld.

A similar result has been obtained by feeding this plant to horses; but in the artificially produced cases the progress of the disease was too rapid to produce the typical cirrhotic condition of the liver. Arrangements have since been made to test this point by the continuous administration of small doses of the plant to horses.

It is surprising that many horses remain apparently healthy, and work well long after their livers must have been in an advanced stage of Cirrhosis. Then suddenly the characteristic symptoms appear. The animal becomes sleepy, staggers in its walk, bores its head against the wall or similar obstruction. This is followed by delirium. The immediate cause of the development of these symptoms is the indigestion and engorged condition of the stomach. But cases of hepatic Cirrhosis in the horse invariably terminate in this manner. "Stomach Staggers" as it is called, may, however, arise from an engorged stomach, quite independent of hepatic Cirrhosis.

Osteo-Malacia or Stijfziekte and Lamziekte.

This is a disease which is characterised by a gradual softening of the bones of the skeleton, accompanied by a highly vascular condition of the articular extremities of the bones of the limbs, causing acute lameness, which is locally called "Stiffsickness." In other cases there is a highly congested condition of the vertebrae, which gives rise to an effusion of a clear serous fluid into the spinal canal, which leads to paralysis, most frequently of the hindquarters only; but in acute cases the whole of the spinal canal is affected when the paralysis is complete. This receives the local name of "Lamziekte," meaning limpness or loss of function.

Etiology.—It is a dietetic disease, due to a deficiency of phosphates or bone-forming salts in the vegetation. This is clearly indicated by the following facts :—

(*a*) The animals most subject to this disease are heifers with their first calves, then cows either in an advanced stage of pregnancy, or giving a full supply of milk, and young growing cattle of both sexes.

(*b*) Cattle which graze on veld where this disease prevails, manifest an intense craving for bones, and all kinds of animal matter. So intense is this craving at times that cattle have been observed to kill young lambs and eat them; while every vestige of the carcases of cattle that die are greedily eaten by the survivors. And (*c*) The artificial supply of broken bones, or bone meal, *in sufficient quantity* to the stock which graze on such veld, acts as an effective preventive. Similar beneficial results are obtained when the natural vegetation is supplemented by a liberal allowance of any cereal crop such as barley, oats, lucerne, etc.

Acute Paralysis and Death by Coma—Arising from Acute Indigestion and Congestion of the Liver.

Cattle, more particularly stall-fed cows, frequently suffer from paralysis, rapidly ending in Coma and death, unless prompt relief is obtained. It is generally understood to be due to the absorption of *ptomaines*, or similar products, which are formed in the mass of undigested food in the stomach. The principal causes are congestion of the liver, and acute indigestion.

This is clearly indicated by the success which invariably attends the following treatment when given in time. Give Calomel in from 1 to 2 drachms, depending on age and size of the animal, place it dry on the back of the tongue and wash it down with a little water. If the animal is already comatose, it is better to omit the water. As soon as consciousness is restored, or about ten hours after giving the Calomel, give a good dose of Epsom or Glauber Salts.

Cases similar to the above frequently occur in veld-fed cattle, more especially where "Stiffsickness" and "Lamsickness" prevails. It is, therefore, very probable that congestion of the liver, giving rise to indigestion, may act as the exciting cause, and produce a serious complication of these cases of so-called acute Lamziekte. Mr. Bowhill has recently found a pasturella in the blood and glands of similar cases, which he has met with in Lower Albany. The treatment indicated is a prompt and active purgative.

2. INSECT PESTS IN SOUTH AFRICA.

By Charles P. Lounsbury, B.Sc., F.E.S., Government Entomologist, Cape Colony.

Insect pests in South Africa are neither more numerous nor destructive than they are in other countries of warm temperate and sub-tropical climates. Indeed, were it possible to make comparisons with precision, it would probably be found that the losses occasioned by insects, other than animal parasites, are considerably less, relatively, in this sub-continent than in the countries of Europe and America and the older states of Australia. But, as is perhaps the case everywhere, there are few plants cultivated in South Africa that are not subject to the attack of one or more destructive insects; and in most instances the losses which these pests would inflict may, to a great extent, be avoided by intelligently applied preventive or remedial measures.

Government Entomologists.

Appreciation of the fact that most insect pests may be profitably combated has led the Governments of Cape Colony, Natal, Transvaal and Orange River Colony to attach economic entomologists to the staffs of their respective agricultural departments. These men are charged with the study of pestiferous insects, chiefly with the view of ascertaining the most practical means of preventing or checking their ravages, and with the task of disseminating such knowledge amongst those in need of it. They are known officially as "Government Entomologists," and have their headquarters at the seats of their respective Governments. The post of Government Entomologist at the Cape was created in 1895, of Natal in 1899, of the Transvaal in 1903, and of the Orange River Colony in 1904. The great area and the diversity of the climatic and other conditions affecting farm operations in the Cape Colony, and also the demand of orchardists of eastern districts for an entomologist to be located in their midst led, in 1904, to the appointment of a second Cape entomologist with headquarters at Graham's Town. This officer is known as the "Eastern Province Entomologist," and is responsible to the Government Entomologist at Cape Town.

Legislation to Prevent the Introduction and Dissemination of Insect Pests.

The South African government entomologists agree that they can be of inestimable service to their colonies by securing the enactment and intelligent enforcement of legislation restricting and regulating trade in living plants and plant products, and one and all have devoted, and are still devoting, much time and thought to this practical phase of modern economic entomology. Commerce has brought many serious pests, particularly such as may accompany living plants and fruits, from oversea, and many of these have spread far and wide without any serious effort having been made to retard them. The same statement is true in regard to almost every country; but the conditions in South Africa, much more than in most lands, justify drastic restrictions on plant imports and on the internal traffic in plants as a means of checking the importation of fresh pests and the further dissemination of those already introduced, or native ones, now restricted in occurrence. The country has sea connection only, and that through half-a-dozen ports at the most, with the rest of the civilised world. The oversea traffic in living plants is still small, and there is no reason why sufficient nursery stock of all descriptions cannot be grown within one or another of the colonies to meet every reasonable requirement. Of indigenous forest there is only a very limited area, and the government forest officers hope and believe that the wants of the subcontinent for wood and timber of most kinds will, in the not distant future, be met, chiefly from artificial plantings of introduced varieties of forest trees. To a large extent the success of the forestry operations depends upon the exclusion of the pests and diseases that afflict the trees in their habitats abroad; and to a less but still great extent the same is true of horticulture and viticulture.

The Cape has led the way in regulating the importation of plants. The regulations now in force prohibit the introduction of all coffee, eucalypt and coniferous plants, prohibit stone-fruit trees from certain countries, restrict the importation of grape vines to introductions by the Government, and confine the importations of all kinds of *trees*, except seedling stocks of certain fruit trees, to very limited numbers, imported for special reasons and under special authority. As a precaution against introducing scale insects, all woody plants on arrival are enclosed in an air-tight chamber and exposed to hydrocyanic acid gas for an hour, fumigating facilities for this purpose being provided at the principal ports. All plants and fruits are inspected, and are subjected to fumigation, or mayhap confiscation and destruction, if insects thought liable to become pests are discovered. Somewhat similar regulations have recently been adopted by Natal, the Transvaal, and Rhodesia, and the Orange River Colony is expected soon to follow the example. In the course of a few years the different entomologists expect to have practically uniform requirements applying to all the colonies.

Acts to regulate local and inter-Colonial traffic in nursery stock were recently passed in Natal and the Transvaal, and regulations affecting the plant produce of the other colonies were published within a few months by the Rhodesian Government. Attempt after attempt to secure nursery legislation has been made during the past ten years in the Cape Colony, but thus far conflicting interests and fears of racial discrimination have rendered the efforts futile. However, it is probable that in a few seasons all the British colonies will have adopted measures and a uniform procedure be in vogue relative to consignments from one colony to another. The general idea of the entomologists is to have systematic inspections of the nurseries by qualified entomologists, the despatch only of stock apparently free of pests and all diseases, and, as a precautionary measure, enforced fumigation of all stock shortly before shipment. The comparative value of nursery legislation is expected to prove far greater in South Africa than it would in Europe, America, or even Australia.

Locusts.

Locusts are the most important of the indigenous insect pests of South Africa. Every colony, British and foreign alike, and almost every district of every colony, is subject to visitation by migratory species. The better watered inland parts and a narrow strip along the eastern coast are most pested; while the south-western districts of the Cape Colony are very rarely visited. No swarms have reached Cape Town for about sixty years.

There are two leading species, *Pachytylus sulcicollis* (*capensis*) and *Acridium purpuriferum*. The former is closely allied to the common old world locust (*P. migratorius*). and the latter to the more destructive of the North African species (*A. peregrinum*). Both are known by many popular names, such as Old, Brown, Small or Karroo Locust for the Pachytylus, and New, Red, Large or Coast Locust for the Acridium; these names are all descriptive. The Pachytylus is a frequent visitant and seldom comes to the coast, whilst the Acridium is often absent for the space of a generation at a time, and is particularly partial to the sea-board when it comes to the southern colonies.

Little definite information has been recorded in regard to the permanent breeding grounds of either species, and there is room for much investigation to determine the factors which give rise to the immense devastating swarms that from time to time occur. Both species are able to live for a number of consecutive years in all the British colonies, but their numbers do not appear to increase to any great extent in any settled section after the first season. For years at a time neither species is found in swarms in the lower colonies, and they are commonly supposed to be wholly absent. The vast Kalihari Desert and the region northwards to and beyond Lake N'gami are looked upon as the natural home of the insects, and as the country in which the invading swarms are hatched. The great clouds of the Pachytylus that enter the southern colonies certainly come from the direction of the Kalihari, and in 1895 immense swarms of the Acridium entered northern Cape Colony from that side. From the behaviour of the latter species in the colonies, it is probable that its permanent home is in better watered and better wooded country than that of the former, since it is partial to trees and fails to remain in the dry districts; hence the invading swarms of this species may come from beyond the desert. Swarms were reported about Lake N'gami two or three years before any came over the northern border of the Cape.

The Pachytylus does not appear to have been absent from the Cape Colony since 1891. Several times it has been practically exterminated in one way or another in the more settled parts, only to become again a pest through new swarms from the northward; some of the new swarms may have come from the desert, but some of the more important that came down in 1904 appear to have originated south of the Cape boundary. The winged swarms generally appear from late summer to winter, and the eggs left by them hatch with the first spring rains; it often happens, however, that specimens in all stages of life are to be found in one locality. No general return movement of winged swarms is known to occur.

The Acridium has been established along a narrow strip of the coast from about Port Alfred eastward to Delagoa Bay and indefinitely beyond since 1893. Previous to that it had been seen in the colonies only by the oldest inhabitants. Swarms are said to have been in Natal about 1852, and others to have invaded the coastal districts westward to the Cape Peninsula early in the forties. In general the swarms of this species move south and west between November and March, and the eggs left begin to hatch early in the year. If there is any general return movement, as is recorded of the Algerian and Argentine allied species, it escapes observation. Numerous small swarms are known, on the other hand, to winter in the dense bush that here and there occurs near the coast. Late in 1895 immense swarms entered the Cape Colony from the north-west and north-east, and uniting in the south-east of the Colony turned westward through the southern districts along the coast. Vast numbers of the pest flew as far as Riversdale and a few reached Worcester.

Throughout the central and northern parts of the Cape Colony a belief is current that eggs of the Pachytylus locust may hatch after having remained in the ground for a number of years. And it is not uncommon to meet farmers who most positively assert that the occurrence has taken place to their personal knowledge. The occasional appearance of swarms of newly-hatched locusts in localities not known to have been visited by adult locusts for several successive years is the common basis for the belief. Sometimes the period through which the eggs have laid dormant is given as fourteen years or longer; and a few farmers claim to have actually observed that vast quantities of eggs were deposited by the last winged swarms, and that these failed to hatch in the intervening years. Amongst the explanations that have been offered for the non-development of the eggs is that the localities may have chanced to escape soaking rains during the long interval, or that shifting sand may have covered the eggs meanwhile to a depth sufficient to protect them from heat and moisture. It should be mentioned that the idea that the eggs may retain vitality for a period of years is not universally accepted by the farmers in the districts where the occurrence is said to have taken place, many of the most enlightened ones believing it entirely erroneous. The facts, however, that locust invasions of magnitude generally occur in good seasons following protracted droughts; and that the swarms commonly originate in sandy deserts which receive their scanty rains mostly in showers of more or less local occurrence, lend plausibility to the notion. It really seems incredible that a sufficient number of locusts can mature during a drought to give rise to the enormous swarms that sometimes appear on the wing a few months after good rains fall. On the other hand, granting that the eggs may retain their vitality through a drought, it may be imagined that the enemies of the pest die or are compelled to leave the region during the interval, and that the innumerable young locusts awakened to life by copious rains are thus permitted to develop unmolested; then that the resulting winged adults, urged by the migratory instinct to seek afar for food, swarm out of the deserts to the settled districts.

The natural checks of the South African migratory locusts have not as yet been comprehensively studied by anyone. A good compiled account of those that have been recognised is given by L. Sander in his *Die Wanderheuschrecken*; this work, published in Berlin in 1902, deals with the locust pest in all its various phases as regards the German South African colonies. The natural check of greatest interest, because it has attracted world-wide attention, is a fungus which Mr. George Massee, of the Royal Botanic Gardens, Kew, has named *Mucor exitiosus* (Kew Bulletin, 172-174, 1901). Public attention was first directed to the destruction of locusts by this fungus early in 1896 by Mr. A. W. Cooper, of Richmond, Natal. He took diseased locusts to the Colonial Bacteriological Institute at Graham's Town, and ever since cultures of the fungus with directions for the inoculation of swarms have been distributed by this institution. There is still reason to doubt, however, the economic value of the cultures. The fungus is naturally of widespread occurrence, and peculiar weather conditions appear essential for its rapid development. Locusts that had succumbed to it were received by the Cape Government from sections of the Colony hundreds of miles apart before any artificial cultures were made.

Natal is the only colony whose government has taken energetic steps to combat the locust pest. It has had legislation since 1895, and as the law now stands the Government can oblige all occupiers to destroy, or pay for the destruction of, all locusts that hatch on their lands. During the past year or two the campaign has been waged most vigorously. The young locusts only are fought, and the most popular measure is to spray them and the vegetation around them, whilst they are sleeping, with a sweetened solution of arsenic. The Transvaal has a Cyprus trained locust officer, under whose direction many large swarms have been destroyed by the screen and pit system. The Cape and the Orange River Colonies contemplate legislation, and a measure on the Natal lines would doubtless be of great value to the coastal districts. In the sparsely settled inland districts there would be grave difficulties in securing effective enforcement of a compulsory destruction Act, particularly as a section of the public in some parts is opposed to any action. In April, 1904, the Civil Commissioner of Britstown, Cape Colony, reported that at a meeting called to consider measures, fifty out of the eighty farmers present supported a motion that no steps be taken on the ground that the locusts were a visitation of the Almighty and that if efforts were made for their destruction a worse plague would follow. At present the Cape Government loans spray pumps to local "locust boards," and under certain conditions pays two-thirds of the cost of certain soaps and sheep dips purchased for spraying.

Fruit and Vine Insect Pests.

The foremost vine pest in South Africa is the notorious *Phylloxera vastatrix.* It is confined to the south-western district of the Cape Colony, the only portion of South Africa, however, in which viticulture is an industry of much importance. The presence of the insect was first discovered in 1885 at Mowbray, in the Cape Peninsula, but there is some reason to think that it was introduced ten or twelve years before with rooted vines from an English greenhouse. It spread very rapidly soon after its discovery, despite of strenuous efforts to check it, and at the present time it occurs in all the important vine districts of the south-west; few old vineyards now remain within fifty miles of Cape Town, except in the Constantia area, which only recently became generally infected. The vine-growers, Dutch and English alike, have grappled manfully with the problem of re-establishing their vineyards with European vines on resistant American stocks, and it is probable that the acreage in vines is now practically as great as ever.

Next to Phylloxera, the most important insect pest of the grapes vine are Otiorrhynchid beetles, known by the farmers as "calanders." The principal species is *Phlyctinus callosus.* The systematic trapping of this beetle in loose rolls of leaves is part of the routine work in Constantia vineyards.

The greatest of the fruit pests is the Fruit Fly (*Ceratitis capitata*), the disgusting maggots of which are often found in fruits which outwardly look perfect; but in respect to applies and pears, this relatively old pest is rapidly becoming eclipsed in the south-western and midland districts of the Cape by the Codling Moth (*Carpocapsa pomonella*), the great apple worm of most civilised countries. A second species of Fruit Fly (*C. cosyra*) is very injurious in Natal, as is also in some seasons a Tortricid, allied to the Codling Moth, which attacks citrous fruits. In the east of the Cape Colony and in Natal fruit-sucking moths are occasionally extremely destructive. There are a dozen or more species, the principal of which are *Sphingomorpha chlorea* and *Ophiuza lienardi.* The statement that these insects puncture perfectly sound fruit is often disputed, but is supported by competent observers. Almost all kinds of fruits are attacked, and the entire crops of large gardens are sometimes almost completely spoiled.

The Woolly Aphis (*Schizoneura lanigera*) is the worst pest of the apple tree, and is the only fruit tree aphis of much importance in commercial orchards. A black species of *Myzus*, however, is very troublesome to peach trees in some up-country gardens, and another black aphis is almost everywhere found on the young growth of citrous trees. The cosmopolitan Red Scale of citrous trees (*Chrysomphalus aurantii*) has spread into most districts, even having already become established in Rhodesia. At present it is the worst scale pest in South Africa. The Oleander Scale (*Aspidiotus hederae*) is widespread in all the colonies and in some parts is very injurious. The Purple Scale (*Lepidosaphes beckii*) is an important citrous tree scale on the coast of Natal and in a few Cape orchards. The White Peach Scale (*Aulacaspis pentagona*) has long been common as a pest in the coastal districts of the Cape. The notorious *Aspidiotus perniciosus* and *Lepidosaphes ulmi* are not known to occur anywhere in South Africa; both have been present on plants confiscated at ports of entry under the Import Regulations.

Few kinds of caterpillars plague the South African fruit-grower. The larva of *Papilio demoleus* is somewhat troublesome on young citrous trees in all sections. The larva of *Heliothis armiger* often damages young deciduous trees by eating the buds and young growth, and it occasionally eats holes into an immense quantity of green fruit. Altogether *H. armiger* is one of the most troublesome of all South African lepidoptera. It seems to occur as a severe pest in all of the colonies, though not so much to fruit as to mealies (*Zea mays*), peas, tomatoes and lucerne. The Pear Slug (*Eriocampoides limacina*) occurs for about a hundred miles inland from Cape Town, and where not controlled by insecticides often defoliates pear and plum trees.

Boring insects are not numerous in fruit trees, and the only species known to be of much importance is *Cossus tristis*; this caterpillar borer is in most of the south-western districts of the Cape Colony and is extremely injurious to quince trees and some varieties of apple. A species of *Tetranychus*, known as the Red Spider, prevents extensive cultivation of the so-called Cape Gooseberry (*Physalis peruviana*) in the south-western fruit districts; and *Bryobia pratensis*, another mite, does considerable damage some seasons to pear and plum trees in a number of inland valleys.

Miscellaneous Insect Pests.

Termites or white ants of one species or another are more or less troublesome in all of the colonies. In the northern colonies and in parts of Natal several species of *Termes* make themselves most objectionable by their habit of tunneling the woodwork of buildings, and also by their girdling the bark of most sorts of young trees. The only Termite which seems of much importance in the Cape Colony is *Hodotermes havilandi*, a kind which makes no hill and which works in daylight. It is restricted to certain classes of soil. A variety of plants, including grains and vines, are attacked by it.

It cuts slender parts such as leaf petioles and grass stems into short lengths and carries these to its underground burrows. From its method of work it is called houtkapper (wood-chopper). Arsenic in and about the entrances to its burrows is very successfully used for its destruction.

The insect pests of growing grain have been little studied. The most important, perhaps, are *Sesamia fusca*, a lepidopteron that tunnels the stalks and cobs of *Zea mays*, various species of cutworms, certain aphides, several species of plant bugs (*Lygaeidae*), a ladybird (*Epilachna similis*) and a root-feeding Scarabaeid, *Heteronychus arator*. All of these are widely distributed. To some extent the planting season is modified in a few sections to minimise the attack of the *Sesamia* and cutworms, but in general control measures for grain insects are not practised. The larva of *Colias electra*, a native butterfly, is the worst lucerne pest, and to save crops premature cutting is sometimes necessary.

The pests of stored grain are those familiar in almost all countries. The most destructive is *Calandra oryza*. In the Transkei many traders store their grain in cylindrical tanks of galvanised iron as a means of averting injury by granary insects. The tanks are kept practically airtight and the contents quite dry, and when these conditions are fulfilled the grain is said to remain sound indefinitely; a lighted candle is sometimes placed in the tank before the cover is fastened down with the idea of exhausting the air. The Mediterranean Flour Moth (*Ephestia kuhniella*) has been in the Cape Colony for upwards of fifteen years.

The worst potato insect pest is *Gelechia operculella* (*Lita solanella*). It occurs in all the colonies, including Rhodesia. The nematode *Heterodera radicicola* is also frequently reported to have damaged tubers and is widely distributed. *Epilachna dregei* has been said to give considerable trouble in Rhodesia. Crucifers seem to be more molested by insects than vegetables of other kinds. *Plutella cruciferarum*, *Aphis brassicae*, and several species of flea beetles are all destructive; but the insect most complained of is a small Pentatomid (*Bagrada hilaris*), which at irregular intervals abounds in all the colonies, and after a few seasons of remarkable abundance disappears as suddenly as it came. The Transvaal Government Entomologist has proposed to introduce a parasite that affects an allied plant bug in America. Several species of Mylabrid beetles are a great nuisance in gardens, particularly in inland districts. Cucurbs suffer severely in some parts from a phytophagous ladybird (*Epilachna chrysomelina*), and a large Pentatomid (*Aspongopus viduatus*). Whole crops of the fruits are sometimes destroyed by Trypetid flies distinct from the species found in the tree fruits; the maggots work in the pulp and cause decay.

One of the worst pests to indigenous forage plants is *Loxostege frustalis*, a Pyralid which defoliates the Karroo bush (*Pentzia virgata*) from time to time over an immense area. The native Thorn Tree (*Acacia horrida*) bears a wonderful variety of insect life, many forms of which spread to introduced plants and trees. Amongst such insects is *Antheraea tyrrhea*, a large Saturniid, the black-and-white caterpillar of which frequently does serious injury to wattle (*Acacia decurrens*) plantations in the east of the Cape Colony, and which is often a subject of complaint because of its defoliating various kinds of trees in the south-western districts. A Psychid bag-worm, which the Natal Entomologist gives as *Animula sp.*, is another Thorn Tree insect which sometimes afflicts wattles severely. Plantations of pines, both east and west in the Cape Colony, occasionally suffer partial defoliation by the large and handsome caterpillar of *Antheraea cytherea*. One of the most recent plantation pests is *Phylloxera corticalis*, a European bark louse of the oak which within a few years has become established in oak plantations in the south and east of the Cape Colony and in the south of the Transvaal; so serious were the injuries it inflicted two years ago that Cape forest officers questioned the advisability of extending their plantings of oak.

An insect pest of quite another sort is *Sitodrepa panicea*. This tiny beetle and its larva have caused much loss to dealers in boots and shoes in the towns near the coast, and have riddled the bindings of great numbers of stored volumes of official records. The paste employed in the manufacture of the boots and in the attachment of book bindings is the attraction for the insect. As a rule importers now require that any paste used in the preparation of leather goods for them be effectively poisoned; and on the recommendation of the writer the paste used by the Government bookbinder is poisoned with zinc chloride.

Beneficial Insects.

An important feature of recent economic entomology in several countries has been the introduction of parasites and predaceous insects to check insect pests. The fact is now generally recognised that many of the most injurious insects are introductions which chance to have become separated from natural checks that in the country of their origin sufficed to prevent their undue multiplication; and there have been a few highly successful instances of the suppression of pests by the restoration of a natural enemy. South Africa shared in the benefits of the discovery of the ladybird check on the so-called Dorthesia (*Icerya purchasi*). The Dorthesia was observed in Cape Town in 1873, and is thought to have come on plants from Australia. It thrived wonderfully well, and within five years was a severe garden pest throughout the town and suburbs. By 1885 it occurred almost all over the Colony. A wide variety of plants was infested; orange and other citrous trees, and the blackwood (*Acacia melanoxylon*) throughout the south-western districts were so severely injured that they were cut down on nearly every estate. Meanwhile, the pest had made its appearance in California, and was causing immense losses amongst orange growers. Then in 1888 American entomologists were sent to

Australia to search for natural checks. The Vedalia (*Novius cardinalis*) was soon discovered, and when introduced into California this tiny creature increased with amazing rapidity at the expense of the pest, and within two years completely suppressed it. Attempts to introduce the Vedalia to South Africa by mail failed, and late in 1891 a special commissioner was sent to California by the Cape Government to procure it. This man succeeded, and the pest was as speedily suppressed in South Africa as in California. Both the ladybird and its prey are now to be found throughout the colonies, but so scarce have they become that they are seldom observed when not specially searched for.

Stimulated by the magnificent result of the introduction of the Vedalia, the Cape Government has made many attempts to introduce and establish other exotic ladybirds in the hope of securing some relief from several destructive scale insects and aphides. Many species have been introduced from Australia and the United States, and have been liberated in large numbers under circumstances apparently favourable for their welfare; but only two species, *Orcus australasiae* and *Cryptolaemus montrouzieri*, are known to have survived their first winter. The *Orcus*, introduced in 1896, was found in small numbers for three years and then is thought to have completely disappeared. The *Cryptolaemus*, introduced in 1900, has failed to become established in the western part of the Colony, but is thought to be slowly multiplying at King William's Town; it feeds on mealy bugs (*Dactylopius*) and their close allies. The most notable failure was with *Hippodamia convergens*, which was introduced from California in the hope of its proving of value against the Woolly Aphis of apples trees. Hundreds of thousands of this ladybird were liberated, but, though there was no scarcity of food for it, the species failed to establish itself, and disappeared entirely after one generation.

When this work goes to press, the Natal Government Entomologist and the writer will have proceeded to Brazil to secure parasites of the Fruit Fly (*Ceratitis capitata*), found to exist in that country some months ago by an American entomologist employed by the West Australian Government. The expenses will be borne by the Cape, Natal and Orange River Colony Governments. If the insects desired are successfully established, and prove as efficient as the West Australian Entomologist claims them to be in Brazil, South Africa will soon be relieved of its worst fruit pest.

The Cape has offset its obligation to California for the Vedalia by supplying to that State the Chalcid wasp (*Scutellista cyanea*). This tiny parasite was found by the writer to be the principal of several species which suffice to keep the Black Scale (*Saissetia oleae*) so well suppressed in South Africa that it nowhere in the country figures as a pest. In California the same scale was, before the advent of the parasite, the worst orchard scale pest; now it is being rapidly suppressed, and, next to the Vedalia, the *Scutellista* is regarded as the most important insect check introduced into the State.

Insect Parasites of Animals.

South Africa is rich in pestiferous insect parasites of animals; and here the term insect is intended in its broadest sense. Scab (*Psoroptes ovis*) in sheep has long been a plague, and all of the colonies have legal enactments with a view to its control. The Cape has attempted most, and for the last ten years has annually expended from £50,000 to £70,000 in a vain effort to exterminate it. The apathy and ignorance of a section of the flock owners, the scarcity of water in some parts, the unfenced condition of most of the farms, the common necessity of moving the animals in times of drought, and the practice of kraaling at night to avoid the depredations of jackals, have all contributed to making extermination a problem of great difficulty. The present Act is considered faulty, and it is probable that important alterations and amendments to it will be made by Parliament.

Hippoboscid flies of many species are found. One, *Hippobosca rufipes*, occurs in all the colonies and in some parts is very annoying to horses. Dr. A. Theiler, the Transvaal Veterinary Bacteriologist, has evidence that it transmits a *Trypanosoma* of cattle. One species is associated with pigeons, and is thought likely to communicate a blood parasite to which pigeons appear very subject in South Africa. Another species pesters dogs in the north of the Cape Colony, the Transvaal and Rhodesia. Still another, *H. struthionis*, infests the ostrich and leads to serious deterioration of the feathers. The wingless *Melophagus ovinus* is known in the Cape Colony and Natal. The notorious Tsetse Fly (*Glossina morsitans*) is not found in any of the southern colonies, and is now very limited in its distribution in the Transvaal and Rhodesia. The investigations of Lieutenant-Colonel David Bruce, F.R.S., which resulted in the discovery that the fatalities attributed to the bite of the fly were due to infection by a *Trypanosoma* blood parasite communicated incidental to the bite, were conducted in Zululand in 1895. Bots in horses are practically ubiquitous. Warbles in cattle are rarely reported, but specimens of undetermined species are occasionally reported in game. Black flies (*Simulium*) do not appear to be known as a stock pest, but one or more species affect poultry to a slight extent.

Mosquitos have not had the degree of attention by South African entomologists that their probable importance renders desirable; the Transvaal Entomologist, however, is now devoting considerable time to them. They are not really abundant in many parts owing to the conditions of climate and the good natural drainage that prevails; but in some towns through neglect of simple preventive measures they are a source of much annoyance; and they are numerous enough in extensive areas to serve as disease transmitters. Malaria is not known to be endemic anywhere in the Cape Colony. In Rhodesia, and in the low veld of the Transvaal, and in the German and Portuguese possessions it is extremely common; these parts have frequent summer rains, and much greater heat than the Cape. Horsesickness, the terribly fatal equine malady for which

South Africa has long been known, is supposed to be communicated by a mosquito. This theory has been persistently advocated by Dr. H. Watkins Pitchford, the Natal Government Bacteriologist; and experiments by him, reported in the Natal *Agricultural Journal* during the last two years, have furnished weighty circumstantial evidence favourable to the idea. Malarial fever in sheep, a widespread but not very fatal disease, occurs under the same conditions of season and pasturage as horse sickness, and in some other particulars behaves in so similar a manner that it is presumably communicated by a similar agent.

Ticks (*Ixodidae*) are everywhere present; and in most high bush country, particularly near the coast in parts receiving summer rains, are a plague to stock. Many, if not all, kinds of game, some birds, snakes and tortoises, as well as all domestic animals, including ostriches, are subject to infestation. Twenty distinct species are recognised on stock, and most of these are peculiar to the country. The "punaise de Miana," *Argas persicus*, infamous as a cause of sickness to travellers in parts of Persia, is common throughout the colonies as a parasite of domestic fowls. It attacks its hosts at night; and in the long intervals between its visits remains hidden in crevices of the walls of the houses, under the bark of trees, or in other good shelter. The much larger *Onithodoros savignyi* var. *caecus* is well known by the natives in Rhodesia, in parts of the Transvaal and in north-western districts of the Cape, and also in German South-West Africa. It is popularly known as the Tampan or Sampan, and its attack it said to be much dreaded by the natives of some sections. Livingstone. in his *Travels in South Africa* (p. 383), states that its bite is followed by vomiting and purging, and the same story has been told the writer by natives. I have had specimens fed on several persons, and in only two cases did any disturbance of the health follow; it may be that a specific disease is sometimes communicated.

The South African ticks of farm stock have for several years been the subject of special study by the writer because of their economic importance. Results have been published from time to time since 1898 in annual reports and in the pages of the Cape *Agricultural Journal*. The life cycles of a number of species have been traced, and several species have been determined experimentally to be the communicating agents of specific diseases. One feature of interest ascertained is that, whilst some species remain on the host during their metamorphoses from larva to nymph and from nymph to adult, other kinds leave for the second moulting, and most kinds for both moultings; thus species may have one, two, or three hosts during the life cycle. *Hyalomma aegyptium*, known in its adult stage as a particularly vicious parasite of large and small farm stock, appears to avoid such animals in its early stages, and to then attack various birds and rodents. *Amblyomma marmoreum*, which seems practically confined to snakes and tortoises when adult, has been found to feed freely as larva and nymph on goats and cattle, and the larva has been taken from birds.

The Bont Tick (*Amblyomma hebraeum*), long suspected by a few farmers to be associated with the serious disease of sheep known as heartwater, was demonstrated in 1900 to communicate this disease to susceptible animals in the nymph or adult stage of its existence if in a previous stage it had fed on diseased animals. More recent experiments have shown that the infection may be communicated from goats, sheep, or cattle to goats, sheep, or cattle indifferently. Infection from a given source may be transmitted within a month, or, through the failure of the tick to secure a host meanwhile, may not be communicated for upwards of six months. If the tick is not subjected to a considerable degree of warmth during its metamorphosis or whilst it is later awaiting a host it fails to prove pathogenic.

Malignant jaundice or Piroplasmosis of the dog was discovered in 1901 to be communicated by *Haemaphysalis leachi*, the common dog tick in South Africa. In the case of this disease, it was found that the infection was taken up from sick or recovered dogs by the adult tick of one generation and communicated to susceptible dogs by the adult of the following generation.

African coast fever, the latest cattle scourge of South Africa, was determined in 1902 to be communicated by *Rhipicephalus appendiculatus*, a rather common tick which leaves the host for both its moults. Recent experiments have shown that the infection is taken up by one stage and communicated by a later stage in the same life cycle. The Transvaal Bacteriologist, Dr. A. Theiler, has by a single case of the disease shown that *R. simus* may also serve as the carrier of the infection. The details of the experiment, with the details of numerous tests which affirm that the first mentioned species is pathogenic, are given in the Transvaal *Agricultural Journal* for October, 1904.

At the present time the problem of tick suppression is receiving much attention in most sections of the British colonies where ticks are a pest and where the diseases they communicate are known or dreaded. The leading remedial measure coming into vogue is the dipping of the large stock on the farms in a liquid containing arsenic in solution; this results in the death of most of the ticks within a few days. Long, deep tanks of cement or faced with cement are used to contain the poison, and very little difficulty is experienced in making cattle and horses enter them. It is found safe to dip range cattle once a fortnight in a preparation containing three-tenths per cent. of arsenic, and few ticks are able to mature on animals thus treated. The veterinary departments of the various colonies are doing much to encourage the movement; and during the past year the Governments of the Cape Colony and Natal have expended some thousands of pounds sterling in contributions to bodies of farmers towards the cost of dipping tanks. It is quite probable that millions of pounds sterling will be added during the next decade to the farming value of land in South Africa simply through the improvements effected, or seen to be practicable, by systematically dipping cattle to destroy ticks.

3. AGRICULTURAL PROBLEMS AT THE CAPE OF GOOD HOPE

By Eric A. Nobbs, Ph.D., B.Sc., F.H.A.S.,
Agricultural Assistant to the Government of Cape Colony.

The Cape of Good Hope, as all who come to it soon discover, is, before all things, an agricultural country. And Agriculture, the first of the Arts, is the last of the Sciences to have received the honour of recognition as a separate section of the British Association. The hope may, perhaps, then be expressed that in favouring the Cape with a visit that august body will pay special attention to our leading industry and to its own most recent branch. It is not intended in what follows to attempt an exposition of colonial agriculture, but it is hoped that, by bringing to the notice of scientists from beyond the seas some of the difficulties under which we labour here, they may be willing out of their wider knowledge to help us to the solution of some of our problems. The more specialised enquiries of purely scientific interest or with only indirect bearing upon agricultural practice are, as yet, quite beyond the range of our consideration. Our pressing need is still the pioneer work of studying strange conditions, of finding new and profitable uses for our energies and our land.

In spite of its oft-times forbidding aspect the agricultural prospects of Cape Colony are bright, and the future is one of promise. In the face of all possible ills, war, pestilence drought, flood, rust, locusts and a depressed phase of commerce, the country at present supports in comfort a contented people, whose chief demands are for such meritorious objects as new roads and railways, for irrigation works, and generally for facilities to enable them to grow more produce and to secure an outlet for it. Above all, there is an urgent need, fully realised, for more enlightenment in regard to the application of the discoveries of science to agricultural practice which, it is seen, has done so much for other countries, enabling them even to compete with us at an advantage in our own land. Agriculture is by nature in close touch with many other branches of science, and seeks to benefit from each. Its aims are many, but underlying all is the one great problem—that of furnishing to the people the necessaries of life. Compared to the study of the pure sciences or the fine arts, its intentions may be low and humble; it is, however, none the less vital to humanity.

The conditions of soil and climate to which the stranger is introduced on arrival at the Cape are remarkable for their extraordinary contradictions—the tantalising inconsistency which at first sight perplexes and confuses, and is apt to give an altogether false idea of the country and its capabilities. First impressions are proverbially difficult to eradicate, and it must at the outset be admitted that in fertility of soil and extent of land capable of yielding crops the Cape of Good Hope cannot pretend to rival other more favoured parts of the British Empire. Yet the Colony has possibilities all its own, and offers a fair field for profitable agricultural enterprise to those who will study her resources and adapt themselves to her requirements.

It is an old observation that at the Cape all those factors which combined are known as the natural conditions of a country, are usually found in favourable combination save some one essential, and that through such omission wide tracts of otherwise productive land are rendered sterile and of insignificant value. So far, this is unfortunately true; the Karroo lacks only rain, while the soils of our well-watered south coast are sour and deficient in the chemical elements of fertility. While this must be regretfully admitted, it may here be remarked that these are drawbacks which can to a certain extent be combatted by man's industry, and that already much has been done in this direction; astonishing supplies of water have been found in arid regions, while artificial manures are proving what even poor soils can be made to produce when otherwise suitable for cultivation. The barren and uncultivated appearance of our country is more apparent than real, and the Colony should not be condemned, as it so often is, after a mere superficial glance at certain of the least favoured portions. Indeed, it may be said without fear of contradiction, that, as compared with more advanced colonies, while the Cape offers greater difficulties to the immigrant at the outset, yet the rewards to be gained by intelligent application and skill are also larger; that while the initial hardships to be overcome and the risks are great, the number of those who attain to comparative wealth through farming is also more considerable than elsewhere.

A feature particularly noticed by the casual visitor is our waterless rivers, and many jibes are thrown at the country on that account It is, indeed, a regrettable characteristic, and one that has given food for thought to many. Dry water courses will probably ever be found in our wide plains of the north and west, which are only occasionally blessed with rain, though then in torrential form. But transient critics seldom penetrate to where our perennial streams, taking their rise amongst the mountains, flow down through fern-carpetted forests to fertile kloofs, in which the waters are made use of for the growth of all manner of crops and fruits. Nor do those strangers know our rich alluvial islands fringed with willow, and covered by a dense and matted jungle, periodically enriched by the red mud from distant plains. These islands, under cultivation, produce crops such as no other soil or country can surpass, and but few can match.

It is another curious irony that much of our finest grazing veld is ruined by the presence of the germs of certain well-known stock diseases, but there is consolation in the remembrance that some of our most successful achievements in the past, as well as the burning questions of to-day, are connected with the prevention and cure of these ailments. Apart from the deeply interesting veterinary aspects of this question, the effect that this menace to all live stock exerts upon the methods of farming makes it a vital question to the agricultural industry. Lack of manure prevents the cultivation of many crops which would otherwise be remunerative. The discovery of preventive measures or specific remedies will at once give opportunities which will revolutionise the farming methods of wide districts, and materially enhance the productive capacity of the Colony.

Another unfortunate anomaly is that much of our most productive land lies so remote and inaccessible that its natural advantages are more than counteracted by the cost of production and transport. Our trunk lines to the north pass consistently through our least fertile areas, and only now is a network being developed to tap the agricultural portions of the Colony. Our mountain chains are full of valleys of most marvellous richness; soils of superlative quality, but of very restricted extent, are to be found in some of the most remote corners of the back-veld; in our semi-desert of the north west there are wheat lands of the greatest fertility, but scantily cultivated on account of the thin population surrounding them; in the Transkei there are to be found regions full of the greatest possibilities, only awaiting an outlet or the establishment of markets in their own vicinity. In due time, possibly quite soon, the economic situation may change.

In the immediate neighbourhood of our larger towns, especially the coast ports and Kimberley, are some of our least fertile soils, but the artificial advantages of situation more than compensate them for such deficiencies, and very profitable farming is followed in these areas.

Given, as is the case at the Cape, a number of rivers draining a large inland plain, the soil of which is characteristically rich, one would expect to find along their banks large tracts of sedimentary deposits admirably adapted for irrigation, with rich alluvial deltas at the mouths. Such is not, however, our good fortune at the Cape. Geologists explain that the rivers of the south coast have cut their way across the series of synclines and anticlines that form the crumpled edge of the continent, forming gorges and ravines. Only in a few exceptional cases—as in the Breede River, the Gamtoos and the Sundays River Valleys—do our rivers get an opportunity of spreading out and depositing their silt before falling into the sea. But these exceptional cases have given us some of the best lands we have, and they are of wonderful fertility.

In the Karroo, which occupies one quarter to one third of the total area of the Colony, fields or gardens, though rare, yield phenomenal crops as far as the limited water supply will let them, proving the great potentialities of these regions, if the existing subterranean waters can be successfully tapped. By the irony of fate, in many instances where underground water has been found, particularly in certain formations, it has proved valueless, quite brack and occasionally poisonous.

One of the first facts which must strike the traveller passing through the Cape Colony is that by far the greater part of the country is essentially pastoral, and that though altered from its pristine condition by burning and grazing, it must of necessity always remain chiefly a stock country. Perhaps it is not altogether a misfortune, at least, for the next few generations that this is so, since it renders more valuable the land that can come under the plough. It is not as in England, where for miles the arable lands continue in unbroken succession of fenced-in fields and meadows. Even in our more highly-cultivated grain-growing districts, the "lands"—that is, the cultivated fields—only occupy a fraction of the whole farm, and the impression given is that of patches of cultivation surrounded by leagues of untilled land. Under irrigation the scene is somewhat different, the more valuable crops grown and the limited extent of such favoured areas have led to continuous cultivation and a most highly intensive system of agriculture.

A specially-marked feature of the Cape Colony is that it has been divided by natural agencies into a number of distinct areas, each uniform throughout its extent, but very clearly differentiated from adjoining districts. The methods in vogue vary little throughout any particular zone, and we have regions almost exclusively devoted to one special branch of farming, or noted for one particular product, such as grain, fruit and vines, pineapples, ostriches, angora goats or merino sheep. The boundaries, too, of these areas are frequently quite sharply defined. The conformation of the country, the successive sudden changes of altitude, the clearly-defined range of winter and summer rainfall, and other climatic influences, account sufficiently for this phenomenon. It is this fact that renders it unwise to attempt any generalisation with regard to agriculture at the Cape, and which has brought so much contumely upon those who attempt to make sweeping assertions on the subject.

Over and above the natural conditions influencing agriculture at the Cape, a number of economic factors are at work, to which attention must for a moment be drawn. The population of the Colony is but limited, the local demand restricted, and still suffering from the commercial disorganisation consequent on the war. Cultivation of every kind, except in a few favoured areas, was at a standstill for three years, while the requisites for production, the labour, draught animals, wagons, and so on, were otherwise employed. During those years, and the subsequent seasons of drought foreign trade has obtained a secure footing and become so highly developed and so firmly established that now our own products compete at a disadvantage with those from oversea. Surplus military and naval stores, disposed of at nominal prices after the close of the war, further materially assisted in paralysing local efforts at production. This artificial and abnormal state of affairs is not in the interests of the community at the Cape, of which by far the major portion is dependent upon the agricultural prosperity of the country.

The products of our land are required primarily for the immediate use of the rural population, including the consumption of the villages, next for the larger centres, the ports, the Rand and Kimberley, and finally for export. Farm consumption is placed first, since to this day the ideal of a very large number of our farmers is to supply their own needs, only producing for market sufficient to enable them to purchase such necessaries as cannot be grown at home. The nearest dorp usually takes dairy produce, fruit and vegetables, but one wagon-load of produce is apt to glut these limited markets. The great consuming centres are our larger towns where Cape produce meets the competition of Europe, Australia and the Argentine. The reliable quality and steady supply of the latter products have completely captured the markets and "colonial grown" does not to-day stand, as it readily might do, for the acme of perfection, but rather the reverse.

At the ports colonial produce carried overland is in competition with sea-brought foodstuffs. When taken up-country both are heavily burdened by railway rates. Colonial-grown supplies have certain advantages granted over the foreign article, but in practice not sufficient to enable them to compete against the better organisation of the import trade. This is particularly disconcerting in view of the fact that it is to a great extent the same sort of produce which we can ourselves grow—mealies, lucerne, forage, flour, beans, jams, raisins, dried fruits, eggs, poultry and fresh meat. It will be one of the great tasks of the next few years to win back for the Cape her proper place in her own markets. The export trade offers great scope for profitable development. Much has already been done, and our trade in wool, mohair, feathers and fruit is known the world over. Fruit exportation is the youngest; but is a rapidly-growing business, and is capable of very great development.

The conditions of labour in the Colony have had a very material effect upon the present state of agriculture. Practically all the unskilled and much artisan labour is supplied by natives, who provide also for the mines, and during the war worked for the Army. Although plentiful, the demand for labour was for some years so great, and the natural inclination for work so small that wages rose to a figure altogether prohibitive for agriculture, and the farmer suffered accordingly. Happily now matters are returning to their normal condition, and agricultural labour is again fairly plentiful.

At different times in our history efforts have been made to introduce a class of white agricultural labourers, but all attempts have failed or ended disastrously, and it is unlikely that such efforts can ever succeed, as we are not in a position to offer the same inducements to this class of settlers that other new countries are able to do.

The tenure of land has certain features of special interest. The desire to own large farms amounts to a passion, to possess the land as far as one can see in every direction, and if possible to build a home out of sight of any other human habitation; these are sentiments frequently encountered. The landlord leasing portions of his property is uncommon, although signs are not wanting of such arrangements coming into vogue in the more advanced and highly-cultivated districts, and it is a system altogether to be welcomed. Tenants ("bijwoners") working on the share system are, however, often met with, the owners usually furnishing, besides land, draught animals, implements, seed and manure, the tenant giving only the labour.

Some farms are in the hands of families, all being joint heirs and owning a portion. Such undivided farms are seldom well run, and the complications, especially where water rights exist and irrigation is practised, are confusing in the extreme and apt to lead to much friction and trouble.

As a rule it may be said that of the total amount invested by our farmers, an undue proportion takes the form of land, with a corresponding deficiency of buildings, implements, machinery and livestock. This distribution of capital prevents the fullest use being made of the soil, whether on pastoral or arable farms. The drawback is, however, fast disappearing, and at the present time there is a marked tendency to increase the other forms of capital by the investment of profits on the land in the shape of dams and irrigation works, fences and other permanent improvements. The number of stock in this country is also rapidly recovering from the devastations of rinderpest and the war. In this way the balance is being approached, and is hastened by the return of land values to a more normal level, after a period of undue inflation following on the war.

Having now briefly discussed certain of the natural and social conditions affecting the agricultural situation at the Cape, let us turn to some of the difficulties which the Cape farmer has to combat to-day. It is his daily work to face them, and it is in overcoming them that success is to be achieved and wealth attained. These problems, like the conditions of which they are the outcome, may be grouped in two classes—those due to natural phenomena, which are in their origin practical or rather technical, and those arising from social or economic causes, and which tend to raise political issues.

The soils of the Cape Colony, like those of any country of such great size, are not of constant character, and within its boundaries all manner of soil is to be met with. A striking peculiarity of this country, already alluded to, is the well-defined zones into which it can be divided. The loess-like red and grey loams of the Karroo, the red sands of Kimberley, the pale gravelly clays of the south-west, and the humus sands of the south coast, are all well known and widely distributed types of soil. There are many other equally distinct sorts. In the past as occasion served, samples of soil have been examined by the Analytical Department, and all analyses have been carefully recorded. The data so collected are necessarily incomplete and irregular, but will serve as a nucleus round which to build up a systematic survey of the soils of the Colony. This is a pressing need as the information so acquired would serve as the starting point for many other enquiries and researches on behalf of the farmers. At the present time it cannot be said that much is being done towards this end, nor is there any likelihood of such investigations being initiated at the present time; the need, however, remains. The figures hitherto obtained point to a very general deficiency of lime. There are, however, wide areas well supplied, indeed too rich in this element. Very frequently the analyses indicate what in other countries would be taken to imply poor soil deficient in the essential plant foods, yet the yield of crops belies this description. This matter has not yet been studied, but it would seem as if, in our warm and genial climate, vegetative energy and chemical and fermentative processes were more active than under European conditions. Whether this accounts for the fact or not yet there is no doubt that good returns are consistently obtained from lands, the analyses of which, judged by European standards, promise but light crops.

Alkali soils such as occur in most arid and semi-arid climates are commonly met with at the Cape, particularly on ill-drained spots and on irrigated lands, due to seepage and to excess of water or lack of drainage. Economy in water, that is its use in irrigation to the best advantage, has still to be learnt, extravagance and waste of the precious commodity is only too frequently seen on land so fortunate as to be irrigable.

A peculiar feature of many portions of the Colony, especially in the south-west, is a spotted appearance of the land, with a more luxuriant growth of crop or natural herbage corresponding to these richer and often slightly raised patches each a few yards in diameter. Sometimes they are close together, while again they may be found only every few hundred yards. Invariably the soil is deeper and richer on these "heuveltjes" than elsewhere, and the crops heavier but unevenly ripened. To this extent they are a disadvantage, and the soil surrounding the "heuveltje" appears to be poor inversely as the mound is rich. They are worthy of examination by those interested in the study of soils, as their origin is still a matter of doubt, though a partial explanation may be ventured that they are striking examples of cumulative fertility, though the primitive cause seems somewhat obscure.

With so much spare land on every farm, there are always ample facilities for practising a bare fallow system whereby after two or three successive grain crops the land is left a few years to recuperate. In the corn-growing areas the use of stable manure has long been necessary and artificial fertilisers are now very generally employed. The demand for concentrated manures is growing, if slowly, and is extending to inland districts and to the Eastern Province. But for recent droughts the growth of trade in these commodities would probably have been larger than it is to-day.

The Cape farmer is singularly fortunate in that a benignant Government, which fortunately owned a number of rocky islands along the coast, has determined that it is more advisable to dispose of the annual deposits of bird guano at a low profit to its own people than to sell it to greater direct pecuniary advantage in Europe. Besides furnishing him with a cheap and excellent manure this broad-minded policy has familiarised the Cape farmer with the use of concentrated fertilisers, and at the same time has doubtless tended to lower the price of the artificial commodities which have to compete against the Government product. Naturally farmers living near the port of entry, Cape Town, are able to obtain their guano at a less cost than those living far inland, especially those remote from the railway, but then the back-veld farmer is at a similar disadvantage for all his articles of consumption, and land itself is cheaper, a compensation for its remoteness.

Artificial fertilisers are now largely dealt in, though as yet we are but at the threshold of our experience of them, and we have still much to learn as regards their best modes of use. One fact is certain, that here only a quarter to a third of the amounts applied in England need be sown, a curious feature corresponding with what we also know of the fertility of soils of apparently deficient composition, and due perhaps to the same causes.

Amongst other manurial experiments the possibility of soil inoculation for leguminous crops, which has aroused so much interest in other countries, is also being tested at several centres in the Colony.

In view of the growing importance of the trade in artificial fertilisers there is a widespread opinion that both for the protection of the farmer and in the interest of honest dealers a system of control of the chemical composition of such manures, similar to that exercised in other countries, is urgently required. This implies legislation, and a bill with that object in view has just been published, and will probably be introduced next session.

During the last two seasons a beginning has been made in the direction of carrying on manurial experiments with a view to ascertaining what fertilisers are especially adapted to different districts, and in what manner and quantity they should be applied. It is also hoped in this way to stimulate an interest in the use of artificial manures and to encourage farmers to study the subjeet for themselves, and ascertain what is best for them to use. The experiments are conducted through the Department of Agriculture. Without entering into tedious details, it may here be stated that encouraging results have been obtained, but that facilities are lacking for prosecuting the work on the scale which its importance warrants, and which would by multiplying results enable definite and reliable rules to be laid down for the guidance of farmers and those who import artificial fertilisers. Drought in the Eastern Province has in the past seriously militated against these trials in portions of the Colony which are only now awakening to their needs in this direction.

Except on the guano islands, no natural deposits of fertilising material are known in the Colony, unless limestone and gypsum, which are not yet so utilised here, may be reckoned as such. Attempts made at one time to start artificial manure works came to nothing, though to-day in the Eastern Province there are two mills turning out crushed bones, mainly for feeding, but also for manurial purposes. In the pastoral districts, owing to the ancient custom still adhered to, of bringing the cattle and sheep into the kraal every night, enormous heaps of manure have accumulated. However undesirable the practice may be, it must continue until the jackal is exterminated or got under control. Meantime the wealth of the farm is concentrated in one useless spot. Facilities for the sale of this "kraal manure" exist in the form of specially low charges for carriage by rail from the Karroo to the grain and fruit areas, but this only affects up-country farmers within immediate reach of the trunk lines.

The veld is of many kinds, and is described either according to the characteristic of the herbage or to its uses. The first great sub-division is into grass-veld and bush-veld, the former being characteristic of the regions under the influence of the wet summer monsoon, the latter covering the parts under winter rains, but extending along all coast lands, over many mountain ranges, and usually, even in the Eastern Province, occupying the kloofs and valleys. The Karroo plain is peculiar, for while what rain it gets falls chiefly in summer, yet it is essentially covered with bush, grasses only appearing for a short time after rain and on the mountains.

The term "bush" includes a great variety of plants, the short shrubs of the Karroo, the knee-high "boschjes" of the Western Province, the dwarf-trees of the mimosa type, the dense scrub of our coasts, and the majestic timber trees of the natural forest. Grasses, too, vary, though not to the same extent, and combinations known as mixed veld are not uncommon.

Again, the veld is characterised as "groot-vee veld" and "klein-vee veld," accordingly as it is suited for cattle and horses or for small stock, while every class and breed of domestic animals has veld especially adapted to its use.

The two phrases "sweet" and "sour," as applied to our natural pasture land, have no connection with the usual English acceptation of the words. "Sweet" implies rich land producing nutritious food whether natural or cultivated. In some localities both classes occur in patches, such country being described as "broken" veld, while elsewhere the veld over large areas is of distinctive degrees of sourness or sweetness. The modifications depend chiefly upon the composition rather than on the physical nature of the soil, the sub-soil and underlying rocks, but is also due in a large measure to natural drainage. Absence of lime is characteristic of "sour" veld, probably not only on account of the neutralisation of acid where lime is present but rather because lime soils are usually well drained, and well supplied with other plant food. Lime is an essential plant food, very generally lacking in Cape soils; wherever it does occur marked fertility—and "sweet" veld—results. Excess of humus does not explain "sour" veld, for, while in some sour-veld districts, like the Knysna, organic matter is abundant, yet on the whole "sour" soils are lamentably deficient in this respect. The application of the terms "sweet" and "sour" is then somewhat unfortunate, but once comprehended should give no further difficulty.

Sour veld gives good grazing during certain months of the year, but when old it becomes harsh, dry and fibrous towards the end of the summer months, and is then of little or no value. For this reason, and to promote an early growth of young and succulent grass, the very general practice of burning such veld during the dry season has arisen. The propriety of so doing is one of the great questions of the day. Many insist that in order to get grazing for certain seasons, veld burning is a necessity, and that this is the only way of removing the old growth, which by sheltering the young vegetation would prevent cattle and sheep from getting at it until it was itself old and woody. The practice enjoys the popularity which attaches to old customs. While in a sparsely-stocked country this mode of getting rid of rank growth and hastening the new vegetation is perhaps unavoidable, there can, on the other hand, be no doubt that the practice is a very detrimental one. Not only is the already scanty supply of organic matter lost to the soil, but the ash constituents are removed by the wind, and the bare surface of the soil is exposed to erosion by rain, and the baking influences of sun and wind, harmfully influencing its physical properties. Furthermore, burning materially alters the character of the veld. The more valuable feed appears also to be that most easily killed. No doubt the pasturage is improved the first year, the second season a marked deterioration takes place and burnt veld becomes more sour than ever. Burning sweet veld is a much less objectionable practice.

The only alternative is heavier stocking coupled with resting of the veld at certain seasons to allow the more valuable classes of herbage to increase. In this direction much yet remains to be learnt as to the duration of such periods of rest, and the best means of encouraging good natural herbage. A great advance in this direction is the sub-division of farms into camps and paddocks, thus limiting the stock to certain parts at certain seasons. Of late years much has been done in this way and the practice is on the increase. A great difficulty arises from fires spreading across neighbours' lands, especially as in many districts it is considered that veld once burnt must be continuously burnt, and so the burning extends, and farmers are at the mercy of those round them. The question of veld-burning is indeed a vexed one, which will continue to disturb us for a long time to come, but the feeling against it is certainly growing.

A question closely connected with the veld is that of vermin. This term includes several kinds of jackal, lynx, leopard ("tiger"), wild cats, and lesser beasts of prey. For years the Government has attempted to exterminate them by offering rewards for tails, but the plague continues unchecked. It is on this account that the almost universal custom of confining stock to the kraal at night has arisen. Every morning the flock must sally forth to the grazing land, returning again at dusk, spending therefore much time in travelling to and fro, which were better employed in laying on flesh or resting. At night the sheep or goats stand on the accumulated manure of years, closely confined without the possibility of feeding, and in an ideal condition to contract any contagious disease which may break out As mentioned above, when dealing with the question of manure, all the dung is concentrated near the homestead in quantities which render its distribution over the land again quite impossible. Moreover by the continuous grazing which necessarily takes place no part of the veld is ever rested. Flowers are eaten off and possible seed destroyed; young plants are nibbled down or tramped out, and bushes are gnawed, especially by goats. In this manner the veld is becoming positively worn out over wide extents of country, and several years of drought have brought matters to a very acute stage. This reckless depasturing while very reprehensible was hardly to be avoided on account of the events and circumstances of the last few years.

The best remedy yet devised is the construction of jackal-proof wire fences round whole farms or groups of farms, within whose shelter stock can graze at will, undriven by the shepherd and allowed full freedom day and night. Further, sub-division of the farms into camps with ordinary fencing gives the opportunity of resting the land, and allows the sheep to have that change of pasture which is so necessary for them. The system is still in its infancy, but there can be no doubt that in this way lies the redemption of our veld.

The destruction of herbage has led to other serious consequences. Owing to the absence of a natural covering, and the loss of humus in the soil, the rain not only fails to be absorbed by the sunbaked, hard-caked surface of bare ground, and so to be preserved for future use, but it rapidly collects into streams and torrents, which in an astonishingly brief space of time carve out deep gullies in the hitherto unbroken veld, and remove from wide areas the best of the surface soil. The paths worn by stock under the prevailing system of pasturing has materially facilitated this process of erosion, until at the present time the problem has become one of the greatest seriousness and urgency, demanding vigorous and immediate steps for the remedy of this growing peril. That it is within the power of the individual farmer to do much to minimise the damage and prevent its continuance has been amply proved by the zealous enterprise of leading private individuals, such as Mr. W. R. Southey, Varkenskop, Middelburg, and Mr. P. Weyer, of De Toekomst, Somerset East, whose work, already well known, deserves even wider recognition.

A great field lies before this country in the utilisation of such water supplies as it has got, either known and on the surface, or hidden beneath and unsuspected. Recent developments have quickened the hopes of many that in this direction lies great future prosperity. State undertakings have done something in the past, but it is now generally accepted that it is not in gigantic irrigation works, but rather in numerous and small private enterprises, encouraged and directed by a liberal form of Government control and financial assistance that salvation for the country in this respect is to be sought.

Considering the advantages and variety of soil and climate it is somewhat surprising to find a comparatively small number of crops under cultivation on a large scale. The range of crops that can be grown is extraordinarily wide; there are many places where the strawberries from the north ripen side by side with the bananas of the south; and rye, the cereal of cold latitudes, may be found growing close to the tropical date palm. But the number of crops grown for market, apart from fruits and vegetables, is inconsiderable. Throughout the Colony we find wheat, oats, beans, pumpkins, melons, and very generally lucerne, tobacco and potatoes. Widely distributed though not everywhere we get vines, mealies (maize), Kafir corn, rye, barley and sweet potatoes. Many of these crops could doubtless be grown on a large scale, and to pay, if only the initial difficulties of a commercial outlet could be overcome. The merchant demands a guarantee of quantity and quality before embarking on the business of manufacturing or exporting, while the farmer requires an assurance of price before risking a crop. A most unreasonable prejudice seems to exist against colonial-grown produce. We can and do produce foodstuffs of all kinds equal to the finest imported article, but admittedly in only small quantity. Foreign competition is keen and well organised, while our facilities for storage and distribution are still in a rudimentary condition. If only these preliminaries could be overcome and a reasonable profit assured to farmer and merchant alike, there can be no doubt but that many so-called industrial crops might be advantageously added to our list of common crops, and that in this manner the productive capacity of the country might be materially increased. Amongst others deserving trial in this connection, flax and cotton and the castor-oil plant deserve special mention.

As regards our present staples, we have to contend with many difficulties which materially diminish the profitableness and increase the risk of farming in this country. The locust, which used to be regarded as an occasional visitor, has for some years past, been constantly with us, and takes away everything except lucerne. Rust attacks all our cereals. Some five years since our Cape oat was the universal forage crop, though Scotch and Tartarian oats were also grown in the Eastern Province. These kinds will now only be found in a few remote places; rust, which previously did but little injury, practically annihilated them in a couple of seasons, and but for the fortunate discovery of the resistant properties of certain imported oats, oat-hay would now be a thing unknown. These came from Texas, from the Argentine—known to the trade as "Algerian"—and from Australia, misleadingly called "Egyptian."

But useful as they are, they cannot be compared to our old Cape oat. As regards wheat, we are in an almost equally unfortunate position. A great number of kinds are grown, every small district possessing varieties peculiar to the neighbourhood. New sorts are constantly being tried, but most succumb to the fell disease, and at present only one solitary kind—"Rietti," from Italy—can be depended upon, although others, such as "Medeah" and "Red Egyptian," are resistant in certain districts.

Potatoes at the Cape exhibit a surprising and hitherto unexplained tendency in the course of a very few seasons to deteriorate in size so as to become unsaleable, and fresh seed has constantly to be obtained from Madeira, England, France and Germany. Perhaps varieties produced in this country from the "apple" might possess more constant properties.

There is much room for improvement in our mealies, for while we have several excellent kinds, probably of South African origin, yet all might be improved by selection, while the production of new varieties and the acclimatisation of the best foreign sorts offers a wide and promising field for experiment.

Oudtshoorn at one time had the reputation of alone suiting lucerne, but fortunately that myth has been exploded, and this most valuable of all forage plants is now widely grown, and its many good qualities fully appreciated. Unlike other crops, lucerne is comparatively free from pests, though dodder and the caterpillar of *Colias electra* do harm at times. Its cultivation is extending rapidly, particularly in our deep alluvial Karroo soils, where water can be led on to it, but also on poorer, shallower "sour" veld under rainfall. However, even lucerne has its limitations, and there are many other forage crops as yet but little known in the Colony, and well deserving of more attention or, at the least, of a fair trial.

Besides crops for direct market, we have yet much to learn in the growing of fallow and forage crops and their conversion into more valuable marketable commodities of beef, mutton, pork and dairy produce. The value of green manuring has yet to be learnt and appreciated. Something in this direction is already done, but it cannot yet be said to be the general practice, and before its value can be demonstrated we have to learn what crops are suitable for such purposes in this country, as well as to find out the best modes of growing them.

An obvious need, and one of the first to strike the stranger, is our want of statistical information, of a concise but systematic statement of the experience of the past. Such data are tedious and costly to prepare, and individually convey little information, but collectively are of the utmost value, enabling us to compare our position at any one time, with that at any other. Constant enquiries are being made as to our sources of supply, the quantities produced in different districts, our ability to support our population, and so on. Last year's census has furnished much interesting information, and dispelled many erroneous ideas, but much of the evidence therein contained is so all important that it would be well to have it prepared annually, as is done in other countries.

Adequate statistics would be especially useful in Cape Colony in furnishing information to the public regarding supply and demand, to regulate both to the advantage of producer and consumer alike, thus preventing those conditions of feast and famine which have become proverbial with us. Further, such reliable information—crop reports, market returns, and the records of past years—serves as a useful guide in preventing the great fluctuations of price which are a marked feature of our commercial condition, and would at the same time add a sense of security to our trading.

The labour question is a fruitful source of anxiety and speculation to politicians, farmers and manufacturers alike. All are agreed as to the difficulties, few as to the solution, but the question is one demanding the most earnest thought of those who call the Colony their home, as on its solution depends, perhaps more than on any other single factor, the future prosperity and the conditions of life in the Colony.

Closely allied to this problem is that of the education of the native. While far from being settled, there seems to be a growing feeling that training in the useful arts of agriculture would be more beneficial to themselves and to the Colony at large, than the long tried and still prevalent attempts at literary and æsthetic culture.

Immigration and its influence on the labour market is a problem of pressing urgency, this country having now reached a stage when considerations of the character and industrial qualifications of newcomers are of more importance than their mere numbers.

Anything that will tend to bring together our farmers, whether for the purpose of discussion of matters of mutual interest, or for combination for mutual help, for agricultural shows and the like, deserves hearty support. A strong feeling in this direction is at present abroad, as may be instanced by the growing numbers of farmers' associations, of agricultural societies, and of combinations of farmers for co-operative undertakings, such as irrigation works, joint selling and buying, and for the advancement of particular objects, stud-book societies, and the like. Legislation in the same direction is at present on foot, so that the matter may be said to be within the range of practical politics.

Closely allied to this subject is that of agricultural co-operation, which has recently come to the front very prominently. As yet the matter is only in the initial stages of enquiry and discussion, but it is receiving earnest attention from all classes in the country, and several proposals of a practical nature have been made. A great danger that threatens us is that, in considering this matter, we pay too much attention to the methods of other countries, modelling our schemes blindly on their plans, instead of adopting their principles but modifying their practice to suit our conditions. Co-operation in Cape Colony ought surely to be a natural growth of our own veld, however small the original seed may be, rather than an exotic graft of imposing appearance, but without root of its own in this country. Aid and advice on this subject, however, will be welcome from competent sources, our want in this respect being, as in so many others, knowledge and experience.

This suggests yet another matter in which the Colony is anxious to advance, has indeed done something, but for which there is still great scope, namely, the vital problem of agricultural technical education. For practical instruction in the various branches of the farmer's art, especially in wine-making, the growing and curing of tobacco, butter-making, cheese-making, pruning and grafting of fruit trees, and the like, there is a real demand, not only by youths, but also by adult farmers. There are, however, many difficulties, and as yet, it must be confessed, little has been done in this direction. Unfortunately the classes most in need of instruction are the very ones least anxious to benefit. In the back parts of the country distances are so great that anything of the nature of short courses by itinerant lecturers is almost impossible. With the limited facilities at present available more benefit is probably derived from the personal visits and by the dissemination of pamphlets, and also through the "Agricultural Journal," a monthly magazine of farming issued by the Department of Agriculture, than if the same labour were expended in lecture courses. A combination of both methods is, of course, highly desirable, and may be looked upon as the goal to be aimed at.

Love of individual freedom is a traditional sentiment of our people, yet it has been recognised that, without in any way offending this feeling, much may be done by Government to assist one particular class, the farming community, without pauperising them or interfering with their independence.

The principle of State aid to agriculture has come to be generally approved, but the mode of its application leaves much room for discussion. The main object of the existence of a Department of Agriculture is the protection and encouragement of farming interests. While being specially concerned with the administration of acts of Parliament affecting agriculture, yet it is to a great extent regarded as a bureau of information. Numerous enquiries reach it daily upon the greatest variety of topics, live stock in health and disease, crops grown and possible, fruit, viticulture, dairying, tree-planting, geology, botany, entomology, and a host of other matters. To many of these a brief reply is ample, at other times lengthy explanations are called for. But to a proportion of the enquiries it is impossible to prepare a satisfactory answer. The information is not forthcoming. There are many practical problems, especially those appertaining to arable farming, which have never been taken up and studied in the Colony, and for which the experience of other countries is without value. To this category belong questions relating to crops, new and possibly advantageous to the Colony, improved methods of propagation, cultivation and subsequent treatment of crops, and other cognate problems. In almost every civilised country in the world where agriculture is of importance—and where is this not the case?—there exist special institutions for the purpose of investigating these questions. The work of the experiment stations of England, America and Germany are known to the world, and their beneficial influence upon the agriculture of the countries where they are found can scarcely be exaggerated. Hitherto Cape Colony has been without such facilities for research, but it is an extreme pleasure to be able to announce that it has definitely been decided to establish experiment stations in the Colony, and that Parliament has voted the funds necessary for the commencement of this great work.

Experiment stations in Cape Colony cannot be established slavishly upon the lines adopted in certain other countries, since no other country possesses precisely the same conditions. Emphasis has above been laid on the great differences which exist from place to place within the Colony. On this account it has been decided to establish not one large and elaborate institution, but rather a number of small separate stations, each working out the problems of its own region. The crude state of our knowledge has been commented upon; accordingly it has been decided to make the work in the first instance eminently practical, to restrict it to questions that will appeal at once to the pockets of the people, deferring to a later stage the study of matters less immediately advantageous. Another restriction is the limited nature of our resources, but it is trusted that when the first stations have justified their existence, a more liberal treatment may be accorded them, and that then perhaps private generosity, which has done so much for this cause elsewhere, may also endow the work, and permit of its extension. Unfortunately it is the initial outlay which is heavy, upkeep is a comparatively trifling matter.

The aim in view is simply by the application of the laws of nature to our agricultural conditions, to increase the producing power of the country, and to help our farmers to overcome the many difficulties with which they are surrounded. Supplementary to the experiments it will be necessary to carry on demonstrations of known facts, for it is the argument of "things seen" that appeals most eloquently to the farmer. So far as possible every item of the farm, the buildings, fences, roads and implements, as well as the crops and livestock, should serve some purpose of experiment, comparison or trial, the return to be looked for, being in results and facts learned, and not in the financial balance-sheets.

The proposal for experiment stations has been favoured with a considerable amount of public attention, which it shares as regards matters agricultural, with the questions of technical education and the possibilities of co-operation. These aims may never be realised in their entirety, but the hope may be permitted that in striving towards their attainment we may acquire the best forms of the wealth of a nation—enlightenment, comfort and prosperity. The proof of this will be seen in the changing appearance of the land, in the increasing extent of cultivation, and in the springing up of new homes.

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4. FORESTRY IN SOUTH AFRICA.

By D. E. Hutchins, F.R.Met.Soc., Conservator of Forests, Cape Town.

The Indigenous Timber Trees.

"*I am as certain as I stand here that Nature intended wide tracts of South Africa to be forest country.*"—(Lord Milner's farewell speech, Johannesburg, March 31st, 1905.)

Of the great variety of indigenous trees in South Africa only three have much importance for timber, and two for the peculiar value of their wood. The six chief trees are :—

Podocarpus elongata.—The large or Outeniqua Yellowwood.
Podocarpus thunbergii.—The small or Upright Yellowwood.
Ocotea bullata.—Stinkwood.
Olea laurifolia.—Black Ironwood.
Pteroxylon utile.—Sneezewood.
Callitris arborea.—The Clanwilliam Cedar.

Of these, the two Yellowwoods yielded nearly all the house-building timber used by the early settlers in the Colony for many years; and Yellowwood still represents about three-quarters of the commercial timber in the belt of dense indigenous forest which stretches in a much broken belt along the slopes of the coast mountains from Cape Town to the north-east of the Transvaal. From Yellowwood being the only large timber tree, the dense evergreen indigenous forest of South Africa is commonly known as the "Yellowwood forest." In recent years the Knysna forests have yielded 100,000 Yellowwood sleepers yearly for the Cape Government Railways. Yellowwood sleepers when creosoted are not surpassed by Jarrah, creosoted Baltic pine, or any sleeper known, but it is as a flooring board that Yellowwood timber finds its most valued use.

Ocotea bullata (Stinkwood).—The timber of this tree has a higher value than that of any other timber in the indigenous forest. Stinkwood, however, is rarely a large tree, and the timber is chiefly used for furniture and in wagon-making. Stinkwood furniture is most beautiful, but its cost confines it, at present, to the houses of the wealthy.

Olea laurifolia (Black Ironwood).—This tree reaches the stature of a medium-sized or large timber tree, but the wood is excessively hard and not durable in the ground. It is chiefly used for wagon-making and is occasionally exported as an ornamental hardwood.

Pteroxylon utile (Sneezewood).—This is usually a small tree with a very hard timber, but the timber is almost imperishable in the ground, so that it is highly valued for fencing poles.

Callitris arborea.—The Clanwilliam Cedar holds the first rank for general usefulness amongst the indigenous timbers. It is as easy to work as Baltic pine, it seasons well, and is very durable. It has a sweet lasting fragrance surpassed by no other Cedar. In growth this Cedar much resembles the Atlas Cedar of North Africa. The timber of *Callitris arborea* is more highly scented and more durable than that of *Cedrus atlantica.* Unfortunately Cape Cedar has been so destroyed in the past that its forest has at present no commercial value.

There are three other species of Callitris in South Africa. *C. cupressoides* is usually shrubby. *C. whytei* barely comes south of the Zambesi. *C. schwartzii* is a newly described species whose capabilities are not yet fully known. It may prove not to differ greatly from the tree form of *Callitris cupressoides.*

Apodytes dimidiata (White Pear) } Medium-sized trees prized
Curtisia faginea (Assegai) } for wagon-making.

Goniami kamassi.—Kamasi is a Boxwood substitute exported from Knysna.

Buxus macowani is a second-rate Boxwood formerly exported to some extent from East London.

Olea verucosa.—The common "Wild Olive" furnishes a good fencing post. The European Olive can easily be grafted on it.

Leucadendron argenteum.—The Silver Tree has practically no timber value. It is not known to occur naturally farther than fifty miles away from Cape Town.

There are in the Yellowwood forest altogether about 108 species of trees; but these, with the exception of those mentioned above, have little commercial value. They are occasionally brought into use for fencing poles, wagon-wood, etc., and all are employed on the eastern side of the Colony, in building Kafir huts.

With the exception of the Clanwilliam Cedar the indigenous timber trees are of weak natural reproduction and difficult artificial propagation. The indigenous timbers are also of slow growth and of delicate constitution. It is difficult to obtain seed of Sneezewood; it is impossible to procure any satisfactory supply of Stinkwood seed. Hence the improvement of the indigenous forest is no easy matter. The stock of commercial timber in the indigenous forest probably does not average above one-twentieth a full stock, and in the more accessible portions it is less. Instances have occurred where the *total stock of timber* in a good indigenous forest was only equal to *one year's growth* of timber in a Eucalypt plantation yielding a first-class hardwood, such as Ironbark. The value of the standing timber in the indigenous forest, taken at 3d. per cubic foot, may be averaged at :—

Forests of Cape Colony	£6 per acre.
,, ,, Natal	£5 ,, ,,
,, ,, Transvaal	£4 ,, ,,

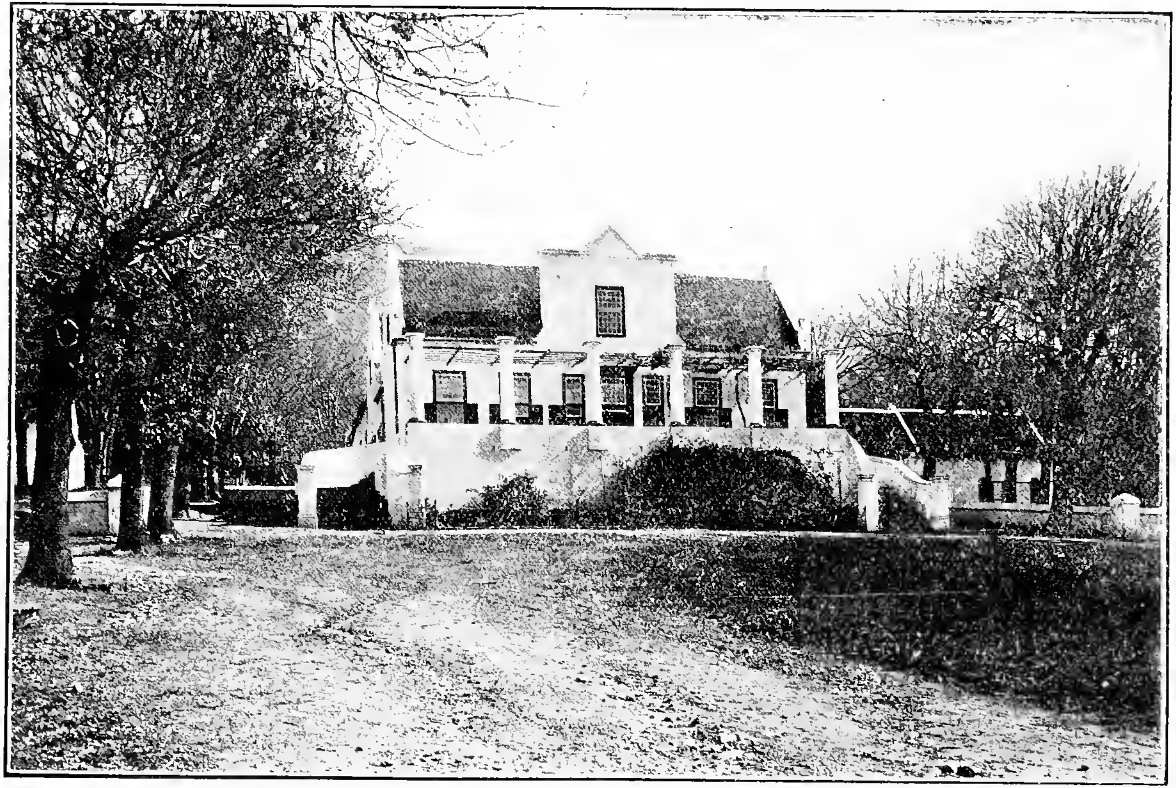
It is certain that without the assistance of the picked timber trees of larger forest floras, Forestry in South Africa could never be the remunerative business it now is. Which of the introduced trees is best fitted to re-stock and restore the indigenous forest is still an unsolved problem.

I have mentioned that the Clanwilliam Cedar is an exception to the difficult propagation, the slow growth, and the delicate constitution of the indigenous trees generally. Unfortunately, that tree will not thrive away from its home in the rugged Cedarberg country—an area of 150 or 200 square miles on the western side of the sub-continent, situated 120 miles due north of Cape Town. The re-foresting of this area has been pushed forward as rapidly as the slender provision of funds has allowed of. Fires have been restrained, goat-grazing stopped, and only dead Cedar trees are now allowed to be felled, while 81,000 trees have been planted over 94 acres by the inexpensive process of plowing the ground and sowing the seed broadcast. Seed is obtainable as easily as Pine seed, and the growth of the young Cedars is as fast as that of the Cluster-pine on the Cape Flats. Such Cedar timber as is obtainable from dry trees sells easily in Cape Town for the same price as Stinkwood or Teak. No doubt in the future Clanwilliam Cedar will largely replace the costly imported Teak, but since the Cedar will not flourish away from the rigorous climate of its snowy mountains, it can play but a restricted part in the general re-foresting of the country. Hence the supreme importance of the introduced timber trees to the South African Forester.

The Introduced Timber Trees.

Some of the finest timber trees of the Northern Hemisphere have now been under cultivation in South Africa for 200 years, and may reasonably be considered to be completely naturalised. Most of them show an abundant natural reproduction from seed, and they flourish in localities where drought, frost and parching winds are a complete bar to the cultivation of the delicate indigenous trees. It is of course necessary to see that in their new home they are properly fitted to the climate—winter rainfall trees (such as those of the Mediterranean) to a winter rainfall climate; summer rainfall trees to a summer rainfall climate; all-the-year-round rainfall trees to an all-the-year-round rainfall climate; inland trees to an inland climate; and coast trees to a coastal climate. Hence, to the South African Forester, the prime importance of the study of climatology. The following trees are those which have shown themselves to be most hardy and useful in South Africa.

Pinus pinaster (Cluster-pine).—Grows like a weed along the southern coast of Cape Colony, wherever there is a good rainfall; particularly on the coast mountains and on the plains of the south-west, where there are winter rains and a Mediterranean climate. It is now being largely propagated for sleepers and firewood by the Forest Department. About 8 tons of seed are used yearly in these operations. For an account of the remarkable growth of this tree



The Tokai Oaks and Homestead.

on the Caledon Mountains see a pamphlet by the author, entitled "Cluster Pine at Genadendal," reprinted in 1904.

Pinus pinea (Stone-pine).—This tree seems to have been introduced by the early settlers before the Cluster-pine. About the old farms there are some noble specimens of this picturesque tree, with its flat umbrella top, so strongly recalling Southern Italy. Unfortunately, about thirty years ago it was attacked by a fungoid disease which has been pronounced to be a species of *Peronospora*. This disease has almost exterminated the Stone-pine, and has led to its being placed entirely outside the operations of the Forest Department.

Quercus pedunculata (English Oak).—This is a favourite tree around the homesteads of the early Dutch settlers in the south-west of Cape Colony, and it has been planted with success within the heavy rainfall area of the eastern mountains, particularly along the Amatolas, north of King William's Town. It does not flourish in the drier parts of the Colony, but in all the more fertile parts it is highly prized for its incomparable beauty in Spring and its heavy yield of acorns. To the farmers the acorns are a valuable crop; indeed, it has been truly said that the Oak in South Africa is more a fruit than a timber tree. The Oak in South Africa bears acorns abundantly every year, and these acorns average almost double the size of those commonly seen in England and northern Europe. The foliage of the Cape Oak is also denser than that of the same tree in Northern Europe.

Populus alba (White Poplar).—This tree was probably one of the first to be introduced to South Africa, and is now completely naturalised, in vleys and damp places from Cape Town to he Northern Transvaal. The Poplar bush is a standing institution in many up-country farms, and the Poplar in South Africa furnishes a light useful timber for farm purposes and second-rate house building.

Populus nigra (Black Poplar).—This tree has also been long introduced to South Africa, but it is less hardy and less wide-spread than the White Poplar. It is usually seen in the form of the Lombardy Poplar, and as such is used as a break-wind in the vineyards and fruit orchards of the South-west of Cape Colony.

Populus monilifera has been introduced more recently, but it seems quite at home, and is very fast growing.

Eucalyptus globulus (Blue-gum).—This was not introduced to South Africa till 1828, but is now the most wide-spread and generally hardy tree on the sub-continent. From Cape Town to the Northern Transvaal, wherever trees are planted, the Blue-gum will be seen generally occupying the largest space. It commends itself to farmers on account of its hardiness and rapid growth. But the efforts of the Forest Department are now directed to replacing it by other Eucalypts which may be equally quick-growing and produce a timber of superior value.

Eucalypts Generally.—Of the 150 odd species of Eucalypts nearly all have now been planted in South Africa. There are nearly

100 species in the Government arboreta at Tokai. Of these among the most valuable for sleepers and general use as hard woods may be mentioned *Eucalyptus pilularis*, the fastest grower known in the Cape Peninsula, *E. microcorys* or Tallowwood, *E. resinifera*, yielding a Jarrah-like timber, *E. paniculata*, an Ironbark, and *E. saligna*. The above are being planted on a large scale for the production of sleepers, for which item alone Cape Colony has now to spend yearly £100,000, most of this money going to Australia. After the Blue-gum the tree that has been most widely planted is *E. tereticornis*, commonly known in South Africa as the Red Gum. Up-country it flourishes at all elevations, from Johannesburg at 6,000 feet to Delagoa Bay, where it may be seen growing with Cocoa-nut Palms and other tropical trees. *E. maculata* flourishes on poor soils within the summer-rainfall areas of the sub-continent, and the closely-allied *E. citriodora*, with its scented foliage, in the warmer parts of the same region. Of Iron-barks, the pearl of Eucalypt timbers, *E. paniculata* has given the best results near the coast, and *E. sideroxylon* inland. *E. paniculata* is one of the fastest-growing Eucalypts in South Africa, and a hardwood of unsurpassed excellence. Other valuable Eucalypts being largely propagated are *Eucalyptus diversicolor* or Kari, a hardy free-grower, and one of the giant trees of the world in its home in West Australia. *E. marginata*, the West Australian Jarrah, has not proved to be one of the most profitable of the Eucalypts to plant for timber, though it grows well enough in its own climate in the south-west of Cape Colony. *Eucalyptus corynocalyx*, or Sugar-gum, is a tree recently introduced to the drier districts, and growing with great success at Robertson and elsewhere. It also produces a first-class timber. Other Eucalypts suited to the drier parts of the country are *Eucalyptus tereticornis*, *E. leucoxylon*, *E. hemiphloia*, and the two Coolgardie gums from West Australia; *E. salmonophloia* and *E. salubris*. *E. polyanthemos* is the Eucalypt that has proved hardiest against frost and drought in the severe climates of the high South African plateaux. All the above Eucalypts are being planted on a large scale in the Government timber plantations.

Pines.—Most of the extra-tropical pines are now being grown by the Forest Department. Of the Pines recently introduced the most promising appears to be *Pinus canariensis*. The timber of this tree is justly esteemed at a high value in the Canary Islands. On the southern mountains of Cape Colony it appears to rival the Cluster-pine in hardiness and quickness of growth. It is also being successfully planted in Natal and the Transvaal.

Pinus insignis.—This handsome Pine has been largely planted in recent years in South Africa. It is only climatically suited, however, to the winter rainfall districts, and the wholesale planting of this tree in Natal and the Transvaal has produced disappointment. This is a large, rapidly-growing tree, particularly at first.

Other Pines being planted more or less extensively are *Pinus halepensis* or Jerusalem Pine, *P. muricata* and other Californian Pines, the two Japanese Pines *P. thunbergii* and *P. densiflora*, together with the four Pitch Pines of the Gulf States of the United States of America, *P. australis*, *P. mitis*, *P. cubensis* and *P. taeda*.

The Mexican and Chinese Pines remain for trial in the summer-rainfall, high-plateau country—Transvaal, Orangia, Basutoland, Transkei and Natal.

Cypresses: Junipers and Cedars generally.—Trees of the genus *Cupressus*, with their valuable Cedar-like durable timbers, have naturally not escaped the notice of the Forest Department, but their planting is somewhat restricted by considerations of expense. They grow slowly, more especially at first, and are frequently costly to establish. There are, however, extensive areas under Cypress at Tokai, Ceres Road, Fort Cunynghame, and elsewhere in the Government timber plantations. The Cypress that has been most largely planted (and often out of its climatic habitat) is *Cupressus macrocarpa*. This rapidly becomes a tree of much beauty. *Cupressus guadalupensis* may almost be looked upon as the hardy, drought-resistant form of *C. macrocarpa*. The planting of this tree is rapidly extending. Quite equal to *C. macrocarpa*, however, is *C. lusitanica*, which, under various names, has been extensively planted throughout South Africa, and, judging from its natural reproduction, it seems to have become naturalised in the Transvaal, Natal and Cape Colony. *C. goveniana*, *C. lindleyana*, and *C. torulosa* have also been planted to a less extent.

Junipers.—These trees yielding the Cedar of commerce have naturally claimed the first attention in an extra-tropical country. *Juniperus virginiana* has proved extremely hardy, but it seems too slow-growing to produce timber economically, and the same is true with regard to *J. bermudiana*, *J. chinensis*, *J. mexicana*.

J. foetidissima and *J. procera* remain for trial on the plateau country. I have lately received from Dr. Perez seed of the almost extinct *Juniperus cedrus* of the Canaries. Altogether there are some fifteen or twenty Junipers under trial in the Government plantations of the Cape and the Transvaal.

Cedrus.—*Cedrus deodara* is being planted on a large scale in the Transvaal, where it shows an excellent growth.

Taxodium.—*T. dystichum* has given but poor results, even on swampy ground, in Cape Colony. It promises better in the Transvaal. The Mexican *T. mucronatum* awaits seed for trial planting in the Transvaal.

Callitris.—Eight or ten Australia species are under trial. *C. robusta* and *C. calcarata* seem the most promising.

Cedrela.—Several species are under cultivation in the warmer summer-rainfall climates, but the proper testing of this most valuable genus of all the Cedars has as yet scarcely begun.

Wattles.—The so-called Wattles of Australia belonging to various species of Acacia form an extremely valuable forest resource. Their exact utility lies in the production of tan bark and in their rapid and early yield of small wood for fuel. Of the Wattles planted, the best known are the Black Wattle in Natal (described under "Natal") and the plantations of *Acacia saligna* and *A.*

pycnantha in the south-west of Cape Colony. *A. saligna* (sometimes called Port Jackson Wattle) grows like a weed on the Cape Flats and elsewhere in the south-west of Cape Colony, and it furnishes a bark which has been largely used by the Cape Town tanners, and which bark contains up to 23 per cent. of tannin. The Wattle, however, which yields the largest percentage of bark, surpassing even the Black Wattle, is *A. pycnantha*, or the Golden Wattle of South Australia. This is now being grown on the Cape Flats and elsewhere in the Government plantations. It flourishes throughout the whole region of winter rains from Cape Town to Knysna, and should be more largely planted than it is by farmers. Wattles yielding a return in from five to seven years can be produced by private enterprise and have thus not been so largely planted in the Government State Forests.

These are the most important of the introduced trees now being planted for timber in South Africa. Many more are being grown; the range of choice in the extra-tropics is wide. It would be impossible here to even mention by name all that are being and have been tested by the Forest Department. Of trees not falling within the four chief classes—Eucalypts, Pines, Cedars and Wattles—there are such valuable timbers as Blackwood (*Acacia melanoxylon*); Californian Redwood (*Sequoia sempervirens*), Camphor (*Cinnamomum camphora*), several species of Podocarpus and Araucaria, and others which cannot even be mentioned here.

FORESTRY IN CAPE COLONY.

The forests of extra-tropical South Africa occupy but a small portion of its area, and are still less fitted to supply the wants of the country in timber. This had long been recognised. As early as 1819 there was a Superintendent of Lands and Woods at Cape Town. In 1876 Forests and Plantations were constituted a separate department of the Ministerial Division, its principal officers corresponding directly with the Ministerial office. The chief forest officer was then at Knysna. At last in 1881 a separate Forest Department was organised, and the Cape Government obtained the services of an eminent French forester, the Count de Vasselot, as head of the Cape Forest Department. This gentleman had obtained his professional training in the French National Forest School at Nancy (than which there is no better), and had since obtained distinction by particularly good work in connection with the great re-foresting operations in Gascony. The work there was with Cluster-pine (*Pinus pinaster*), which is at the same time the pine that has been most largely employed in the pine plantations of South Africa. Count de Vasselot made a forest tour through the country, and his recommendations after this tour will be found in the valuable report which was translated and presented to Parliament in 1882. This report should be referred to by those who may wish for further information on the position of Cape Forestry at that time. In 1883 the writer, who had also been trained at Nancy, arrived from India, and was subsequently transferred from the Indian to the Cape Forest Service. By 1884 the newly-formed Forest Department had got to work, the oldest of the western plantations being founded by Mr. J S. Lister, now Conservator of Forests in charge of the Eastern Conservancy. The Cape Forest Department may thus be said by now (1905) to have had twenty clear years working existence. During that time the timber plantations near Cape Town, the chief Colonial market, have been largely extended, more especially recently with the object of supplying sleepers to the railways. At the same time the "high-timber" indigenous forest of the country has been demarcated, and the wasteful system under which it was formerly worked replaced by systematic fellings under the supervision of competent Forest Officers.

For administrative purposes Cape Colony is divided into four Conservancies, each in charge of a Conservator of Forests, the Conservator stationed at Cape Town having at the same time consultive functions on technical matters.

As soon as the forests had been demarcated, it was seen that a Forest Act was necessary to give effect to the demarcations, and to regulate and enforce the working of the forests. In 1886 I submitted a draft tounded on the Madras Forest Act of 1882, and in 1888 was passed the Cape Forest Act, No. 28 of 1888, which has since been in force, and which has has served as a model for other Colonial forest legislation, not in South Africa only. In 1902 this Act was strengthened and amended in certain particulars, the chief of these being a provision which requires that the National Forests cannot be alienated, nor any forest rights granted, without the previous sanction of both Houses of the Legislature. Further measures may be necessary in order to entirely safeguard the forests from the loss to which they are liable as long as they remain under political control.

The total cost of forest work during the last twenty-two years in Cape Colony has been over three quarters of a million pounds sterling, of which sum more than a quarter of a million pounds sterling has been spent on the timber plantations in the neighbourhood of Cape Town and the south-west. There is a total Forest Staff of twenty-six (Conservators and their assistants) in the upper grades, and eighty-four European Foresters, besides a few native guards in the Native Territories.

It was early recognised that an efficient Forest Staff required that the superior officers should have a technical training beyond what was obtainable in South Africa. In 1892, Mr. C. B. McNaughton, the present Conservator at Knysna, was sent for a special course of training to the Cooper's Hill Forest School in England, and he has since been followed by four others, all of these, except Mr. K. Carlson (at present Conservator inthe Orange River Colony), obtaining a grant from Government which averaged som what less than half their total expenses. Partly on account of the high cost of this training, the last Forest Officer sent from the Cape for his professional training has proceeded to the American Forest

School at Yale; and he has been joined by a forest apprentice from Orangia. But for the obstacle presented by a foreign language, the training at Nancy is that which would best satisfy the requirements of Cape students; since, in the South of France most of the trees now cultivated in the timber plantations of Cape Colony are to be met with, and the climatic and fire-conserving conditions resemble those in Cape Colony. In view of the fact, however, that there is no English speaking forest school devoted entirely to extra-tropical forestry, the expense of sending forest students abroad, and the increasing demand for forest education in South Africa, the project of a South African Forest School has been recently revived, and has obtained the serious consideration of Lord Milner and the South African Governments.

The policy of the Cape Forest Department may be said to have two chief objects :—

(1) Production at home of the timber now imported from abroad. This is to be accomplished by conserving and improving the indigenous forest, and by forming plantations of the most valuable trees of other countries, near the railways and chief centres of Colonial consumption.

(2) The furtherance of general tree-planting in a nearly treeless country, by advice and assistance to landowners and the public. The principal trees planted have been sketched above. It remains only to mention that the cause of tree-planting generally is assisted; by professional advice in the form of pamphlets, lectures, and visits to the forest centres; and by practical aid in the issue of young trees and seeds to the public at cost price. In round numbers, 550,000 young trees are issued yearly to the public at an average price of about ¾d. each, each of these trees being securely rooted in a planting tray. These planting trays are formed of old paraffin tins cut lengthways. During the last ten years the average value of the plants and seeds sold to the public has amounted to £1,844. These figures are rapidly increasing, thus during the last year in the Western Conservancy the sales amounted to £3,859.

Under Act 4 of 1876, one half the cost of all the tree-planting done by Municipalities and Divisional (County) Councils (up to a limit of £250 in one year) is re-imbursed by Government. The administration of the tree-planting grants made under this Act, rests with the Forest Department, as also the adjudication of the special grants sometimes made to private tree-planters.

The Government Timber Plantations.

The total expenditure on forest work since the Forest Department was organised on its present basis in 1883 amounts to £778,000; of which £293,000 has been spent on the large plantations near Cape Town and on Forestry in the south-west of Cape Colony; and £485,000 on plantations and Forestry elsewhere in Cape Colony. The large timber plantations are situated near the chief Colonial markets, and either on or close to, lines of railway. The trees planted are Eucalypts, Pines, and a lesser quantity of Cedar and other trees. The best known of these western plantations is that at Tokai, which runs along the Table Mountain range from the boundaries of the Muizenberg Municipality to Constantia. The total area there planted to date is 2,371 acres, at a nett cost of £28,791, so that the average cost of planting has been £12 3s. per acre. The revenue from this plantation up to December, 1904, was £16,766. The total area of the estate is 6,475 acres. Planting began twenty-one years ago, in 1884. A preliminary valuation of the timber made in 1900 worked it out to a total of £51,825. The revenue realised from this plantation varies from half to two-thirds of the expenditure, and this revenue is obtained from the sale of plants, seeds and thinnings, none of the main crop being yet fit to cut, so that the financial results of this plantation cannot be considered otherwise than satisfactory. In the best portions of the estate the growth of timber is scarcely exceeded in any portion of the world. Thus, from a thirteen-year-old plot of Kari, *Eucalyptus diversicolor* (Prinz Kasteel block) there has been a mean yearly yield of timber amounting to 625 cubic feet. From a six-year-old plot of Kari on Cedar Ridge there has been a mean yearly production of timber amounting to 533 cubic feet. And similarly, another block of Kari on Manor House Ridge has yielded a figure of 377 cubic feet. The largest trees on the plantation are some particularly fine specimens, now over 100 feet high, of *Eucalyptus saligna.* These, at eighteen years old, showed a mean yearly production of timber (acrim) amounting to 527 cubic feet. When one considers that the best yielding forests in Europe—the Spruce and Silver-fir of Saxony do not average more than 150 cubic feet per acre per year, it will be seen how satisfactory is the growth of timber at Tokai.

At Ceres Road, 84 miles from Cape Town on the main line of railway, is another large Government timber plantation, which, with the addition of the adjoining sleeper plantation, has nearly the same area as Tokai, viz., 6,000 acres. The trees planted here and the results obtained are similar to those at Tokai.

There is a further large Government plantation on the Cape Flats, also amounting to about the same area, viz., 6,000 acres. Here, the soil being poor and sandy, the trees planted are almost entirely tan Wattles and Cluster-pine. The tan Wattle used is mainly *Acacia saligna,* though a little of the more valuable *A. pycnantha* has been planted of late years. For the last thirteen years, however, the planting on this plantation has been confined to Cluster-pine, designed to produce sleepers, firewood, and coarse Pine timber. These Pine plantations are formed by the inexpensive process of plowing the ground and sowing broadcast; the total expenditure, plus interest at 3½ per cent., amounts to £64,104, the revenue with interest to £26,047. The timber is now being valued.

The fourth large Cape timber plantation is situated at Fort Cunynghame on the Eastern line of railway north of King William's Town. Here the area planted amounts to 3,000 acres, the total expenditure to £35,408, while the revenue and estimated value of the timber amount to £160,000. The chief trees planted are Black Wattle (*Acacia decurrens*), Cluster-pine (*Pinus pinaster*), various Eucalypts, and on the lower better ground Oak (*Quercus pedunculata*). There are various smaller timber plantations which, together with the larger plantations mentioned, amount altogether to about 23,000 acres.

Drift Sand Plantations.

Among the most successful plantations undertaken by the Cape Forest Department must be reckoned those performed with the object of fixing the sands. Of such plantations there are large areas on the Cape Flats, undertaken some years ago to protect the Railway from drifting sands. At the head of False Bay an artificial

Morram Grass-planting at Agulhas, 1904

coast dune like the "dune littorale" of Gascony, has been run along the shore, stopping the further ingress of sand. Even at Port Nolloth, where the rainfall is only four inches per annum, it has been found possible to stop a serious sand drift threatening the harbour by the planting of Eragrostis and other grasses. The grass that has been most largely employed for sand fixing is Morram, (known as Bent grass in Scotland), *Psamma arenaria*. Drift sands threatened to overwhelm the Agulhas Lighthouse: nowhere has the planting of Morram grass succeeded so remarkably as here. Its growth can be seen from ships passing some distance out at sea, and it opens up wide possibilities for turning to account the dreary areas of sand which mark the extreme southern point of the African Continent. Morram grass has been planted successfully further east at "Still" Bay, but this, so far, is the limit of its successful growth. At Port Elizabeth, where are the largest sand-drift fixing operations, Morram grass has been found not to succeed: and it is necessary there to proceed by the more expensive process of covering the sands with town refuse, conveyed on to the sands by a special line of railway. After the sand has been temporarily fixed with town refuse, it is sown with seeds of various sand-fixing vegetation, and the Wattles *Acacia cyclopis* and *A. saligna*.

The Cape Budget for the Financial Year 1903-1904 showed a total expenditure of £31,500 on the Forest Staff and £60,000 on Forest work. Owing to the present financial crisis the total forest expenditure has been cut down to £50,000, viz., £30,000 Staff and £20,000 work.

FORESTRY IN NATAL.

Natal has been called the "Garden Colony" of South Africa. The part of the Colony from which it derives this name is the central, well-watered portion traversed by the belt of Yellowwood forest. In the southern portion of this belt is situated some of the finest of the indigenous Yellowwood forest. About many of the homesteads in or near this belt have been planted introduced trees which are growing with a vigour unsurpassed elsewhere in South Africa.

Natal has a large native population (about seventeen blacks to one white) and as the natives were settled in Natal they were unfortunately given destructive forest rights. These forest rights and the settlement of the country produced a deplorable destruction of its rich forests. In 1886 the services of a Cape Forest Officer, Mr. H. G. Fourcade, were obtained, who, after a tour through the country, submitted an able report (Maritzburg, 1887), which may be read to-day with the utmost interest. Unfortunately, Natal was at that time a Crown Colony, and practically nothing was done to give effect to Mr. Fourcade's recommendations, or to those of his successor, an eminent young German Forest Officer, Herr Schöpflin. At last, in 1901, when the Colony was managing its own affairs, Forestry was again taken up. Mr. J. S. Lister, Conservator of Forests in the Eastern Districts of Cape Colony, was deputed to visit and report on the forests, and at his recommendation the present Conservator, Mr. T. R. Sim, was appointed in 1902; and Forestry in Natal is now organised on much the same footing as in Cape Colony and other South African States. Mr. Sim's preliminary report for 1902 and his last report dated June, 1904, are interesting documents, and show what is being done in Natal to make up for the long years of forestal neglect. It is a sad tale of waste and ruin!

The Conservator of Forests has his headquarters at Maritzburg, and is assisted by a European staff of thirty permanent Forest officials and five apprentices. The Natal Forest Staff now ranks second after that of Cape Colony. A list of reserved forest trees has been published, and a modification of the Cape Forest Act embodied in the Forest Regulations. Game reserves under the charge of the Conservator of Forests have been established in Natal. There is an area of about 20,000 acres in the wild country near Giant's Castle, at the headwaters of the Bushman's and Tugela Rivers in the Drakensberg. There are also game reserves in Zululand.

At Cedara, lying at an altitude of between 3,500 and 5,000 feet, in the strip of well-watered country immediately north of Maritzburg, are being formed a large distributing nursery, forest arboreta and forest plantations. An area of 407 acres here has been planted, 100,000 trees have been issued from the nursery, and 170,000 remain in stock (1904).

On the semi-tropical coast lands of Zululand a plantation has been formed at Empangeni, with a nursery for the supply of plants to the public. Cocoanuts and Dates are amongst the trees being planted in this warm country. Attention is also being given to the cultivation (here and elsewhere in Zululand) of the Rubber Vine (*Landolphia kirkii*), and interesting figures regarding the good natural reproduction and growth of this rubber producing tree in Zululand are given in Mr. Sim's report referred to above.

Private Plantations in Natal.

There is more forest planting on private plantations in Natal than anywhere else in South Africa. Round many of the substantial homesteads forest arboreta have been formed which I found of greater interest and variety than anything I have yet seen in South Africa outside the Government timber plantations in Cape Colony. The area of private timber plantations in Natal is estimated to amount to not less than 5,000 acres; these plantations, though embracing a great variety of trees, are in the main composed of Eucalypts. Besides this, in Natal is to be seen the most remarkable and successful instance of private timber planting in the modern world. The plantations of Black Wattle in Natal now embrace an area of 25,000 acres, and give a return of £100,000 yearly. They are being extended steadily. The Black Wattle used almost exclusively in Natal is *Acacia decurrens var. mollis.* I have seen the open-leaved variety (*Acacia decurrens var. normalis*) on some of the plantations, but it is stated that this does not give as good a result as the *mollis* variety. The Black Wattle plantations occupy the middle districts of Natal on a belt extending north and south above Maritzburg. In 1886 thirty-nine packages of Black Wattle bark were exported to the value of £11! During the three years, 1901–1903, an average of 13,814 tons of bark, valued at £71,662 has been exported, the average value being thus about £5 per ton. The great rise in value of the Wattle plantations that has taken place in recent years is due to the good prices obtained for the poles concurrently with the bark. From the Railway returns it appears that about 20,000 tons of mining props pass over the Railway yearly, and of these the greater portion is exported for use in the Transvaal mines. The bark is exported from Natal in the form of roughly-ground chips. Other outlets have been sought for the Wattle timber, particularly paper pulp. The reports of the trials made in 1899, however, are not favourable. The wood is too hard for mechanical pulp, and has been found unsuitable for chemical pulp by the sulphide process. The soda process yields a coarse pulp of inferior quality.

The total present yield from the Black Wattle plantations, including bark, pit-props and firewood, is put down at not less than £100,000 yearly. The £10 shares of the Town Hill Wattle Company at Maritzburg, whose fine plantations I visited in 1903, were then quoted at £100! The average cost of these Wattle plantations is set down at £6 per acre. And it is considered that for land well suited for Wattles from £1 to £6 an acre may be paid. It is now twenty years since the Black Wattle was first planted in Natal. The Wattle is fit to cut from five years upwards, the average cutting time being ten years. The yield naturally varies much with the different plantations, especially as many of the early plantations in Natal have been planted in unsuitable localities, but the average may be taken at 5 tons of dry bark and 30 tons of dry timber. The price paid for this bark at Dalton, the centre of the Noodsberg district, now averages from £6 to £6 10s. for bark in bundles, ground and bagged £1 more. Black Wattle firewood fetches up to £1 per ton, put on the railway; good pit-props double this price, or £2 per ton.

The forest expenditure provided on the current year's budget amounts to £9,028, and the Conservator of Forests also administers the two allied items of expenditure, viz.:—Fruit trees, £2,752; game reserves, £1,176.

FORESTRY IN ORANGIA.

The Orange River Colony consists of elevated treeless plains so subject to drought, frost, and drying winds that tree-growing is a matter of great difficulty. Nevertheless, the beauty and comfort of trees in such a country, and the necessity of doing something to replace the large importations of timber, have been fully recognised at Bloemfontein. In 1903, Mr. J. S. Lister made a forest tour in the country, and his report was followed by the founding of a Forest Department, which will doubtless soon develop beyond its present American modelling. Orangia Forestry is in charge of Mr. K. Carlson, an able and experienced officer, formerly in the Cape Service. He is assisted by a staff of three or four foresters and seven probationers, one of whom has been sent to the Yale Forest School to obtain a professional forest training. Plantations are being formed near Bloemfontein, and in the only part of the country where trees can be grown without great difficulty, that is to say, the Eastern frontier bordering Basuto-land. Here, two or three large Government nurseries are in process of formation, and at Prynnsberg, near Clocolan, are the oldest timber plantations in South Africa, formed by Mr. Newbury.

There is no natural forest in Orangia, and there has been much disappointment in the tree-planting efforts that have been made. This disappointment is almost entirely due to the haphazard selection made. As an instance, Bloemfontein may be mentioned. Here, for years there have been persistent efforts at tree-planting, but the tree mainly planted has been the Blue-gum, a tree making the largest demand on water supplies, while Bloemfontein has an uncertain and small rainfall, and but a poor supply of irrigation water!

The Forest expenditure provided for the Orange River Colony during the current year, 1904–1905, is £10,600.

FORESTRY IN THE TRANSVAAL.

The indigenous high timber forest of the Transvaal, with Yellowwood as the chief species, is limited to the better watered districts on the Eastern frontier. From Belvidere (near Pilgrim's Rest) one looks down on to a forest scene recalling that of the Western Ghauts of India. Here, on the top of what would be called the Ghauts in India, is the dense Yellowwood forest, stretching in a nearly unbroken line along the eastern slopes of the mountains, and spreading in patches over the plateau, occupying the southern and eastern sides of the mountains and deep dark valleys. Below the heavy Ghaut forest stretches the open forest of the hot, low country, gradually tailing away to the thorn bush and scrubs of the coastlands. The area occupied by the Yellowwood forest in the Transvaal, to enjoy the same amount of effective moisture as at the Cape, must, on account of the lower latitude and greater altitude, have a considerably heavier rainfall. This rainfall may be estimated at from 40 to 80 inches. The largest area of dense evergreen forest (Yellowwood) in the Transvaal is the Woodbush, which, with the adjoining Helsbush (so-called on account of the difficult nature of the ground) amounts to about 10,000 acres. While the Yellowwood forest does not extend beyond the heavy rainfall area of the eastern mountains, all the eastern side of the plateau, and the better watered areas on the plateau are either treeless or carry only low thorn-wood and scrub forest; there thus remains a very large area, in fact the best portion of the Transvaal, which, though nearly treeless now, is suited to produce first-rate timber forest, using the hardier trees of larger and stronger forest floras.

The first Boer settlers planted Poplars and Willows in the vleys. Afterwards the more enlightened settlers planted Blue-gum and Tereticornis gum; and, in certain localities under irrigation, such as Lydenburg (the capital of the old Lydenburg Republic), most of the winter rainfall Cape trees were planted. As long as they were irrigated such trees succeeded fairly enough. It is interesting to see the results of these early tree-planting efforts under irrigation in the townlands of Potchefstroom, Pretoria and Lydenburg.

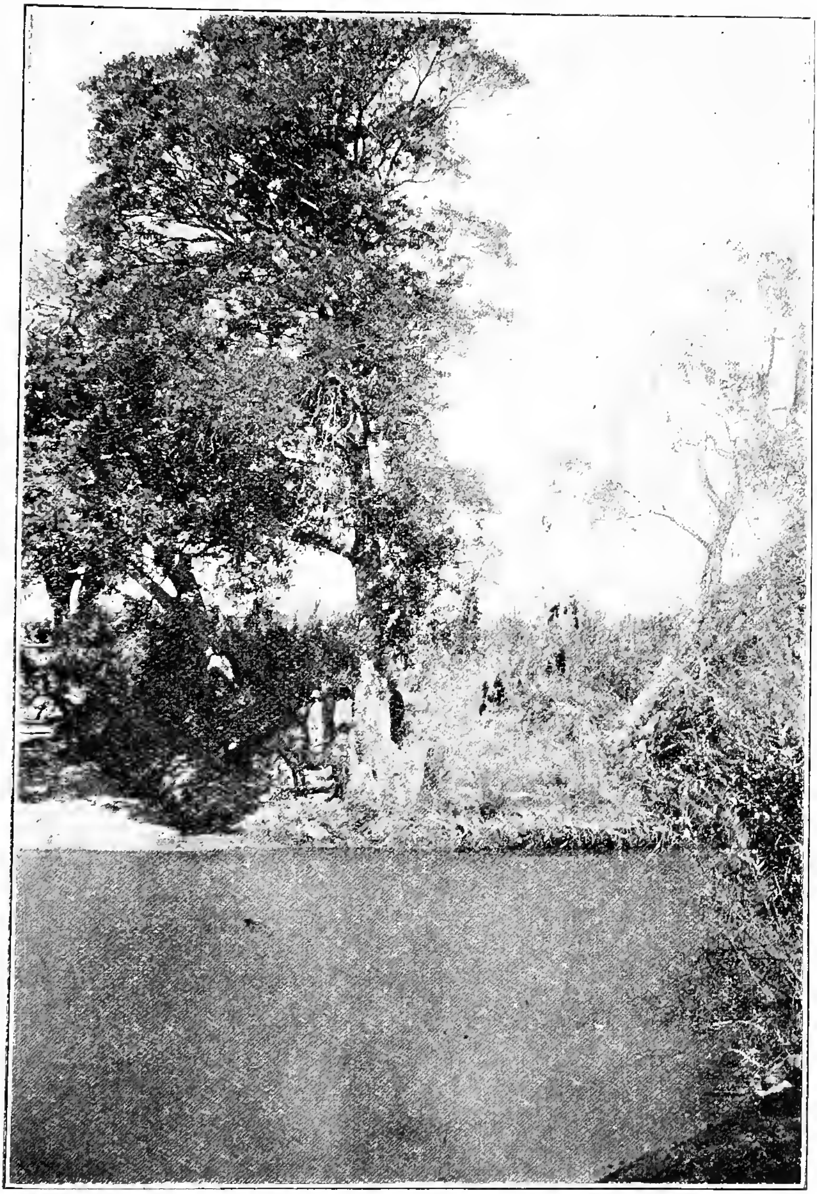
Indigenous Yellowwood Forest, M'Dich, George, nr. Pilgrim's Rest, Transvaal.

But such planting was naturally limited, and practically did not extend beyond the planting of trees for ornament and shade. With the discovery of the Johannesburg goldfields there came a change. It was recognised at once that pit timber was one of the most expensive items in working the mines, and the mine-owners laid down considerable areas of timber plantations, mostly in the neighbourhood of Johannesburg. Unfortunately, altogether fallacious estimates were based on the profits to be realised from these plantations. The rapid growth of isolated and avenue trees was taken as a basis for the growth of trees in masses. Sufficient allowance was not made for the reduced growth consequent on the increased drain on subsoil moisture when trees were planted in dense forest. It was often assumed that so many trees planted per acre would leave a nearly equal number of trees to fell at the final cutting; and, worst of all, there was little climatic selection. Fifteen years ago we were positively assured that all the trees that grow at the Cape would succeed at Johannesburg! This was an astonishing assumption!

It was assumed that trees growing naturally near the sea with winter rains would succeed on an inland plateau, between 4,000 and 6,000 feet above sea level, and where the rains fall entirely in summer. The countries to which one would naturally look to furnish trees for the Transvaal are not winter rainfall areas such as the Mediterranean and California, but summer rainfall areas such as Mexico, the drier western Himalayas, and part of the Argentine; while for test purposes, trees should be tried from the more southerly latitudes of inland eastern Australia. The slopes of the Andes will also supply certain trees. The failure of much of the early planting done around Johannesburg must not be considered any criterion of the prospects of future Forestry in the Transvaal. The largest of these mining timber plantations are at Bramfontein, near Johannesburg; the Willows (H. Struben) near Pretoria; and just across the border at Vereeniging (S. Mark's). In the latter an open, low-lying, damp, soil makes up, to a large extent, for the deficient rainfall.

In 1903 I visited the Transvaal and framed a forest scheme, which was published in a report to the Transvaal Government (Pretoria, 1903). This scheme contemplated an expenditure of £100,000 yearly for six years. The report gave a list of over 450 species of timber trees *suitable* for cultivation in the Transvaal. Of these only a small proportion are already growing there. The following year I again visited the Transvaal, and this was followed by the appointment of Mr. Charles Legat as Conservator of Forests, with a moderate staff of assistants. Mr. Legat himself is a former member of the Cape Forest Department.

During the short time that the Transvaal Forest Department has been in existence a central nursery and seed store has been established at Irene, in charge of a Forest Officer who was also for some time in the Cape Forest Department. This nursery during its first season (summer 1904–1905) had a revenue of £2,000 from



Dry Open Forest, Inchlomu Tree on Bank of River, Nelspruit, Transvaal.

the sale of young trees, which is the largest revenue of any forest nursery in South Africa.

Government plantations have been established in the following five localities :—

Lichtenberg.
Ermelo.
Pan.
Potchefstroom.
Belfast.

In these plantations excellent work has already been done. It is anticipated that 2,000 acres will be planted next season. Hardly any Mexican trees have yet been planted owing to the great difficulty in obtaining seeds of forest trees from that country. Difficulty has been experienced also in obtaining Deodar and other Himalayan seeds from India. A small plantation (350 acres), successful but costly, near Pretoria, was taken over from the late Government; and a fine estate near Johannesburg has been mape over to the Transvaal Government by Messrs. Wehrner, Beit and Co. A considerable portion of this princely gift has already been planted with forest trees. Test planting is being also undertaken in and around the indigenous forest at Woodbush, at Sàbi and at Pilgrim's Rest. Here the climatic conditions are of the best and there is every prospect that some of the finest timbers of the extra-tropics will succeed, notably many of the noble Conifers of Japan.

During its first complete working year the Transvaal Forest Department raised 1¾ million young trees, and 1¼ million were distributed to the public and various Government institutions. There were also nearly 1,000 lbs. of tree seed sold. In the various plantations there was a total area of 682 acres planted, the greater part of this planting being at Pan, a favourably-situated locality on the Delagoa Bay line, not far from Belfast.

Good progress has been made with the demarcation of the indigenous forest in the north-east of the Transvaal, an area of about 14,000 acres having already been brought into the Forest Reserves. This forest possesses peculiar interest. It lies at an elevation of from 4,000 to 6,000 feet, and marks the northern end of the dense evergreen indigenous Yellowwood forest of South Africa. North of this, across the great valley of the Limpopo, occurs forest of quite another character, the dry, open, leaf-shedding scrub-like forest of semi-tropical Rhodesia.

Timber Imported into the Transvaal.

In his last annual report, the Conservator of Forests gives the following return of timber imported into the Transvaal :—

	Unmanufactured.	Manufactured.
1896	£271,868	£328,947
1897	178,145	258,741
1898	130,013	217,447
1899	74,258	118,368 (6 months)

	Unmanufactured.	Manufactured.
1900	.. .. ..	..
1901	£15,283	£8,542
1902	275,332	67,328
1903	781,409	241,445

The forest estimates for the current year provide for an expenditure of £16,770; for the ensuing year (1905–1906) the estimates amount to £25,000.

FORESTRY IN RHODESIA.

Here we have a country in which forestry should play an important part. The natural timbers of the country are almost all excessively hard, while the majority of them are not durable and season badly. The larger portion of the high veldt of Southern Rhodesia is covered with forest of an open character, which, though better than scrub, is far from being good timber forest. Doubtless, it can be improved by demarcating out the areas that are best wooded and best supplied with moisture, and then husbanding the subsoil moisture by thinning into groups. But very much must remain to be done by planting more valuable exotic timbers, particularly Cedars and other timber of that class which fall under the description of durable softwoods. We may particularly mention several species of the genus *Cedrela*, *Taxodium mucronatum* of Mexico, *Cedrus deodara* of the Himalayas, *Callitris calcarata* and *C. robusta* of Australia, and lastly the slow-growing true Cedars belonging to the genus *Juniperus*. A list of trees suitable to Rhodesia will be found in a report prepared by the author for the Rhodes' Trustees in 1903. In this report are enumerated 440 valuable timber trees, which are more or less climatically suited, to Southern Rhodesia. This list is divided into two portions, the first embracing the more suitable trees, and the second comprising trees which, although not entirely suited climatically to the country, are worthy of test planting. Planting in Rhodesia is at present almost entirely confined to the Botanic Gardens at Bulawayo and Salisbury, and the fine work initiated by the Rhodes' Trustees in the Matopa Park. In his will, leaving the Matopa Park and its road and railway as a gift to the country, Mr. Rhodes enjoined the planting of every suitable forest tree in the Matopos. This injunction is now being carried out by the Rhodes' Trustees, and the planting of the Matopa Park will, it is hoped, soon afford an object lesson of the greatest value to the residents and others interested in the country. The Matopa Forestry scheme embraces the formation of a National Arboretum, which, for this semi-tropical country, will supplement the extra-tropical arboreta in Cape Colony and the Transvaal.

The first step to be taken as regards Forestry in Rhodesia is to determine what areas should be definitely reserved as forest, to demarcate these out, and to protect them from fire.

AREA OF FORESTS—SOUTH AFRICA.

The following statement shows the area of forests in South Africa brought up to May, 1905. This area includes the whole of South Africa south of the Zambesi, with the exception of Rhodesia and the Portuguese Territory, for which data are wanting. Though there is much open forest in the Portuguese low country, and the whole of the Rhodesian plateau is more or less covered with open forest, it is believed that in neither country is there any appreciable area of dense forest comparable to the Yellowwood forest of Cape Colony, Natal and the Transvaal. This does not mean that there is no valuable forest in Rhodesia. The Wanki Forest, yielding Rhodesian Teak, may be cited as one of probably great economic value, but the areas that it is intended to reserve as forests in Rhodesia have not yet been demarcated, and I have no data, even approximately, of their size.

Cape Colony.	Forests.	Plantations.
	Acres.	Acres.
Transkei: Demarcated, indigenous	102,000	
Plantations (1,500 wattles, 562 timber)	..	2,062
Actual Forest area, Eastern (Cons. Rep.) ..	168,000	
Plantations (including sand drifts 4,000 wattles)	..	8,877
Actual Forest area, Knysna (Fourcade) ..	90,818	
Plantations	..	905
Forest Area, Western:		
Plantations (excluding sand drifts) ..	..	11,691
Cedarberg Forest	116,494	
Indigenous Yellowwood	1,555	
	478,867	23,535

If we allow another 27,500 acres for forests in the Transkei not yet brought on to the Reserves, that would make a total of 529,902 acres of Government timber forest in Cape Colony: there are 413,408 acres of Yellowwood forest and 18,035 acres of timber plantations exclusive of wattles.

The following may thus be stated as the approximate areas under timber forest in South Africa :—

		Acres.
Cape		529,902
Natal (excluding scrub forests):		
Old Natal	40,000	
Zululand	50,000	
		90,000

Three-quarters of the Natal forests have been alienated, and of the 40,000 remaining one-third is on Native locations. For the forests of Zululand 50,000 acres is merely a very rough estimate.

	Acres.
Swaziland :	
Numerous small detached areas, say	1,000
Transvaal :	
Demarcated (1905) 14,000	
The total area of Government forest is probably about	20,000
Total Forest area of South Africa	640,902
Excluding the very poorly-stocked Cedar Forests there remains of Indigenous Yellowwood Forest	524,408

With the exception of Cape Colony, Forestry in the various South African States dates only from the reconstruction following the war: and it is only in the Transvaal that there is, as yet, any notable forest expenditure.

In Cape Colony systematic Forestry has been practised for nearly a quarter of a century, during which time over a million (£1,000,000) has been spent in the formation and conservation of the forest estates, reckoning interest at 3½ per cent. The value of the Cape Forests is estimated now at about two millions (£2,000,000).

The average value of the timber imported to Cape Colony is estimated at £450,000 yearly, and the total South African timber bill at 1½ millions (£1,500,000) yearly.

5. VITICULTURE IN CAPE COLONY.

By Professor P. Daniel Hahn, Ph.D., M.A., Professor of Chemistry, South African College.

It was Van Riebeek, the founder and the father of the first European settlement at the Cape, who planted the first vines in Table Valley in 1653. These vines were brought to the Cape from the banks of the Rhine, and, since they flourished very well, many more vine sticks were brought in 1656, principally from the Rhine and from France. We have no record as to what induced the first commander to plant vines in the "Company's Garden." There are a large number of wild vines in South Africa, and one variety particularly—*Vitis capensis*, bearing large grapes, which up to the present day are used for making preserves—is met with in woods on the slopes of the mountains of the Cape Peninsula. It is very probable that Van Riebeek, a very keen observer of nature, finding the wild vine on the Peninsula mountains conceived the idea of trying in the new settlement experiments with vines from Europe.

The earliest account of a vintage is from the muscadel grape in 1659. It appears that the first settlers took up this industry vigorously, for we hear that as early as 1681 the first wine-brandy was distilled, and that in 1687 the total number of vines planted in the vineyards of the settlers and in the Dutch East India Company's plantations was more than half-a-million.

It has been thought that the Huguenots brought with them the art of viticulture, and also the principal varieties of vines which are now cultivated in the Colony. But this is not so. The Huguenots only arrived at the Cape in 1688, whereas the first vine cuttings were introduced to the Cape twenty-five years earlier. The Huguenot settlers certainly gave a powerful impetus to the cultivation of the vine, and they have done much to improve the character of the wines produced. Soon after their arrival French Hoek, Drakenstein, and Paarl—the early Huguenot settlements—became, and are still, the centre of viticulture in South Africa.

In 1710 the increase of cultivation was so great that, according to a return furnished by the Governor of the Colony, Lowe van Assenburg, to the Governor-General of the Dutch East India Company, the vines planted amounted to 2,729,300, and some small quantities of wine began to be shipped by the Company to Java and Europe. In those days viticulture was the most prominent branch of agriculture at the Cape, and a much larger proportion of the population of the young Colony was engaged in this industry than at the present day.

The vines cultivated at the Cape for white wines were known as Steen, Green and Hanepot Grape, for red and dark wines Pontac, Frontignac and Muscadel Grape. The original vines imported had their character somewhat changed under different climatic conditions and methods of cultivation, and it is now impossible to determine accurately the varieties of European grapes corresponding with the above-mentioned Cape grapes.

In the year 1821 the number of vines in the vineyards of the Cape was 22,400,000 and the total quantity of the wine grown was 21,333 pipes. Very few people at the Cape are cognisant of the fact that at the beginning of last century the wine export from the Cape was very considerable, and that during the time 1815 to 1822 more wine from the Cape was imported into England than from France.

The following table gives the quantities imported into England :

Year.	From France. Tons.	From the Cape. Tons.
1815	2,116	1,512
1816	1,612	1,631
1817	802	4,218
1818	1,798	3,648
1819	1,543	1,648
1820	1,090	1,925
1821	1,057	2,113
1822	1,193	2,244
Total	11,211	18,939

Although viticulture at the Cape now extends over many of the south-western coast districts, and although the area under cultivation of the vine yearly increased, the export of Cape wine gradually decreased, and represents at this time a truly "negligible quantity" in the exports of the Cape. For some time the very existence of the vine was threatened when, in 1858, a certain destructive fungus, *Oidium tuckeri*, appeared in the vineyards of the Cape. It was, however, found that this fungoid disease was checked by the application of sulphur, and by its proper use the crops were restored again. In December, 1885, the *Phylloxera vastatrix* was discovered for the first time in the vineyards of the Colony, near Mowbray, and in several vineyards of the Stellenbosch district. At first it was thought that the eradication of the vines in all infested areas would prove an effective way of combating this pest. But it was soon evident that the insect spread too rapidly, and the struggle against the Phylloxera had to be abandoned. The experience gained in Europe with grafted American vines, which resisted the attacks of the Phylloxera, was then utilised at the Cape, and large nurseries of American vines have since been established at Constantia, Stellenbosch and the Paarl.

Although there is some fluctuation in the yield of the vineyards at the Cape, the Cape vigneron can always reckon on a crop which amply repays his labour. According to official returns the Colonial output of wines and spirits in 1889-1890 was 4,680,000 gallons of wine and 1,115,308 gallons of spirits; and in 1890-1891 it was 3,857,430 gallons of wine and 1,460,000 gallons of spirits. It is due to the inevitable fluctuation of trade, caused by greater or less demand, that the crop of 1889-1890 was valued at £529,932 and that of 1890-1891 at £331,730. The last census returns (1900) show the number of vines in the Colony to be 78,574,124, and the amount of wine and brandy produced therefrom to be 6,012,522 and 1,423,043 gallons respectively. The prices ruling at present are very low, and it is impossible to say how the newly-imposed excise on brandy—viz., 6s. per gallon proof spirit—will affect the future development of the industry.

The cultivation of the vine is met with in nearly all parts of South Africa, but the production of wine is limited to the Cape Colony. Even at Klein Wind Hoek, in German South-West Africa, wine is produced, and the samples of wine which the author tasted at some of the wine-stores of the settlers and of the Roman Catholic Mission at Klein Wind Hoek were very fair considering the climatic difficulties with which the growers have to contend. Table grapes are grown on some farms in the Transvaal and the Orange River Colony, which favourably compare with the best grapes in the Western Province of the Cape Colony.

In the Cape Colony the production of wine is limited to the following districts :—

Districts with more than 10,000,000 vines: Paarl and Stellenbosch.

Districts with from 1,000,000 to 10,000,000 vines: Cape, Malmesbury, Caledon, Worcester, Robertson, Oudtshoorn.

Districts with from 100,000 to 1,000,000 vines: Piquetberg, Clanwilliam, Tulbagh, Swellendam, Riversdale, Ladysmith, Prince Albert, George, Willowmore, Jansenville, Uitenhage.

The production in other districts, such as Uniondale, Graaff-Reinet and Bedford, is insignificant.

Nearly all these districts are situated in the western part of the Cape Colony, in which the climate is more favourable to the cultivation of the grape than in any other part of the globe. Here we have in spring a sufficient number of fine days with bright sunshine and also as much rain as will cause a very vigorous development of the buds, and a most luxuriant growth of the young shoots. Towards summer bright sunshine reigns supreme, but the humidity of the air is still sufficient for the further growth of the bunches, which in January and February mature under an almost cloudless sky and in a tropical temperature.

A very great contrast exists in the climate of the western and eastern part of South Africa ; whereas the climate of the Western Province is distinguished by a wet and cold winter and dry and warm summer, the eastern part of South Africa has a dry and cold winter and a damp or wet and hot summer. The heavy rain in summer in the eastern part frequently destroys the grape crop almost completely, and much damage is done nearly every year by heavy hailstorms accompanying the tropical thunder weather. In addition to these climatic drawbacks the eastern part of South Africa is more frequently exposed to visitations by enormous swarms of locusts, whose tracks are marked by the absence of everything green.

The viticultural districts in the Western Province may be suitably divided into coast districts and inland districts, being distinguished from one another by the nature of soil and climate, and consequently also by the mode of cultivating the vineyards.

The principal coast districts are Malmesbury, Cape, Paarl, Stellenbosch and Caledon ; all other wine districts may be called the inland districts. The soil in the coast districts is formed from the disintegration of granite, clay, slate and sandstone, and rarely contains as much as 1 per cent. of lime. The best vineyards in these districts are situated on the slopes of granite hills or mountains such as those of Constantia, Bottelarij, Moddergat, Jonker's Hoek, Simons Berg, Paarl, Drakenstein, Groeneberg, Riebeek Kasteel, Paarde Berg and Groene Kloof. Also at the Cape the truth of the words *Bacchus amat colles* has been observed, inasmuch, as the wine grown on hills is of a much superior quality to the product obtained from vineyards in the valleys—" vleys," where the wine thrives in a rich alluvial soil, yielding large luscious grapes containing much albuminous matter, which, however, renders the manipulation of these wines more difficult than the wines grown on hills.

The stiff, clayish soil on the hills and in the vleys of the coast districts possesses a wonderful power of retaining moisture, in consequence of which there is no need for irrigation. It is true the rainfall in the coast districts is a little greater than in the inland districts, but the difference in the mode of cultivating the vineyards is more due to the difference in the physical and chemical conditions of the soil. In the inland districts the vineyards are in the plain or in valleys where irrigation can easily be carried out. The loose, somewhat calcareous soil in these districts does not retain moisture to the same extent as the stiff clay soils of the vineyards in the coast districts, and the grapes in the inland districts do not come to perfection unless the vineyards are irrigated two to four times according to the porosity of the soil, and also in most cases according to the available supply of water, which is either collected in dams or obtained through furrows from rivers or rivulets in the vicinity. The yield of the vineyards in the coast and inland districts varies very considerably, inasmuch, as the quantity of wine obtained from a given number of vines in the inland districts is on an average more than double the quantity of wine obtained from the same number of vines in the coast districts.

In the Cape, Stellenbosch, Paarl, Malmesbury and Caledon districts the average annual yield is $1\frac{1}{2}$ leaguers* per 1,000 vines, corresponding with $86\frac{1}{2}$ hectoliters per 10,000 vines, which are, as a rule, planted in Europe on 1 hectare of land. In the Worcester, Robertson, Montagu and Oudtshoorn districts the yield is generally 3 leaguers, and even more, per 1,000 vines, which corresponds with 173 hectoliters per 10,000. But there are many wine farmers in Montagu, Ladismith and Oudtshoorn who obtain as much as 5 leaguers from 1,000 vines, corresponding with the fabulous quantity of 287 hectoliters per 10,000 vines. These inland districts are more suited for the production of sweet vines, brandy and raisins, whilst the wines of the coast districts are very light, containing about the same amount of alcohol as Rhine wine, unless they are fortified by the addition of brandy, an operation which is quite needless if only proper care and cleanliness is observed in the making and manipulation of the wines.

It is of interest to compare the yield of the Cape vineyards with the yield of vineyards in the chief wine-producing countries of the world; the following data are taken from the standard work on viticulture by the late Baron von Babo of Klosterneuburg, near Vienna:—

	Hectoliters per Hectare.
Hungary (1861-1872)	24
Hungary (since appearance of phylloxera)	6
Germany	24
Austria	14–$18\frac{1}{2}$
Switzerland	42
France	18–22
Italy	$14\frac{1}{2}$
Spain	17
Greece	$17\frac{3}{4}$
Algeria	$25\frac{1}{2}$
United States	$14\frac{1}{2}$
Australia	$14\frac{1}{2}$
Cape Colony, Coast districts	$86\frac{1}{2}$
,, Inland districts	173

The productive power of the vineyards of the Cape greatly exceeds that of any other viticultural country in the world, a fact which has not yet been properly turned to account in the economics of the country. The area under cultivation of the vine in the Cape Colony is comparatively very small, the export of wine is insignificant, and the whole industry has been since the appearance of the

*A leaguer is a Colonial measure equal to 127 imperial gallons, or $5\frac{7}{10}$ hectoliters.

Phylloxera in a critical condition. In the opinion of the author and others this critical condition has been considerably aggravated by the imposition of an extraordinarily heavy excise on brandy, the effect of which undoubtedly will be to discourage many farmers in the inland districts, where mostly brandy is made, from restoring their vineyards by grafted American vines after the old vineyards have been destroyed by the ravages of the Phylloxera.

However favourable the beautiful climate of the western part of the Cape Colony is for the luxuriant growth of the vine, it militates against the making of wine of the delicate bouquet which is so characteristic of the wines made on the Rhine, in Northern France, Austria and Hungary.

At the Cape the grapes ripen in midsummer heat, and the first fermentation is a rather tumultuous process, which proceeds at a high temperature and is over in four to eight days. The young wine has of course lost a large amount of the more volatile bouquet compounds which cannot be restored again. On the Rhine the grapes are gathered on the approach of winter. Many cellars must be artificially heated to bring up the temperature to the proper fermentation temperature. The first fermentation is a very slow process, which goes on for six to eight weeks at as low a temperature as possible, and the young wine retains all volatile compounds which, under proper manipulation, develop into that beautiful bouquet which fills the connoisseur with admiration and inspires the poets with enthusiasm. Formerly—that is, before 1880—the Cape wines were heavy and more or less fortified by the addition of brandy. It remains the great merit of the first Colonial wine expert, Baron Carl von Babo, to have demonstrated and introduced the method of making light wines—white and dark wines—with a minimum amount of alcohol. Although these wines are wanting in bouquet, for reasons explained above, they compare in every other respect very favourably with Rhine wines; they are light, wholesome, and deserve the patronage of all who wish well to the wine industry of the Colony. For the sake of comparison a few analyses made of light wines, 1904 vintage, from Klein Constantia and Stellenbosch districts are given; the data referring to Rhine wines are taken from the standard work on viticulture by Baron von Babo (1883, page 807):—

District and Name.	Total Acidity. per cent.	Alcohol. volume per cent.	Ash. per cent.
Wines from Klein Constantia:			
Stein	·574	13·25	.164
Stein	·536	12.88	.170
Hermitage	.605	11.41	.200
Wines from Stellenbosch District:			
Stein	·575	12.69	.151
Stein	·585	11.77	.199
Stein	·585	13.06	.171
Hermitage	·762	10.96	.250

District and Name.	Total Acidity. per cent.	Alcohol. Volume per cent.	Ash. per cent.
Rhine Wines :			
Deidesheimer	.68	12.33	.21
Steinberger	.75	12.64	.22
Rauenthaler Berg	.75	12.36	.17
Rüdesheimer	.78	10.57	.19
Forster Jesuitengarten	.63	11.16	.25
Schloss Johannisberger	.57	12.09	.17
Markobrunner	.79	12.10	.30

The quality of the light Cape wines is steadily improving, because most wine farmers are beginning to take more care in the making of wine by paying attention to the proper stage at which the grapes must be gathered, by keeping the temperature in the fermenting casks as low as possible, by the use of attemperators and, above all, by observing greater cleanliness in all operations.

The Cape climate brings all those grapes to perfection which are used for making sweet wines, ports and liqueur wines at the same time. We shall not be able to gain a footing with our light wines in the European market, but sweet wines, ports and liqueur wines, such as can only be made in warm climates, as at the Cape, are the brands by which the Cape wine industry will re-conquer the export trade, which it possessed nearly one hundred years ago, as soon as it has passed through the present critical condition brought about through the appearance of the Phylloxera in the Cape vineyards.

Shortly after the Phylloxera was discovered at the Cape, in December, 1895, seeds of American vines were imported into the Colony and planted at the Government Farm, Groot Constantia, for the purpose of establishing a large nursery of American vines to supply the wine farmers of the Colony with cuttings for the reconstruction of their vineyards. Although it was well known at the Cape that in all European wine-producing countries afflicted with Phylloxera all attempts to eradicate Phylloxera had proved futile, it was still hoped that by using very stringent measures of quarantine in connection with the fruit trade, by destroying affected vineyards, and in other ways, it would be possible to destroy the Phylloxera at the Cape. These hopes have not been realised. In order to save the wine industry all vineyards destroyed by Phylloxera have to be replanted with American vines, on which our varieties have to be grafted.

It had been observed in Europe that the American vines were not affected by Phylloxera, and that American vines on which other varieties were grafted were likewise immune, and remained immune. Large areas of devastated vineyards have subsequently been replanted in the European wine-producing countries, and the wine farmers of the Cape have now to follow the example of their confreres in Europe.

There exists a large number of varieties of American vines which may be used as stocks to graft on, but it appears that they differ very considerably as to their suitability for different soils and the different varieties of grapes. Only by patiently and properly-conducted experiments is it possible to ascertain which of the American vines has to be used for certain soils and for certain grapes.

This important question has not received sufficient attention yet at the Cape, and our knowledge of this subject is at present very meagre indeed. Some important facts, however, have been brought out with reference to the vineyards on the stiff clay soils of the coast districts, and they have served the farmers in their work of reconstituting the devastated vineyards on this soil. But much has to be done yet in this direction, because at present we do not know which American vines are to be used for the Hanepot grape and the Muscadel grape, both grapes being highly valued for making sweet wines. We may expect that under the direction of Mr. R. Dubois, the Government Wine Expert at Groot Constantia, this important question will receive the fullest attention. There are large nurseries under the management of the Agricultural Department at Constantia and at Stellenbosch, the mother plantations at Constantia covering 5 acres and at Stellenbosch 13 acres. The cuttings sold last year were as follows :—From Groot Constantia, 577,600 thick and 153,000 thin cuttings of Rupestris metallica, which has been found to be most suitable for clay soils ; from Stellenbosch, 133,825 thick and 39,000 thin of Rupestris metallica, 23,097 thick cuttings of Jacquez, 281,100 thick and 11,400 thin cuttings of Aramon rupestris, and 235,938 thick and 1,501 thin of Riparia Gloire de Montpellier, together 1,456,455 cuttings. A large proportion, however, of these cuttings perishes in transport, others do not take the graft, some die when planted out in the vineyards ; only about 40 per cent. of all the cuttings finally form the stocks of the grafts in the new vineyards. Last year a new plantation of 12 acres was set out at Groot Constantia, from which a limited number of cuttings will be available for distribution next season. Many of the reconstituted vineyards have been in full bearing for some years. The same observation which has been made in Germany, Switzerland, France and Austria with reference to the quality of the wine obtained from grafted stocks has also been made here, namely, that there is no essential difference in the quality of wines obtained from grafted stocks and original stocks, except that the wines obtained from grafted stocks are somewhat lighter in alcohol. This is principally due to the larger production of grapes of the grafted stocks and a smaller amount of sugar in the grape juice of the ripe grapes. However, by training and pruning a vine the production can be reduced and the amount of sugar in the ripe grape increased. On account of the enormous growth of the grafted stocks they are planted at a greater distance than was the case in the old vineyards, in which the vines were frequently planted at a distance of 3 by 3 feet or 3 by 4 feet, giving an area of 9 and 12 square feet respectively to each vine. The grafted American stocks are, on an average planted 5 by 5 feet, giving each vine an area of 25 square feet. Since there is more room between the vines the working of the ground, the pruning and sulphuring of the vines, and other operations can be more effectually carried out in the new vineyards than in the densely-stocked old vineyards.

Viticulture in Cape Colony is at present passing through a very severe trial, and it will take still many years before the Phylloxera will have run its course and destroyed the last vine of the old stocks. The replanting of the vineyards is a slow process as compared with the simple methods of planting a vineyard in the ante-Phylloxera days. For some years, whilst the diseased vineyards are being taken out and the new vineyards planted, the wine farmer has no revenue from his industry, and must try to work his way through as well as he can, but not all are able to bear the strain.

The only redeeming feature in this affliction of the wine industry is that the production of the new vineyards is in quality and quantity not inferior to what it was before. The wine industry brought here by the founder of the European Settlement of the Cape, Commander Jan Anthony Van Riebeek, is not doomed to destruction, but all who are more intimately acquainted with the past and present of this industry are confident that there are still bright days in store for the Cape wine farmers—that is to say, for the survivors of the present critical times.

6. THE SUGAR INDUSTRY OF NATAL.

By A. N. Pearson, Director of Agricultural Experiments and Chemistry, Natal; and
Alex. Pardy, Analyst, Department of Agriculture, Natal.

An industry which is capable of putting on the market £600,000 worth of produce in one year, which maintains in active work thirty mills, having a total capital value of £1,000,000, and employing nearly 8,000 persons, which keeps under cultivation about 33,000 acres of land, and which has at its doors a market of the present value of £1,250,000, must be regarded as an important one. Such is the Natal sugar industry, which from very small beginnings fifty-five years ago has grown to be one of the principal rural industries of South Africa.

The history of this industry has been written more than once. An excellent account of its rise and progress was prepared twelve years ago by Mr. David Don for the *Official Handbook of the Cape and South Africa*, edited by John Noble, 1893 (J. C. Juta and Co., Cape Town). This account, with but few alterations, would almost serve to describe the industry to-day. Mr. Don made quotations from Holden's *History of Natal*, 1855; *Notes on Natal*, by Robinson; *The Natal Journal* of 1858; *The Colony of Natal*, by Dr. Mann, 1859; *Report of Indian Immigrants Commission*, 1885–7; and the *Sugar Cane Magazine*, 1892. An early reference was made to the industry by George Russell in his *History of Old Durban*, 1855; a description of it from the pen of Mr. William Campbell appeared in *Davis' Almanack* of 1874; and in the numerous volumes of the official *Statistical Year Book of Natal* its gradual growth may be traced.

Historical.

Sugar cane appears to have been grown in Natal before the advent of the white man. In the early days a variety of sugar cane was found to be grown in small quantities about the kraals of the Chiefs, the Zulus calling it *umoba*. It is believed by some that the early European settlers brought this cane into industrial cultivation, the variety now known as Green Natal being considered to be its lineal descendant. This view is countenanced by Mr. Medley Wood, who states that the native *umoba* was cultivated by

Morewood in 1852, and that he has been unable to trace any other origin for Green Natal. On the other hand, Mr. Wm. Campbell, writing in *Davis' Almanack* of 1874, suggested the possibility of another variety having descended from the indigenous cane. "China cane," he wrote, "is now universally used in land that will not bear other cane well. Whether it is the real China cane is a moot point. Some say it was in the country many years ago, long before cane-planting was thought of." Be this as it may, the first recorded attempt of the European in Natal to grow sugar cane for industrial purposes was in the early days of settlement.

Natal was proclaimed a British Colony in 1843; it was constituted a separate Government in 1848; and between 1848 and 1850 thirty-five vessels arrived bearing Byrne's 3,792 immigrants, who swelled the European population to 7,600. It was at this early period that the sugar industry was started. Holden in his *History of Natal*, written in 1850, stated (we quote from Mr. Don's article): "Sugar is now beginning to attract attention, and it is thought it may grow advantageously. One gentleman has planted several acres. Two years ago (*i.e.*, 1848) I purchased a few plants which were brought to this place from the Isle of Bourbon. I planted them in two different situations; one failed, the other brought forth abundantly, producing canes 6 feet long and 6 inches in circumference." The gentleman who had planted "several acres" was Mr. Morewood, of the Compensation Flats on the Umhlali, 35 miles north of Durban, and it is to him that the honour of founding the industry is ascribed by old planters.

"Mr. Holden's dates are not very precise," writes Mr. Don, "but we gather that the Compensation Plantation was begun in 1849, and that Mr. Morewood's *first crop* was reaped in 1851 the implements employed in the manufacture being a pair of wooden rollers, hewn from an old mast, for crushing the canes, and an ordinary Kafir cooking-pot, of about 3 gallons capacity, for boiling the juice. Thus was obtained the first sample of indigenous sugar in Natal."

According to Mr. Mack, of Isipingo, 15 miles south of Durban, three of the settlers in that district, namely, Messrs. Platt, Burket and himself, in 1852 sent a cart and oxen to Compensation Flats to obtain cuttings from Mr. Morewood, and obtained from him four varieties, named Bourbon Yellow, Purple, Ribbon, and Green Natal. They themselves gave the name to the latter variety. They paid £3 per 1,000 for these cuttings, and brought away 3,000 or 4,000. The Isipingo Flats soon became an important centre of the young industry, and we read that in 1858 there were in Durban County alone twelve sugar mills and 1,490 acres under cane. These were chiefly on the Isipingo Flats or on the Umgeni, immediately to the north of Durban. In the Victoria County there were only four or five mills at that time, but the average acreage of cane to each mill was greater than in the Durban County. Plantations and one or two mills had been started further south also, at Umzinto and near the mouth of the Umkomaas.

The early machinery used was primitive; the first rollers were of wood—Morewood's, as already related, having been made out of a ship's mast; but iron rollers worked by oxen were early introduced, and these in their turn were soon superseded by steam-driven machinery. In George Russell's *History of Old Durban*, written in 1856, it is stated that H. Milner and J. B. Miller—of the Redcliffe Estate (?)—in the year 1855 "started new machinery to demonstrate the conversion of cane juice into sugar by steam." The machinery was small, but its introduction was regarded as a notable event in the history of the young Colony. The report of the day ran as follows:—"The beautiful little steam engine (the first introduced into Natal) and the wonder-working centrifugal machine displayed their powers to perfection, and excited the delighted surprise of all present. A quantity of thick, dark-coloured syrup was poured into the inner perforated cylinder of the centrifugal, and in exactly four minutes after the revolutions commenced (of which there were 1,700 every minute) the syrup was converted into a beautiful sample of bright, dry yellow crystallised sugar, equal to the finest qualities imported from Mauritius. In seven minutes the same syrup was converted into sugar of still finer quality, almost white in colour and far superior to the imported article. Several quantities were sold, the price averaging 30s. per cwt."

The progress during these early years was not an untroubled one. As was natural in a hilly country the favourite lands for first cultivation were the river flats. The cane was planted in the flats and the mills also for convenience of haulage were built on the same level. The result was that the cane was liable to injury from frost, and both crops and mills were in frequent jeopardy from floods. Fire also from the grass burnings, practised then as now, often swept through the cane crops. The injury from floods was serious. The mill at Springfield, in the bank of the Umgeni was, says Mr. Don, "almost totally destroyed by the great flood of 1856. The Umgeni rose 28 feet, and not only submerged the Springfield cane fields, but rushed through the factory to a depth of 9 feet and, among other havoc made, carried the heavy battery of boiling pans clean out of the masonry. On the same occasion another sugar mill was similarly destroyed on the banks of the Umhloti." A glimpse of the condition of the country in those days is furnished by an incident of the flood at Springfield, when an elephant, trumpeting furiously but vainly struggling, was swept past the factory by the irresistible flood.

It can be well imagined that difficulties innumerable arose from want of knowledge of the technicalities of the industry. The planters at first knew little about the cultivation of the cane, and practically nothing about the processes of sugar extraction. But probably their chief troubles were financial. Mr. Wm. Campbell, writing in *Davis' Almanack* of 1874, said:—"This was a poor country, and without credit, at least for purposes of agriculture. The little money there was was under the control of a few, who gave or withheld as seemed to suit themselves; 12 per cent. to 14 per cent. per annum was the rate of discount at the banks, $7\frac{1}{2}$ per cent. per annum to the merchant for his name to discountable paper, 10 per cent. commission for selling sugar. Sugar sold at four months' credit. Goods bought at an advance of 5 per cent. to 10 per cent. on market price, depending on the kind of dinner the agent had overnight, for planters were bound to purchase from him at whatever price his lordship might condescend to fix." A few years later the planters suffered from the opposite evil of a glut of money. Bank managers, anxious to find investments, induced planters to launch out beyond their strength, with the result that several were ruined when the re-action set in. In many cases estates changed hands, passing to mortgagees, absentee proprietorship being thereby introduced. From this the industry suffered in various ways. To quote Mr. Campbell :—" A creditor, being mortgagee, or company or other, insists upon all sugars going to one particular market, no matter whether it be the worst—whether to England, the Cape, or elsewhere, it must be sent where the mortgagee or the director or his agent may realise a commission on the sale. It frequently happens also that the mortgagee or the director or his agent are troubled with a love of meddling, and write to the manager, or go on to the estate and tell him what to do, when to crush, when to plant, and give directions generally as to what is to be done; and the proprietor may obey to his loss any such directions, being fast bound by the creditor."

Notwithstanding these many obstacles the industry owing to inherent fitness grew steadily until it attained such dimensions that it reached the limits of available labour, and was prevented from further expansion and even threatened with extinction from the want of hands to keep it going. To a new arrival it must always seem remarkable that with a teeming black population exceeding the whites ten-fold a labour difficulty should exist in this country. But so it is and has been for years. The aboriginal is not a worker; his ancestors have been fighters for generations, and he has not inherited the instincts of labour. He is able bodied, hardy and enduring, and in many directions teachable, but he wearies of sustained exertion and nothing but compulsion, physical or moral, would cause his race to devote itself to steady work. The Kafir works by fits and starts, but the sugar industry requires reliable labour. To meet this requirement the Government in 1859 legalised the importation of indentured coolies from India, and the first shipment arrived in 1860. By the year 1866 5,600 Indians, men and women, had been introduced.

Whatever may be the ultimate effect on the country of this introduction of coolie labour—and the effect must be very considerable, for the Indians, mostly free, now in Natal exceed in number the Europeans—there is no doubt that it had a most salutary immediate effect on the sugar industry, and not only on this industry but on the general prosperity of the country also. Mr

J. R. Saunders, of Tongaat, speaking as a member of the Indian Immigrants Commission of 1885-7, said on the subject:—"The question resolves itself into this: can the Colony afford to put a check on production, and what effect would this have on the revenue or progress and the employment of Colonists? I view it as affecting Colonial industries and their development in the broadest sense, as a question affecting the progress of the Colony, its revenues, public benefit and comfort, and, above all, as being the most practical way yet suggested in which *white Colonists* may secure profitable occupation in a Colony situated like ours. If we look back to 1859 we shall find that the assured promise of Indian labour resulted in an immediate rise of revenue, which increased four-fold within a few years; mechanics found their wages more than doubled, and progress gave encouragement to every one from the Berg to the sea. A few years later well-founded alarm arose that it would be suspended. Simultaneously down went revenue and wages, immigration was checked, confidence vanished, and retrenchment was the main thing thought of. Some years later—in 1873—a fresh promise of renewed Indian immigration created its effect, and up again went the revenue, wages and salaries, and retrenchment was soon spoken of as a thing of the past."

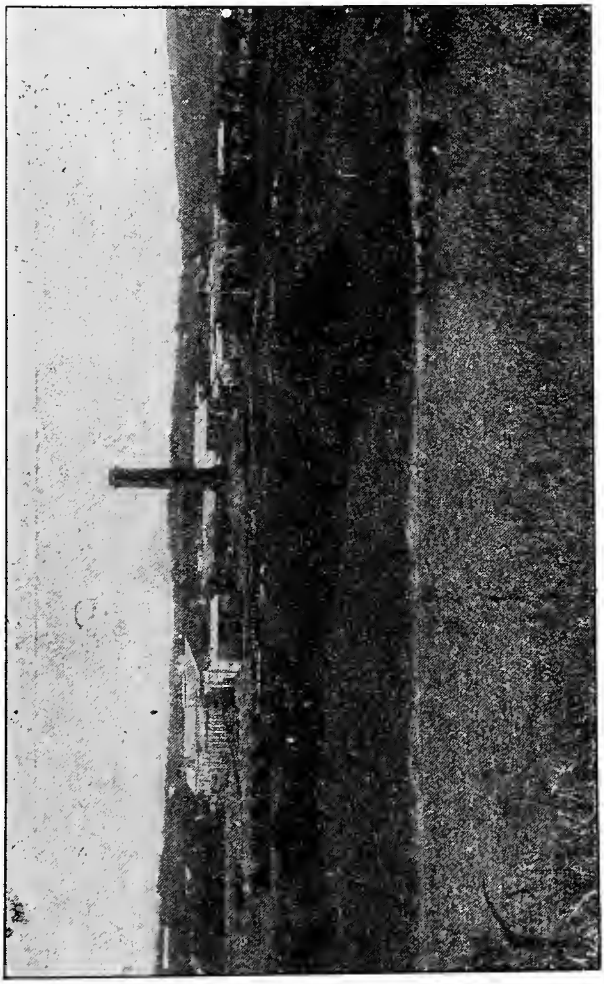
The Indian question has been and still is one of prime importance to the Colony. Its prominence is shown by the fact that since 1859 no less than thirty-three laws relating to it have been passed by the Legislature. The *indentured* cooly is a valuable and steady labourer, intelligent, industrious and generally to be trusted in his work. But the *free* Indian seldom works as an agricultural labourer for the white man, though he offers himself in limited numbers for higher classes of work. Generally he acquires land of his own, principally in the coast belt, where he now cultivates 44 per cent. of the total acreage under crop. The Indians have multiplied exceedingly since their first introduction, and now number 100,918 as compared with 97,109 Europeans. In fact, they now equal in number the estimated native population at the time of the founding of the Colony. Whether the free Indian will in time become an important source of agricultural labour for the European is a moot question.

Shortly after the first introduction of Indian labour two attempts were made to interest the Kafirs in sugar growing by providing them with mills of their own, in order apparently to see if they could be trained to habits of industry by being allowed to work for themselves. Mr. Don states that the idea was attributed to Sir George Grey, who visited the Colony—once in 1855, and again with Prince Alfred in 1860. The first mill was erected at Umvoti in 1860, but had not "even moderate success" until 1870. For some years it was under European control, and in 1872 produced 150 tons of sugar from cane grown by forty-seven natives on 300 acres of land The factory still existed in 1893, being then in the hands of two or three natives, who paid Government one shilling a year rent for it. It has since closed. The second mill was started as a result of missionary effort. It was erected in 1865 on the American Mission Station at Amanzimtote, at a cost of £700. It was the first and only steam sugar mill owned and managed by natives. In 1867 it sent sugar to the Paris Exhibition. It survived seven or eight years, and then died a natural death.

Notwithstanding the various obstacles—flood, fire and frost, want of knowledge, want of money, glut of money, inadequate labour, and financial crisis—the struggling planters persevered in building up the industry, and in the year 1864 it made an important advance, the output of that year being "three or four times that of any previous year." In 1867 a duty of 3s. 6d. per cwt. was imposed on imported sugar. In 1868 rum began to be exported, "Mr. Thomas Reynolds," says Mr. Don, "being among the first, if not the first, to recognise the distillery as a necessary complement to the sugar factory." In 1869 the census showed that there were 15,892 acres under cane, of which 5,757 were cut by Europeans and 164 by the natives at Umvoti and Amanzimtote; 7,823 tons of sugar were produced and 34,778 gallons of rum. The yield of sugar, not counting that in the molasses, was, it will be noticed, at the rate of $1\frac{1}{3}$ tons per acre harvested. In 1870-1 the opening of the Kimberley diamond fields gave a general stimulus to South Africa and enlarged the market for Natal sugars, so that whereas in 1870 only three factories possessed vacuum pans, by 1873 nine more had installed them. A few years later the attention of the Mauritius planters seems to have been directed towards Natal as a new field of operations, and a few of them together with some trained sugar artisans settled in Natal, introducing their expert knowledge into the local industry. Concomitantly with this immigration there was erected in 1877-8 the first large sugar mill in Natal. This was the Natal Central Sugar Company's factory at Mt. Edgecumbe It was built under the supervision of Mr. Alfred Dumat, from Mauritius, and was fitted up with machinery also from Mauritius. The machinery, though not new, was up to date and in advance of anything previously in Natal. The mill had a capacity of 20 tons of sugar a day, or 5,000 tons in a season. It was intended to be worked as a central factory, but from the outset the Company had themselves to grow cane in order to supplement the supply from planters.

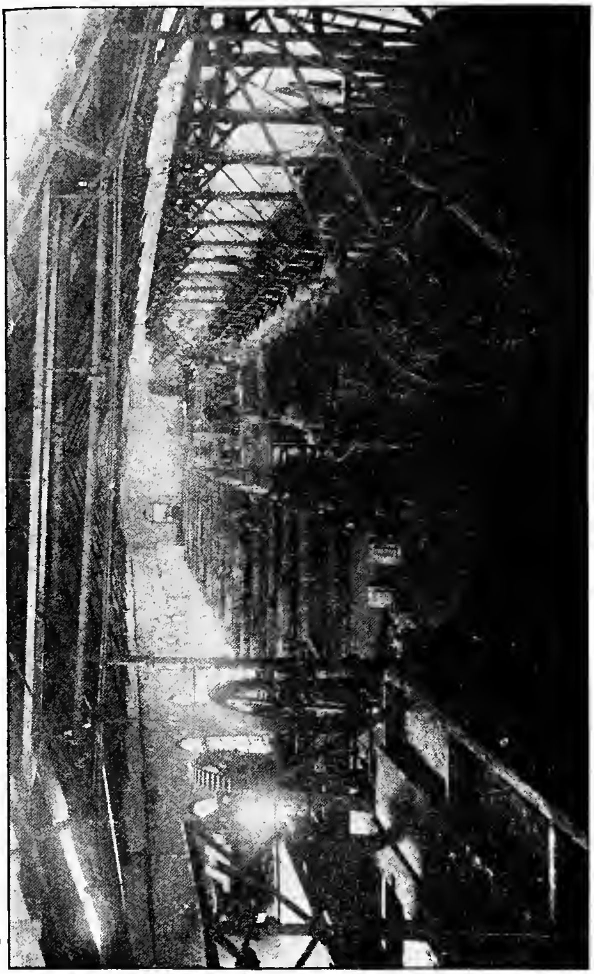
Up to this time all internal transport had been done by ox wagon, but in 1876 the railway from Durban to Maritzburg was commenced, and was opened in 1880. In 1879 a short line was opened along the north coast from Durban to Verulam. But it was not until 1891 that, in order to meet the rapidly-growing requirements of Witwatersrand goldfields, to which a rush had taken place in 1886, the main line was completed from Maritzburg to the border at Charlestown. The sugar industry responded to the growing demands of the neighbouring market and to the increasing facilities of transport, and by 1892, 26,000 acres were under cane, and the output of crystallised sugar in that year was approximately 18,000 tons.

Simultaneously with this growth of the industry, there was a course of development—observable in all progressive sugar countries—from numerous small factories to a fewer number of large factories, the latter effecting a more thorough extraction and a less working



A Sugar Factory, Natal—Exterior.

cost per ton of sugar. The mllls used in the early days were capable of crushing only half a ton of cane a day. In the Isipingo district alone there were at one time seventeen of these little mills, every planter being his own manufacturer. To-day there are in that district only two factories, one capable of crushing 175 tons of cane in a day of twelve hours, and the other probably 100 tons. In 1892 there were in all thirty-six factories at work in the Colony, thirty of these having a capacity of from 14 to 35 tons of cane per diem of twelve hours, and the other being larger. In the present year there



A Sugar Factory, Natal—Interior.

are—according to the statistical returns—only thirty factories at work, six of which may be designated first class, having capacities varying from 100 to 300 tons of cane per diem of twelve hours.

Present Position and Prospects.

Having now traced the growth of the industry from its early beginnings, it remains to examine into its present condition. So far as planting and milling operations are concerned, it does not differ in any important features from the cane sugar industry in other countries. The varieties of cane and the details of cultivation have, of course, been selected to suit local circumstances; and the present condition of the work in the mills is a natural outcome of the historical development of the industry.

Varieties of Cane.—Besides the Green Natal, supposed to be indigenous, many imported varieties of cane have been introduced. At one time a variety known as China cane was extensively grown, but it suddenly succumbed to a species of smut, *Ustilago sacchari*, and had to be discarded. The other varieties tried are princ'pa ly Lousier, Fotiogo, Bois-rouge, Imperial, Tamarand and Belle-ougete, said to be from Mauritius; Ribbon, Bourbon Yellow and Bourbon Purp'e, probably from Bourbon; also White Queen (one of the best in good seasons), Port Mackay, Gold Dust (white and red), and Rose Bamboo. None of these are now generally cultivated; they have almost everywhere been supplanted by a variety the correct name of which is unknown, but which is here called *Uba*—a name, it is said, formed of the only letters remaining legible on a damaged label attached to the variety on its first arrival in the country. Mr. Medley Wood thinks it was introduced by Governor Sir Charles Mitchell who, on returning from a visit to India in 1884-5, brought two Wardian cases containing cane plants, only three of which were alive. These were propagated by Mr. Wood, the resulting plants being given to Mr. Anthony Wilkinson. It is generally admitted, however, that this cane was introduced in quantity by Mr. De Pass, of the Reunion Estate. From a milling point of view this cane is undesirable; it is thin, tough, wiry and fibrous, and the juice needs special care in the treatment—mill managers say that from 10 to 30 per cent. more mill power is required for this cane than for any other variety. But the planters like it, since it endures the uncertainty of the Natal climate better than any other variety yet tried; it is hardy, bears frost and drought, stools prolifically, recovers readily from locust attacks, is subject to no fungus pests, and but little damaged by white ants and the borer. Recently it has been successfully grown on the highlands of the interior as a forage for cattle.

Within the last few years several varieties have been introduced from the West Indies, British Guiana, Mauritius, Queensland and Honolulu, the Department of Agriculture having co-operated with the planters for their importation. The Inanda Association have taken a leading part in this movement, and several of the canes have been propagated for distribution on their behalf by Mr. H. W. James, of Verulam. Some of these from the West Indies were recently sampled by the Department of Agriculture and analysed.

Hitherto it has not been the custom to analyse Natal canes, the chemist in fact being but little recognised by the industry, and therefore no exact comparison of the juice of the different varieties as grown in Natal can be made. The following few statements of analysis are, however, available :—

Uba Cane.

	Average.	Maximum.
Total solids in juice per cent.	20.32	22.79
Sucrose	18.61	20.79
Glucose	.18	.27
Non-sugars	1.53	1.73
Glucose ratio	1.00	1.30
Purity	91.6°	91.2°
Per cent. of juice in cane	84.28	82.30
Fibre in cane	15.72	17.70

The above analyses show a large proportion of fibre in the cane, but indicate no inferiority in the juice; in fact, the quality of the juice so far as disclosed by the analysis would not be readily surpassed anywhere.

The West Indian canes grown by Mr. James for the Inanda Association, though sampled unseasonably, gave results as follow:—

	B.109	D.95	B.15
Total solids in juice (per cent.)	15.31	17.04	16.78
Sucrose	12.68	15.83	15.19
Glucose	1.78	.28	.37
Non-sugars	.85	.93	1.22
Glucose ratio	14.17	1 .78	2.46
Purity	82.8°	92.9°	90.6°

These three juices were, it will be seen, dilute, but the purity and glucose ratio of the last two samples was good. In fact, the analyses generally show that so far as quality of juice is concerned, the soils and climate of Natal admit of cane being grown here as well as anywhere.

Soils.—The soils of the planting districts vary considerably, there being light grey sands, red sands, light loams, chocolate loams, sandy clays of all degrees of texture, grey alluvials and black alluvials. Many of these soils may be on the one farm and even in one cane field. The prevailing soil is a red or chocolate ferruginous sandy loam, light in texture and easy to work when once broken up. This class of soil is often very fertile when first cleared of bush, and has been known to give yields in good seasons of 4 and 5 tons of sugar crystals per acre from the plant canes. At one time the cane was grown exclusively in the alluvial flats, some of which have been in continuous cultivation for forty years, and still yield well. But many are of poorer quality, and as crops grown in them are subject to flood and frost, it has been found advantageous to plant on the hills, even on the steeper slopes where only hand labour can be applied. According to Mr. Wm. Campbell, "tambootie grass" land is excellent for cane.

Preparation of Ground.—In newly-cleared bush land the canes may be planted without ploughing. The bush having been cut, the timber stacked and the scrub burnt, holes may be grubbed out with hoe and axe, and the cane planted straight away. Grass land, however, requires to be broken up, allowed to lie for a time, and then cross-ploughed and harrowed. For planting old cane lands the ratoons are ploughed out—with the mould board plough, and recently with the disc plough—and the land is then cross-ploughed and harrowed.

Manures.—Very little manure is used other than mill refuse, but in the neighbourhood of Durban stuff is carted out from the Corporation stables, and in a few cases small quantities of artificials and bone dust are applied. Experiments now being conducted by the Department of Agriculture both on the Coast Experiment Farm and on private farms suggest that many of the cane lands may be materially benefitted by the judicious application of phosphatic manures.

Planting.—The cane is planted in rows 5 or 6 feet apart, or even nearer in poor land, and further apart in very rich land. The land is either drilled out with the drill plough working 9 or 10 inches deep, or it is holed out in lines by hand hoes, the holes being made 1 foot wide, 8 or 10 inches deep, and 1½ to 2 feet long, a space of from 6 to 18 inches being left between each. Sometimes whole canes are used for planting, these being laid two together in the drills, or the canes are cut into lengths of 5 eyes to each; many, however, prefer only the tops which are cut off when the canes are being harvested for the mill. These are laid, two, three or four together, in the holes or drills, at distances of 1 to 2 feet apart. The cuttings or sets, having been planted, are loosely covered with about an inch of soil. As the young shoots grow up the covering of soil is increased until the drills or holes are filled. The shoots appear in from ten to thirty days according to the weather and the vitality of the sets. The general time for planting is August to September, but it may be done as late as December and January.

Weeding and Trashing.—The weeds are kept down until the cane has grown sufficiently to cover the ground. Later on the crop may be trashed or not according to individual preference and the labour available. Trashing, by which term is meant stripping off the dead leaves and leaving them to rot on the ground between the rows, is an operation regarded as essential in nearly all cane-growing countries, the object of it being to open out the crop to air and sunshine the latter especially being considered beneficial in promoting sugar formation. In Natal the utility of the operation is by many called in question, more especially as applied to the thin-leaved Uba cane, and it is undoubtedly the case that many excellent crops are grown with no trashing save one shortly before harvesting. Where labour is scarce trashing has been done with the lucifer, the dead leaves being swept off by fire. But this burning is universally condemned by the central mills, for as might be anticipated it injures the working quality of the juice. The question of trashing will be investigated at the Coast Experiment Farm.

Harvesting.—The crop is ready for harvesting in from twenty to twenty-four months. This remark applies not only to the first cutting—the plant canes—but also to the subsequent ratoon crops. Thus if five cuttings are obtained from the one planting, that is to say one cutting of plant canes and four cuttings of ratoon canes, the crop may occupy the ground ten years. In other countries the usual time for maturing is from twelve to fourteen months. So long as land is plentiful a cutting every two years has no grave disadvantage, but with increased settlement and higher land values it would be a distinct gain if the period could be shortened. The question is one for investigation at the Experiment Farm. The average time of maturity is said to be from the middle of September to the middle of December, but cutting generally commences in August and continues into January; indeed, the shortness of labour and limited capacity of many of the mills often cause the harvesting to extend over nine months or even right through the year. With a growing industry this shortness of mill capacity, with its obvious disadvantages, must always be experienced. It is a defect which time alone can adjust.

The cut cane, having been divested of its leaves and suckers, is put into trucks which run on tram lines, portable or permanent, and is hauled off to the mill, or to the main railway, for transport to the nearest central mill. Animal power is generally used for hauling on these tram lines; but on some estates, such as those of Reynolds Bros., Ltd., at Esperanza, Messrs. Pearce Bros. at Lower Illovo, and the Reunion Estate (Mr. De Pass) small locomotives are employed. The Natal Government Railway carries cane from the estates to the central mills at special rates. Last year it carried 57,575 tons in this way, a revenue of £1,334 being earned thereby, the average distance of haulage being 11 miles.

After the cane has been cut, the trash or dead leaves is raked to the middle of the space between the rows, being afterwards buried after rotting or raked back when the ratoons are above ground; or the trash between the first and second row is raked over into the space between the second and third row, and so on, so that every alternate space is left free for cultivation. In some cases the trash is burnt just as it lies on the ground, the practice being advocated as a means of destroying grubs. The ratoon crop which springs up is treated in every way the same as the first crop after planting. From two to four ratoon crops may be taken, but each succeeding one is less in quantity than the first. From the figures available showing the yield of cut cane to the acre, it appears that the average probably does not exceed 25 tons; 30 tons is considered a first-class crop, though on newly-cleared bush land 60 tons and more have been obtained.

Factory Operations.—The treatment at the mill differs in no important respect from that in other countries. At all the factories the cane is crushed, the diffusion process not having been introduced into Natal. The following brief *resume* of the operations at one of the largest factories will give an idea of the treatment at other large factories. At the smaller mills the operations are of course less complete. At this factory, which has a capacity of about 260 tons of cane per diem of twelve hours, cane from outside suppliers is bought by weight at a uniform price per ton, but if the juice falls below an arbitrarily fixed Beaumé standard, a reduction is made in the number of tons credited. The cane is tipped from the trucks on to an endless carrier which conveys it to the mill. The mill is double, consisting of the first three rollers, an intermediate carrier for maceration, and the second three rollers. It is reckoned that 65 per cent. of juice is obtained out of Uba cane, and 70 to 75 per cent. out of softer canes.

The juice, after straining, is sent from the mill tank by a monte-jus to the sulphuring tank, from whence, after injection of sulphurous anhydride and heating, it is passed to the tempering tanks, where it is limed until neutral; it then circulates through three vertical heaters, passing afterwards to subsiding tanks; from these the clear juice is syphoned off and gravitated to the quadruple effect, the bottoms being pumped into filter presses, from which the juice runs to the quadruples, the cake being thrown to the compost heap. From the quadruples the concentrated liquor goes to subsiders, and the clear liquid from these passes to the vacuum-pan feed-tanks, from which it is sucked into the vacuum-pans. There are in the factory in question three of these pans, two of copper, of 4 and 6 tons capacity, and one of iron, of 20 tons capacity. From the large iron pan the massecuite is dropped into a mixing tank, and from this it passes to six water-turbine centrifugals. The massecuite from the copper pans goes to ten smaller centrifugals, driven by belting. The first sugars from the centrifugals are marketed for direct consumption. From the molasses four other grades of sugars are obtained and these are sent to the refinery. The fuel used for the boilers is the megass—the exhausted cane from the mills—supplemented by a proportion of coal. At most other factories megass alone is used, efficient megass furnaces being installed. To prevent over straining of the roller mills toggle gearing or hydraulic attachments are adopted in some cases. At several factories various trade preparations of phosphoric acid are added to adjust the neutrality of the juice after liming and before defecating. Taylor bags are still commonly used instead of filter presses, the bags being in some cases supplemented by "eliminators." At the Esperanza factory a Yaryan double effect has been installed. Generally speaking the large factories are up to date, so far as the machinery and processes are concerned. The principal central factories, naming them from north to south, are the Tinley Manor (Messrs. Hulett and Sons, Ltd.), recently erected, with machinery from McOnie, Harvey and Co., Glasgow, capacity 200 tons of cane per diem of twelve hours; the Tongaat (Tongaat Sugar Company, Ltd., Managing Director, Mr. E. Saunders), fitted with machinery from the Mirrlees Watson Co., Glasgow, capacity 270 tons; the Mt. Edgecumbe (the Natal Estates, Ltd., Managing Director, Hon. Marshall Campbell, M.L.C.), the earliest central factory in Natal, fitted with machinery from Mauritius, capacity 300 tons; the Reunion Estate (Mr. De Pass), with Jones and Abel's green megass furnaces and Wetzel evaporators, capacity 180 tons; the Isipingo (Mr. Platt), with toggle gearing to the mills, and machinery by

Manlove Alliott and Co., the Mirrlees Watson Co., and others, capacity about 100 tons; and the Esperanza Estates (Messrs. Reynolds Bros., Ltd.), with toggle gearing to rollers, Yaryan evaporators and electric-driven centrifugals, capacity about 220 tons. In 1876 a Fryer's concretor was installed by the Umhloti Sugar Company, and by its use from 1.72 lbs. to 1.86 lbs. of sugar per gallon of juice were obtained on the average of two seasons.

It is stated that it takes variously from 12 to 20 tons of Uba cane to produce one ton of crystals. A first-class factory has been known to obtain 1 ton of crystals from 12½ tons of Uba cane as a season's average; that is to say, every 100 tons of cane produced 8 tons of crystals. These crystals, of course, would not be pure sugar, they would probably contain 7⅔ tons pure sugar. Assuming the cane to have contained originally 13½ per cent. of sugar, there would have been obtained 13½ tons of pure sugar from 100 tons of cane had it all been extracted. What, then, became of the balance? In the absence of systematic chemical examinations it is impossible to say, but probably 3⅓ tons passed away in the megass and were burnt, ⅓ ton was lost in the filter residues and waste waters, and 2⅓ passed away in the molasses. The latter is not lost as there is a good market amongst the natives for molasses. At the small mills worked by the planters themselves it very likely, as an average, requires 16 tons of Uba to produce 1 ton of crystals. With other canes a good factory has been known to produce 1 ton of crystals from less than 11½ tons of cane as a season's average. The most serious loss at the large factories is in the megass, and the only known way of preventing this is by the adoption of the diffusion process.

Besides the factories there is at the South Coast Junction a refinery belonging to the Natal Estates, Ltd., and managed by Mr. John L. Malcolm; it has a capacity of 6,000 tons refined sugar per annum, and is fitted with thoroughly modern refinery plant from D. Stewart and Co., of Glasgow.

Present Output and Market.—According to the *Statistical Year Book* of 1903, there were harvested in that year 32,830 acres of cane from which 441,555 tons of cane were crushed, 31,628 tons of sugar produced and 34,050 tons of molasses, part of which were converted into 70,717 gallons of rum. The value of the products (not counting the rum) was put down at £608,200. According to these statistics the average yield per acre harvested was 13½ tons of cane, .96 tons of sugar crystals, and (supposing the molasses to contain 40 per cent. crystallisable sugar) .56 tons of sugar in the molasses, making a total yield of 1.52 tons of sugar per acre harvested. It is doubtful if the statistics give a correct statement of the area cut, and therefore the above yields per acre must be taken as a somewhat uncertain estimate. Possibly the true averages may be somewhat higher than here stated, for it seems likely that the statistical returns in some cases include the whole area under cane, not merely the area cut.

The total output is considerable, and for some years has been showing an upward course. *The British and South African Export*

Gazette estimates that since its start fifty-five years ago the Natal sugar industry has contributed £11,000,000 sterling to the Colony's wealth.

The value of the South African market is indicated by the statistics showing the total sugar consumed therein. The sugar consumed includes that produced in Natal and that imported from oversea. The statistics of imports and exports of sugar into and from Natal in 1904, as furnished by the Collector of Customs, were as follows :—

IMPORTS.

			£
Refined Sugar	3 434,455	lbs. worth ..	23,107
Unrefined Sugar	14,043,723	,, ,, ..	80,315
Golden Syrup	1,157,111	,, ,, ..	11,074
Glucose	125,745	,, ,, ..	606
Saccharum and Molasses	138,035	,, ,, ..	731
			£115,833

EXPORTS.

OVERSEA :	Natal Produce.		£	Imported Produce.		£
Refined Sugar	15,902	lbs. worth	136	55,575	lbs. worth	334
Unrefined Sugar	9,685,368	,, ,,	81,404	208,876	,, ,,	1,363
Golden Syrup	42,935	,, ,,	246	4,700	,, ,,	52
Molasses and Glucose	107,005	,, ,,	358	436	,, ,,	6
		Total Value	£82,144			£1,755

OVERLAND :			£			£
Refined Sugar	4,309,020	lbs. worth	38,570	933,337	lbs. worth	7,467
Unrefined Sugar	31,155,562	,, ,,	223,149	3,471,245	,, ,,	18,903
Golden Syrup	123,000	,, ,,	1,320	960,478	,, ,,	9,073
Molasses				1,385	,, ,,	15
		Total Value	£263,039			£35,458

The oversea exports were practically all to South African ports or used as ships' stores.

The imports other than from Natal into the Cape and Delagoa Bay for 1904 were as follow :—

Total imports into the Cape (estimated from eleven months returns)	£617,771
Imported from Natal	81,870
Sugar other than from Natal	£535,901
Total imports into Delagoa Bay	? £1,251
Imported from Natal	1,196
Sugar other than from Natal	? £ 55

The sugar produced in Natal in 1903 was worth £608,200 ; and its production in 1904 is likely to have been worth not less than £600,000. The total sugar consumption in South Africa in 1904 may therefore be shown as follows :—

The Natal production	£600,000
Imported into Natal	115,833
Imported into the Cape, from elsewhere than Natal	535,901
Imported into Delagoa Bay from elsewhere than Natal	55
Total consumption in South Africa ..	£1,251,789

This figure represents the present value of the market available for Natal sugar. It is evident that if the Natal output were double what it is it would still find a local market. That market is protected by an import duty of 3s. 6d. per 100 lbs. on raw sugars and 5s. on refined, and by differential rates for Colonial produce on all South African railways.

The further expansion of the industry will depend not only on the increase of area under cane, an increase which will soon take place by the opening up of Zululand, but also on the increase of the yield of cane per acre, the shortening of the period of growth of the crops, the increase of the sugar contents of the cane, and on the more complete extraction of the sugar. The increasing of the yield, the shortening of the period of growth and the increase of the sugar contents are matters for experimental investigation and systematic selection of canes, work for which an Experiment Farm has been started by Government at Winkle Spruit, near the mouth of the Illovo River on the South Coast. The more complete extraction of sugar from the cane will result from the increasing use of large central factories, and also from the introduction of the chemist. At present, except for the refinery, the chemist is ignored by the Natal sugar industry; but the results obtained in Australia, at Hawaii, in the United States, and in other countries where the chemist is systematically employed are being watched in Natal, and it is not unlikely that before long a sugar chemist will be imported as an experiment by one of the larger mills.

7. TEA CULTURE IN NATAL.

By A. S. L. Hulett.

Early History.

It appears from records that the first tea-plants grown in Natal were introduced from Kew in or about the year 1850. They were supposed to be of the Indian variety, but subsequent knowledge has led me to the conclusion that they belonged to the China variety. The plants grew healthily, and propagations from them were tried in a small way in the Victoria county and other parts of the coastal districts of Natal. It was not, however, until more than a quarter of a century later that tea culture was taken up practically in Natal.

From causes well known to the oldest residents of the Colony, the Coffee Industry of Natal, which, until the years 1877-78, was in a most flourishing condition, suddenly failed, and it became necessary for those who had capital invested in that enterprise to look out for some other means of livelihood. It then occurred to my respected father Mr. (now Sir) J. Liege Hulett, who was at the time Chairman of the Lower Tugela Planters' Association, that as the tea plant, though of inferior "jat," flourished in several parts of Victoria County (and in no instance had there been any failure in its growth), that it was only a question of the introduction of the proper class of plant in order to establish a new industry. The matter was brought before the Lower Tugela Planters' Association, and the late James Brickhill, of Umbilo, having kindly offered his own services and those of a friend in Calcutta to obtain seed, and have it attended to on the way over, the Government was approached to render some assistance. They acceded to the request, and provided freight from India to Durban in the chartered steamer "Umvoti." A small syndicate was formed to defray the cost, and the seed upon arrival was divided pro rata according to amount invested by each member, the largest share falling to the proprietor of the now well-known Kearsney Estates. The seed left Calcutta about the beginning of January, 1877, was landed from the "Umvoti" about the 13th of March of the same year, and planted out in nurseries as soon as it arrived.

Unfortunately about the time that these plants were planted out the District was visited by a severe drought; the consequence was that the greater portion of the seedlings were destroyed, only 1,200 plants surviving out of the 4,000 which were successfully raised from the imported seeds. The seriousness of this loss can better be appreciated when it is borne in mind that the surviving plants would have to attain the age of three to four years before any mature seed could be obtained from them. It was, therefore, not until the year 1880 that the first seed was gathered from these trees, and then there was only enough to plant five acres. As a consequence no serious attempt to extend the cultivation was made until the year 1881, and again great difficulties had to be overcome, drought and insect pests destroying a large percentage of the young plants. It was, indeed, not without many discouragements that the Tea Plant ultimately became established and increased from the first 1,200 plants, covering a little over half an acre,—which, by the way, are still to be seen in a healthy and vigorous condition, some of them having reached a surface diameter of 12 feet—to the large area under cultivation now covering some 4,000 acres.

Varieties of Tea.

There are two main varieties of tea under cultivation in the tea producing countries of the world, namely the China and the Assam, and there are many hybrids between these. The two varieties were at one time regarded as distinct species under the names *Thea Chinensis* and *T. Assamica*, but no tea has yet been discovered growing wild in China, and botanists are now inclined to regard the indigenous tea of Assam as the parent species of all cultivated varieties.

The variety introduced into Natal from Kew in 1850 was—as I have already stated—probably the Chinese, though it was at the time supposed to be Assamese. The varieties introduced in 1877-8 were pure Assam from the Rookang Estate, and a China-Assam Hybrid from the Longeeburr Estate, of the Assam Tea Company in India. Experience has shown that the Assam Indigenous is the most suitable variety for the tea districts of Natal; but owing to the ready cross fertilization of the tea blossom, there is probably little or no pure Assam seed now obtainable in Natal, and most of the estates are planted with tea of various degrees of hybridization.

Method of Raising Tea.

There are several methods of propagating the tea plant. First, from seed planted at stake, *i.e.*, direct from the pod to the site where it is to grow; second, from seedlings planted out in nurseries; and, third, from sprouted seed, *i.e.*, seeds planted thickly in beds, with a thin layer of earth over them to sprout them. Each of these three methods has its advocates, but no hard and fast rule can be laid down, as so much depends on the time of year and the weather when laying out the garden. If the ground be ready when the seed is ripe one cannot do better than plant at stake.

It would be advisable, however, to plant three or more seeds in one hole, thus insuring at least one plant winning through, though it will often be found that the whole of the seeds planted will survive in one hole, whilst in the next all will have perished; thus the advantage of having more than one plant in the neighbouring hole will be apparent, for the overplus are available for transplanting on a wet day to the vacant spot. It often happens, however, that the land is not ready when the seed is ripe; in that case it is necessary, in order to preserve it, to plant it out in nurseries, where it will germinate and grow into a plant of some 3 inches to 4 inches high; this is the best height for planting out. The other plan of planting sprouting seed commends itself to many, and if the season is favourable good results are obtained. In each case all the plants should be well shaded with leaves or grass, and these shades should be allowed to remain until the plant is well grown.

The distance between each tea-bush varies from 4 ft. x 4 ft. to 4 ft. x 5 ft. The latter distance is, to my mind, preferable, as giving the plant more room to develop a good wide surface or "top," an object which should always be aimed at, for it is from this wide surface that the "flush" is obtained.

Soil.

The soil most suitable to the successful cultivation of tea is a sandy loam, with sandstone formation. Open grass land also gives good results, provided it is of a sandy nature and without a clay or shale sub-soil. Red chocolate soil, if not too heavy, is often found to yield excellent results, though the tea plant takes longer to establish itself, but when established will often give heavier crops than on the first-mentioned class of soil. Tea plants can be grown in almost any part of Natal, but this fact should not be taken as an indication that it can be grown to pay in every part. Climate and altitude are important factors, and unless those are suitable, the leaf production will be restricted, thus making all the difference between profit and loss. A fairly reliable test as to suitability of soil is to ascertain first the best soil for sugar growing, and then avoid it for tea; for, as a rule, tea will not thrive where the sugar cane is most at home.

Age of Plants.

The tea plant comes of age, so to speak, from four to five years, but plucking may be commenced at 2½ to 3 years. At this age it may be reckoned that it just pays its way; great care, however, should be exercised that the plants are not overplucked when so young, as the tendency would be to dwarf them for all time.

Pests.

The tea plant, like everything else in Nature, is not without its enemies, though, so far as our experience goes in Natal, it has but comparatively few. The principal disease found in the tea plant is what is commonly called Red Spider, a minute insect which attaches itself to the leaf, giving the bush a red appearance. Though the death of the plant rarely if ever follows the attack made upon it by this insect, all leaf production is instantly checked, and when a large area is infected great loss is incurred. In the past Natal tea gardens have not been attacked to any great extent, but during the last two seasons considerable loss has been experienced. This pest is common in Assam and Ceylon, and at times so serious does it become there, that whole gardens are cut down, and the bushes burnt, to free the remainder of the estate from the blight. To the unitiated this would appear to be rather a drastic method of dealing with the disease, but the destruction of the plant does not follow, it soon shoots up again, and in a couple of years is again productive. Another remedy I believe will be found. Mr. Claud Fuller, the Government Entomologist, has suggested sulphur, and if the pest again makes its appearance this remedy will be applied. The Red Spider usually makes its appearance about the middle of the plucking season, and lasts about three months; heavy rains have been found to clear the tree of the blight.

Altitude.

The altitude best suited to tea is about 1,000 ft. above sea level. I do not wish it to be inferred that it will not grow to pay at a lower level, but, that being the altitude of the most successful tea gardens in Natal, one is led to regard it as the most advantageous. The general features of the land at this altitude are usually of an undulating nature, and well watered, the climate sufficiently humid to encourage leaf production, whereas, at a higher altitude, humidity, which is essential, seems to be lacking. Weather plays an important part in the successful growth of tea, plenty of heat and moisture are both necessary, and this state of climate is to be had on the coast of Natal, though recently it has been favoured with more heat than moisture. The average yield per acre of made tea in Natal is approximately 600 lbs., though when the land is very rich and conditions favourable, as much as 1,200 lbs. may be obtained, but this is exceptional. The importance of high cultivation cannot be too strongly urged, and it may be truly said of the tea bush, "the more you do for it the more it will do for you." It may be safely said that the life of a tea planter is more to be desired than that of most occupations, inasmuch as when once a tea garden is established, it is there for all time. The risk from fire and flood is reduced to a minimum, its greatest enemy being drought. The anxiety attendant on sugar-growing is non-existent, it being impossible to burn a tea plantation, and the locust swarm has no terror for the tea planter.

The plucking season commences from September, and lasts to the beginning of June, and during that time each tea bush is plucked about 16 times—to use a technical term, 16 flushes are obtained in the season. The slack time, if such there be, is fully occupied in pruning the bushes, a most important item in tea culture. The coming season crop may be made or marred by the manner in which this process is carried out, and the knowledge of which can only be gained by practical experience. The object aimed at in pruning is to thin out the growth which takes place during the summer months, and which, owing to the constant plucking, becomes very dense and matted. There is a great difference of opinion as to the best manner of pruning, some advocating "heavy pruning," which consists in cutting the plant back and leaving very little vegetation; others believe in "light pruning," i.e., leaving as many leaves and cutting away as few branches of the tree as possible. In some cases heavy pruning is a necessity, as from constant pruning year after year the plant becomes knotted and gnarled, so that a thorough cleaning out is imperative. The tea plant, if allowed to grow unchecked, would reach a height of from 20 ft. to 30 ft., but the trained plant is encouraged to spread rather than ascend, and is kept at a uniform height of about 2 ft. 6 in. After pruning, which should be over by the end of June, or middle of July, the ground ought to be hoed over, and the prunings or lopped branches and leaves, buried, thus returning to the soil some of the constituents which the plant has taken from it. This process is best done by means of forks or pronged hoes, so as to avoid the roots of the plants being cut, which would be the case if an ordinary hoe were used. The cutting or bruising of the roots should be avoided if possible, for every root so damaged will send out a "sucker," which will drain the parent bush, resulting in a loss of leaf.

Manuring.

It is a well known axiom that if something is taken from the soil its equivalent must be returned, and this can only be done by means of fertilisers. Hitherto chemical manures have been but little used on Natal tea gardens, and their suitability has yet to be proved; not that I have any doubt of their adaptability, but, so far as my experience goes, the quantity required per bush to give the desired results would be too costly, and thus counterbalance any gain which might accrue. The old-fashioned farmyard manure has done good service, and to my mind, if this were available in sufficient quantity, nothing better could be desired. It has the advantage over all artificial manures of being bulky, and, when buried at the root of the bush, retains moisture for a considerable time.

Plucking.

Reference has already been made to plucking, which commences in September and lasts until June. The first "flush" is usually ready for picking about the 7th or 10th of September. A "flush" is the term used to signify the leaf which is suitable for the manufacture of tea, and which consists of three or more young growing in one single tender shoot. It is not generally known he different qualities which are to be bought at every grocer's ıe product of the same bush, and are gathered and manu-ed simultaneously, the younger the shoot the higher the of tea; thus the bud or uncurled tender leaf goes to supply the broken or Orange Pekoe, known locally as "Golden ," and the next leaf in size and age goes to make the next and so on, down to the oldest leaf and lowest grade. It is ıs, therefore, that if the youngest leaves only were plucked, er grade of tea would be made, but would, in consequence, t the output. The flushes recur at intervals of about ten according to the weather, and if the tea garden covers a large would often happen that as soon as the first flush is plucked ne to commence again. Indian labour is employed in the pluck-ıd the Indian women are eminently fitted for this branch of dustry. The average quantity of leaf brought in per man per about 36lbs., which represents 9lbs. of manufactured tea, the tion of green leaf to made tea being 4lb. to 1lb.

Manufacture.

thout being too prolix I will give a rough outline of the pro-manufacture. The leaf is brought into the factory twice a being gathered either in baskets or sacks; these are weighed tely, so as to detect any shirking of duty; and the leaf is arried up to the "withering" loft. The first process after ng is to wither the leaf, this takes from 12 to 14 hours, ling to the state of the weather, which can hardly be too hot ltry for the purpose. What is called a "good wither" is a *ua non* for good tea-making. The correct condition of the hen well withered is ascertained by the feel, which should be ıd silky to the touch. From the withering floors the leaf is to be "rolled," this being done nowadays by machinery, has superseded the old method of hand rolling, the process half-an-hour. From the rolling-machine it has to go h the stage of fermenting, or correctly speaking oxidising. is no fixed time for this process, as it is hastened or retarded condition of the atmosphere, a muggy day gives the best and the proper state of fermentation is known by the colour "mash" or rolled leaf, which should change from the l green to a bright copper. It is an interesting fact that the copper colour of the well fermented "mash" when dried or l is retained after it is dry and can be seen in the infused at the bottom of every family teapot. The "firing" or is done in machines of various patterns and designs, each of has its individual merit, the object being to desiccate without ing or burning, and to avoid this, great care and attention mbent on the part of the man who tends the machine.

ıave now given you a description of the four different ses which together complete the manufacture of tea, viz., withering, rolling, fermenting, and firing. For all practical purposes the article is now fit for consumption. When arriving at the last mentioned stage it contains all the different qualities which have to be separated and graded. This is accomplished by means of "Tea sorters," or an arrangement of sieves of different size mesh, the finer mesh separating the higher qualities. After the sorting process has been gone through the tea is ready for packing and despatch to market.

Natal tea has a distinctive character of its own, and while it is not so pungent and harsh to the palate as Indian and Ceylon tea, for which reason it is considered by so-called experts to be of inferior quality, it is in reality a more wholesome tea to drink than either of the Indian teas before mentioned, as it contains a much lower percentage (as much as 7½ per cent. less) of tannic acid, and it is richer in caffein, which is the stimulating principle of tea and coffee, whilst tannin is the most unwholesome.

A blend of Natal and Indian tea is being at present forced upon the Colonial market. Whilst this may be a sound and successful commercial venture it is not, to my mind, calculated to further the progress of the Natal tea industry, for it procures a market for the teas of outside countries which should be supplied by the Natal grown article. This practice is being resorted to, not because Natal teas fail to find favour with the consumer, but because the demand is beyond the present supply. If those who are engaged in this hybrid trade were to concentrate their energies and capital in increasing the output of Natal tea they would be conferring a lasting benefit on the Colony.

Natal is capable of producing every ounce of tea consumed in South Africa, as the following figures will prove. There are at present under cultivation approximately 4,000 acres of tea, and the total output for the Colony is 2,000,000 lbs. The quantity of tea imported into Natal for home consumption during the year 1902 was 145,000 lbs., and for the whole of South Africa, *via* Cape ports and Durban 6,134,697 lbs., thus showing that Natal does not produce more than one-third of the total requirements of South Africa. It will, therefore, be seen that to produce enough tea to satisfy the present South African demand, from 12,000 to 13,000 acres of land need only be brought under cultivation, assuming that the rate of yield per acre is the same as at present realised. In fact there is far more land available in Victoria County alone than these figures represent, to say nothing of other parts of the coast district of Natal and Zululand. To emphasise the capabilities of the Colony in this respect I need only mention that the area of Victoria County is 1,290 square miles, and the Magisterial Divisions of Alexandria and Eshowe comprise an area of 779 and 690 square miles respectively, making a total of 2,759 square miles. I do not wish it to be inferred that all this land is suitable for tea growing, but I wish to point out that a belt of tea land extends right through the area mentioned. Sufficient land to supply all the tea consumed in South Africa at the present time can be found in the Division in which I live, but I regret to say that most of it is in the hands of absentee landlords.

Conclusion

To render this paper of some practical use to intending tea planters, I will give an estimate of the cost of planting 200 acres of tea and of bringing them to the reproductive stage, leaving out the purchase price of the land, which, in these days of gold discovery and land speculation cannot well be arrived at.

I will assume that the garden is opened out in June, 1905.

1st Year's Expenses, from June, 1905, to June, 1906.

	£	s.	d.
Cleaning, Ploughing, Holing and Planting 200 acres, at 65s. per acre	£650	0	0
Cost of Plants, per acre 20s.	200	0	0
3 Weedings, at 4s. per acre each, 12s.	120	0	0
Cost of Tools and Implements	60	0	0
	£1,030	0	0

2nd Year's Expenses, from June, 1906, to June, 1907.

	£	s.	d.
4 Weedings, at 4s. per acre each, 16s.	£160	0	0
1 Hoeing between Plants, at 15s. per acre ..	150	0	0
Cost of Tools, etc.	30	0	0
	£340	0	0

3rd Year's Expenses, from June, 1907, to June, 1908.

	£	s.	d.
4 Weedings at 4s. per acre each, 16s.	£160	0	0
1 Hoeing between Plants, at 15s.	150	0	0
Tools, etc.	30	0	0
	£340	0	0

Total Cost for 3 years £1,710 0 0

Return from sale of tea at end of 3rd year

40 lbs. tea per acre—8,000 lbs. at 6d. per lb. £200 0 0

It will be seen from the foregoing that by the end of the third year's operations, a revenue of £200 is derived, which goes a long way to pay working expenses of that year; and this amount may be augmented by planting catch crops of maize or beans between the tea plants without any injury to them, if carried out in moderation. By the end of the fourth year one may reasonably expect a yield of 250 lbs. per acre of made tea, or, say, £1,250 worth of tea for the whole garden. In the above estimate I have not gone into the question of manufacture, as this should, in my opinion, be treated as a distinct concern, the cost of machinery, and working of same, being kept separate.

Now, having given the characteristics and requirements of the tea plant, it only remains for me to add the necessary attributes of a successful tea planter: plenty of pennies, patience and perseverance.

SECTION VIII.—EDUCATIONAL AND HISTORICAL.

1. NOTES ON THE HISTORY AND STATE OF EDUCATION IN CAPE COLONY.

By Thomas Walker, M.A., LL.D., Professor of Philosophy, Victoria College, Stellenbosch.

To make a succinct statement of the conditions and arrangements for education throughout a wide territory is always difficult. The difficulty is greater than usual in the case of Cape Colony owing to various circumstances. The Colony of the Cape of Good Hope counts already more than two hundred and fifty years of European occupation, and during that time there has been a less or more sustained effort to make provision of a sort for education. But the historic Castle of the Cape of Good Hope, which was Van Riebeek's settlement, has been remarkable chiefly as a point of departure for ever-widening explorations and settlements; and these were often made under conditions not at all favourable to education. To the difficulties arising from the circumstances of a very much scattered population there fall to be added those connected with its curiously-mixed racial elements. In addition to the two leading white races, English and Dutch, there are some not inconsiderable elements from other European countries; and there are the multifarious native races with their very various physical and mental characteristics and possibilities. To frame a system of education which should cover with an elastic and adaptable network a population existing under such difficult and diverse conditions has been the aim of the successive heads of the Department of Education in Cape Colony. Very briefly to sketch this system in its history and its present form is the purpose of the present paper.

A. The Early Days.

From the beginning of the European settlement under Van Riebeek in 1652 the Governor and Council of the Cape kept an eye upon education. Not only were the children of the factory and garrison and settlers provided for, but there were regulations for the baptism and instruction of the natives (slaves) employed by the individual settlers and in the service of the Dutch East India Company. When it is remembered that the Castle in Cape Town was chiefly regarded as a factory and calling station, where vessels might take in supplies on their way to the Dutch East Indies, it becomes easier to understand that exploration, prospecting, big game shooting and farming over vast sheep and cattle runs, opened out the country in many directions, without giving it those settled conditions in which education is likely to prosper.

It must be constantly borne in mind that during the Dutch occupation the population, except in the small south-west corner of the Colony, was exceedingly sparse. The few comparatively important centres of population were the places which had been chosen as locations for churches; and the area which the Dutch Reformed minister had to superintend and visit resembled a diocese rather than a parish. Each of these church-villages had its school, generally taught by the parish clerk, and largely dependent for its prosperity upon the amount of interest taken in it by the clergyman. In the first hundred and fifty years of the Colony—that is, down to the English occupation, at the close of the eighteenth century—only seven congregations or parishes of the Dutch Reformed Church had been fully established, the most distant of these from Cape Town being Graaff-Reinet and Swellendam. In the numerous out-stations of these parishes small centres of population had been gathering strength; and, accordingly, we find that in the first twenty-five years of the nineteenth century nine new congregations (with their full ecclesiastical and educational machinery) were established. The foundation of Grahamstown, in 1812, and the arrival of the Settlers in 1820, mark the beginning of the colonisation of the Eastern Province.

B. The Herschel System.

The increase of settled centres of population and the need thence arising for better educational facilities led to various proclamations and ordinances for regulating education being issued from time to time, as by Commissary De Mist (during the Dutch re-occupation, 1803-1806) and Governors Sir John Cradock and Lord Charles Somerset. In 1839 Dr. J. Rose-Innes was appointed the first Superintendent of Education, and it was under his supervision that effect was given to the so-called Herschel system of Colonial schools. The draft scheme had been set forth in a long memorandum from Sir John Herschel, addressed to the Governor in 1838; and the Superintendent of Education appointed in accordance with that memorandum reduced the recommendations of Sir John Herschel to a working system.

The teachers in the schools under the Herschel system were to be appointed and paid by the Government, and transferred at its choice. Besides the drawback that the teachers in these schools were thus apt to lose touch with the people of the district, there was the fact that the number was felt to be sadly inadequate; and the system was almost from the beginning supplemented by grants-in-aid to Mission schools and to schools among the scattered farming population.

In 1859 Dr. (afterwards Sir) Langham Dale was appointed Superintendent-General of Education, and almost immediately a Commission was appointed to revise and extend the system of public education.

1865, which substituted for the "Established" schools of the Herschel system a system of schools in which (so far as the white population of the Colony was concerned) the principle was adopted of making grants-in-aid from public funds for the establishment and up-keep of schools wherever a committee elected by a body of local guarantors could be formed. Special regulations were made for schools of a humbler class under the management of missionaries of the various Churches, and for schools among the aborigines, in the Native Territories, which were from time to time brought under the jurisdiction of the Governor of Cape Colony.

Provision was made in the Act of 1865 whereby modifications and extensions in the regulations and schedules of the Act, if approved by resolution of Parliament, were to obtain the force of law. It is probably this power of ready modification (under reasonable safeguard) which has enabled the Act to remain in force so long.

Dr. Muir, the present Superintendent-General of Education, who came into office in 1892, has vigorously pursued the work of extending the educational system of the Colony and co-ordinating its parts.

D. The Public Undenominational Schools under the Act of 1865.

The general principles regulating the action of Government in the matter of public education are laid down in the Act of 1865, with its amending and supplementary regulations as approved by resolution of Parliament from time to time.

In the case of the Public Undenominational Schools Government is prepared to issue grants-in-aid towards the maintenance of any school organised by a Municipal or a Divisional (County) Council, or by a local committee elected by a meeting of guarantors who have undertaken to support the committee in making good any deficit in the local contribution required to meet the Government grant.

These Public Undenominational schools are of three classes according to the range of the course of instruction. Schools of the first or highest class are intended to carry pupils forward to the Matriculation examination of the University, and are generally intended for boys or for girls only. Schools of the second and third classes are generally mixed. Government aid is extended to these public undenominational schools in the shape of grants towards the salaries of teachers, grants towards the erection of buildings or towards the rent and furnishing and up-keep of buildings, and grants towards the management of boarding-houses in connection with the schools. The scale of grants-in-aid naturally varies much in the schools of these very different grades.

For the system of grants-in-aid to local committees it is pleaded that it tends to call out private or local exertion and interest. Against the system it is maintained that just those places are left untouched where Government or Departmental initiative is most necessary and would be most helpful. At one time the complaint is made that the local committees are often coteries of one predominating political or ecclesiastical tone. On the other hand, the complaint of those who manage the schools is that they have to perform a thankless task, which not infrequently lands them in serious (or at least annoying) pecuniary indebtedness. Teachers complain that the possibility of such a committee of management dissolving at the end of the three years for which it was originally elected makes their tenure of office very insecure. It is with these difficulties in view that the Colonial Government has brought in a Bill (March, 1905) for establishing school boards for divisional and municipal areas, with continuity of existence, with popular election, and with legal powers for making good any deficits in local school revenues.

E. Mission Schools and Schools in the Native Territories.

In the case of those parts of the community where it is impossible to secure the appointment of voluntary committees, and in the territories, where the population is practically wholly native and uncivilised, Government avails itself of the existing organisation provided by the various Christian Missionary Churches. For each school or group of schools Government recognises the superintending European missionary of the district as its correspondent. Appointments of teachers are made by him subject to the approval of the Department of Education; and all returns from, and payments to, the schools pass through his hands. All the Churches are at liberty to share in these subsidies from Government, if they will undertake to give thorough secular instruction to those under their care. Doctrinaires may object that this system looks very like concurrent denominational endowment. Practical educationists will admit that probably no other means would secure an equal amount of intelligent and continuous supervision for the schools among the vast and varied native population of Cape Colony.

F. Extensions of the Public Undenominational System of Schools.

The foregoing paragraphs will indicate the leading features of the system of public undenominational schools, and of schools for the native population in the Colony and the included territories. As complementary developments of the system may be mentioned the boarding houses for pupils who come to the schools from distant parts of the country, and the industrial schools (or industrial departments of general native institutions) where training is given in carpentry, blacksmith work, wagon making, printing, book-binding, shoemaking, tailoring, farming and gardening for lads, and domestic work and needlework for girls. For white children living on farms more than three miles distant from a public school a system of private farm schools has been arranged, whereby any family or group of families containing not less than five children of school-going age may obtain grants-in-aid (based on attendance and inspection) such as will enable the head of the family to engage a properly qualified governess. Poor schools for destitute or neglected white children have been opened in a number of important centres, where local co-operation and supervision have been secured. Institutions for deaf and dumb pupils are subsidised at Cape Town and Worcester. The Government School of Agriculture is at Elsenburg, in the division of Stellenbosch.

Side by side with the endeavour to bring education nearer to the door of every household in Cape Colony, there has been, under the present Superintendent-General, a vigorous and sustained effort to widen the scope of the common school curriculum, especially on the practical and aesthetic side. Subjects such as vocal music, drawing, woodwork (for boys), domestic economy (for girls), and the natural and applied sciences, have received greater prominence and substantial departmental support. In connection with all these subjects there are special inspectors and annual competitive examinations.

In the important work of providing a supply of teachers for the steadily extending school system considerable progress has been made. It should be remembered also that this progress has been made, not only under the general economic condition that other callings offer greater pecuniary inducements than teaching, but also under the special difficulty arising from the fact that for some years before the recent war the northern states were able to attract into their teaching service a large number of those who had been trained under the Education Department of Cape Colony. To improve the professional efficiency and status of teachers Dr. Muir has revised the regulations for certificates, and has added to the previously existing third class and second class certificates a first class teacher's certificate (open as a rule to University graduates only, after five years' teaching service). In addition to the previously existing scheme for training pupil teachers under the masters or mistresses of approved schools, provision has now been made for the training of aspirant teachers in well-equipped normal schools, and of acting teachers in vacation courses.

All parts of the school system and of its complementary development are duly and regularly inspected on behalf of the Department by a large staff of energetic and highly qualified inspectors. The steady enlargement and differentiation within the school system have necessitated a large increase in the staff of inspectors; and many of these have been selected from among the headmasters of schools. As showing the earnestness of the Department's endeavour to grapple with this problem, attention should be called to a valuable set of special reports, drawn up by inspectors selected for the purpose, giving a minute survey of the more (educationally) destitute parts of the Colony.

G. The Board of Examiners and the University.

In 1858 Governor Sir George Grey appointed a Board of Examiners in Literature and Science. While directly intended to provide machinery for examining candidates for the Civil Service, and aspirants for the professions of law and surveying, regulations were made for examinations in liberal studies, with certificates of three grades, supposed to correspond to the matriculation and degree examinations of universities elsewhere. Provision was also made for the institution of an Educational Council instead of the Board of Examiners, as soon as a certain number of candidates had passed the certificate examination corresponding to a degree, half of the Council to be elected by the certificate-holders, and by holders of non-Colonial degrees and qualifications who had been admitted to equal electoral rights with the certificate-holders. Before the Board of Examiners had undergone its destined change into the Educational Council, its powers were transferred to the University of the Cape of Good Hope, established by Act of Colonial Parliament in 1873. As a necessary and natural extension of this Act the Higher Education Act of 1874 made provision for the establishment or enlargement of Arts Departments (departments of academic and professional instruction) at the more important centres, in connection with the examinations of the University.

The University Extension Act of 1875, and the University Amendment Act of 1896, gave power to the University to admit to its examinations, and to certificates and prizes, persons living beyond the Colony, and made provision for certain other South African Governments taking a share in the administration of the University. Up to the present this last provision has been taken advantage of by Natal only.

Her late Majesty Queen Victoria granted a Charter to the University in 1879. In 1901 H.R.H. the Duke of Cornwall and York (now Prince of Wales) accepted the office of Chancellor of the University.

H. The University and the Schools.

From a very early date in its history the University has, in addition to its own Matriculation Examination, conducted two examinations known as the School Elementary and the School Higher Examinations. These examinations are held annually at local centres all over the Colony on prescribed schemes of work; and the answer-books of candidates are transmitted through the Registrar to the examiners, whose awards are published in the "University Gazette."

There were more than a thousand candidates for Matriculation in 1904, of whom over 50 per cent. satisfied the examiners. The Matriculation certificate is used largely as a school leaving certificate and as a passport to the Civil Service and to professional courses. Consequently, a large number of those who pass the Matriculation examination do not enter the Arts' classes in the Colleges.

ducted by examiners chosen by the Associated Board of the Royal Academy of Music, and the Royal College of Music, London; and the requirements are the same for each examination as for the corresponding examination of the Board in London. The examinations are theoretical and practical, deal with both vocal and instrumental music, and are intended for all grades of pupils and for teachers. Bursaries to further musical study in the Colony and an Exhibition to enable the holder to proceed to Europe for study are awarded annually.

I. The University and the Colleges.

While it is open to candidates for degrees and certificates (except the certificate in mining engineering) to prepare themselves by private study, the great majority of candidates take advantage of the courses provided in the Colleges recognised and subsidised by Government under the provisions of the Higher Education Act. These Colleges receive from Government grants in aid of the salaries of recognised professors and lecturers, and for buildings, libraries, laboratories and other purposes.

Three of the Colleges have been recognised under the Higher Education Act practically since the date of the passing of the Act: the South African College, Cape Town, which was founded independently in 1829; the Victoria College, Stellenbosch; and the Diocesan College, Rondebosch. The Huguenot College (for women), Wellington, was recognised in 1898; and the Rhodes University College in 1903 took the place previously held by St. Andrew's College, Grahamstown. Nearly all the Colleges have recently received considerable expansion in order to meet more fully the requirements of University teaching.

As has been already pointed out, the Board of Examiners founded in 1858 paved the way (as was intended) for the erection in 1873 of a University of the type of the unmodified University of London; that is to say, a University granting degrees and certificates to candidates upon passing certain examinations, without asking where or how long they had studied. But the passing of the Higher Education Act in the following year provided for the growth of local academic centres where the teaching work of the University could be carried on. The students of these Colleges in due course become members of the Convocation of the University, the body which has the right of electing half of the University Council. The strengthening of this College element in Convocation has led to an increase in the number of College lecturers and professors in the University Council, and to a union of the University and the Colleges much closer than, from the mere terms of their respective constitutions, would at first sight appear. In what way to make that union more intimate and efficient is the problem of the immediate future. In a country of wide extent and sparse population, no cautious reformer would seek to uproot institutions which have proved their vitality by substantial increase under great difficulties. Short of the heroic and costly course of abolishing the present University and putting one large teaching and degree-granting corporation in its stead, it has been suggested that some relief and improvement would be secured by a more definite position being granted to the Colleges within the University, so that they might form a federated body of teaching centres, with acknowledged power of concerted action on many important points, while yet free in other respects to follow individual lines of development. This would be to follow so far the line taken by the reconstituted University of London, and by the University of Wales with its teaching centres at Aberystwyth, Bangor and Cardiff.

To realise in any marked degree the hopes of University expansion it is manifest that individual liberality will have to supplement the aid which Government may feel able to give. That this stream of liberality has been sensibly quickened in the last few years is one of the hopeful signs. All the Colleges have been in one degree or another favoured in this way. The University has received numerous endowments for scholarships and exhibitions: and the erection of its new block of administrative buildings it will owe to a recent bequest supplemented by an equivalent grant from Government.

NOTE.—(*a*) The bill for establishing School Boards, referred to in section D of the foregoing paper, p. 450, became law in June of the present year, after prolonged discussion in Parliament, in the course of which two conferences to agree on modifications took place between representatives of the Government and of the Opposition. Provision is made in the Act for the establishment of Divisional and Municipal School Boards, two-thirds of the members to be elected by the ratepayers and one-third to be nominated by the Governor. The school board for each divisional or municipal area is to administer all public undenominational schools, state-aided private farm schools and poor schools within the area. This may be done either directly by the board, or by a committee to be appointed by the board or, if so desired, elected by the parents of the children attending such school. The guarantee system to cover deficits is abolished. Deficits incurred by school boards are to be met, half by Government, and half by a rate levied on owners and occupiers within the area. School accommodation for children of other than European parentage may be provided by the school board, on the request of the parents of such children. Municipal and divisional councils and other bodies empowered to levy rates may vote contributions to the funds of any public school or college within their respective rating areas; and all new townships must on formation set aside not less than two acres of land for school purposes. The principle of compulsory school attendance is (*b*) Information on the subject of Education in Cape Colony is to be found in the successive reports of the Education Department, in the reports of the various Parliamentary Commissions on Education, in the (sectional) pamphlets of the Education Department, and in the annual Calendar of the University. Gazettes are published by both the Education Department and the University. An excellent and interesting resumé of the subject is to be found in the *Special Reports on the Systems of Education in Cape Colony and Natal*, a sectional reprint from Vol. V. of "Special Reports on Educational Subjects," issued under authority of the Committee of Council on Education, London.

2. EDUCATION IN NATAL.

By C. J. Mudie, Superintendent of Education, Natal.

The principle that the State is wholly responsible for the primary education of the children underlies the system of education in Natal. About two-thirds of the European children are educated solely by the State, and the education of one-third is carried out by denominational and private bodies subsidised by Government. Private non-subsidised schools may generally be classed as secondary, and many of these by request are State-inspected.

The race to be taught is mainly British, but there are a good many localities in which the Dutch predominate, and several communities are entirely German and Norwegian, the English language being, in the main, the usual medium of instruction. The race problem is not acute in Natal, but what is known as the Coloured question causes friction from time to time. as the whites resent the intrusion of coloured children into the schools.

In 1878 the present educational system of Natal was inaugurated, and up to the granting of responsible Government to the Colony in 1894, the management of educational affairs was in the hands of a Council nominated by the Governor. Since 1894 a member of the Cabinet, with the title of Minister of Education, has had the control of the Department, with a Superintendent of Education as permanent administrative head, assisted by a staff of inspectors and clerks.

In 1878, before the changes provided for by the new Laws had been carried out, there were only four Government Schools in the Colony—a High School and an Elementary School in Maritzburg and two similar schools in Durban. The Maritzburg High School had an attendance of twenty-two boys. The Durban High School was housed in a granary at the east end of Smith Street, and was attended by forty-six boys. Both were day schools only. Not more than five boys in each school were able to read an easy Latin author, to translate simple French, and to work the propositions in the first book of Euclid. These two schools are now flourishing day and boarding institutions, occupying handsome buildings in the suburbs of each town, and preparing pupils for higher and University examinations. The combined attendance is 380 boys, and the work

The two Elementary Schools were attended by both boys and girls—the Durban school by 160 pupils and the Maritzburg school by 180. They have grown into nine large schools, two for boys, and seven for girls and infants, with an aggregate attendance of 2,740 in Durban and 1,460 in Maritzburg. The work of the two parent schools in Maritzburg and Durban is described, even in those early days, as being equal to an ordinary London Board School and ahead of the average English National School.

In country districts, where there are now twenty-three large and successful county schools belonging to the Government, with 2,530 children in attendance, there were eight small aided schools with a total attendance of 199. Estcourt, Ixopo, Stanger, Weenen and other places had to depend on private tutors and governesses. Twenty-seven years ago the work of the country schools was exceedingly elementary; nowadays it competes successfully in many ways with the best of the work done in the town schools.

Fees in Government schools range from 1s. to 5s. per month according to standard, but no one family pays more than 10s. per month; and free education is given on the production of a satisfactory certificate. At the Government High Schools 10s. per month is the fee for the junior division and 20s. for the higher.

In 1878 only two Secondary Schools for girls received Government aid—the Durban Girls' School and the Maritzburg Collegiate School. The combined attendance was ninety-seven. To-day six such schools are under Government inspection—the Girls' Collegiate School and Thanet House School in Maritzburg, the Ladies' College and the Girls' High School in Durban, the Huguenot High School in Greytown, and the Girls' High School in Dundee. The average daily attendance at these schools is 700.

At that date there were only two school buildings in the Colony belonging to the Government, one in Maritzburg and one in Durban, and each of them occupied by the mixed Elementary School. The schoolrooms in the country were generally of the most inferior description, consisting in many cases of wagon sheds, stables, and store rooms. The furniture was deficient, antiquated, and badly arranged. School books were of all descriptions. In some schools the teachers simply used what ever the children chose to bring. Registers were few and badly kept. Twenty of the aided schools were under the management of local committees, and the action of these committees began and ended with receiving the Government grant and handing it over to the teachers.

There are now in villages and country districts twenty-three school buildings erected, equipped and maintained by the Government, and more are being built. A school for girls, costing nearly £18,000, has been built at the foot of the Berea in Durban on a site granted by the Corporation, and a girls' school and an infants' school have also been built in the Greyville district. These schools and the two High Schools are very favourable examples of modern school architecture. The other school buildings are mostly plain, but convenient and commodious.

In consequence of the substitution of Government Schools for subsidised schools wherever circumstances justify it, the public expenditure on education has been considerably augmented, the average annual expenditure on education in the Colony being approximately £100,000, exclusive of money spent on buildings. The Colonists recognise the advantages of schools managed entirely by the State, and local school committees are only too willing to hand over their responsibilities to the Education Department. The additional expenses, however, are amply justified by the increased efficiency.

In 1878, Infant Schools in the modern sense of the term were almost unknown in Natal. Instruction given in Art and Science was of a very perfunctory character. School handicrafts are now taught in all the Government Schools, and a large number of trained Kindergarten teachers are employed.

Good progress is being made in manual work, and in elementary scientific and technical instruction; but the almost entire absence of manufactures and industries in Natal deprives the students of a practical stimulus to work in this direction. In addition to the Secondary and Primary Schools already referred to, there are also Art Schools in both Pietermaritzburg and Durban, which a considerable number of students attend.

Four Indian Schools in Durban and vicinity and one in Maritzburg belong entirely to the Government. The education given approximates as nearly as possible to that given in the European schools. A good many of the teachers are European. In addition there are twenty-four Government-aided Indian Schools under the aegis of different religious denominations. Two schools for coloured children other than Natives and Indians, also belong to the Government, and are largely taken advantage of. Further effort is being made in this direction, and a school is being built in Durban for 500 of these children. There are, in addition to the purely Government Schools, eighty Government-subsidised schools for Europeans scattered throughout the Colony and 150 subsidised Farm Schools.

Continuation Classes and Night Schools, Commercial, Shorthand, Typewriting, Pharmacy and other classes have also been provided wherever there is a sufficient demand for them.

Native school work was first organised under Government control in 1885, and is regulated primarily by the provisions of a law passed in 1884. The first Inspector of Native Education was appointed in April, 1885. In that year there were sixty-four schools with a total attendance on registers of 3,783 pupils and an average attendance of 2,888 pupils, and an expenditure of £2,494 in grants-in-aid.

At that time every Native School was connected with some missionary body, and, with one exception, the same condition has obtained ever since. In 1886 an attempt was made by the Government to provide industrial teaching, as it was r cognised to be beyond the financial ability of these Missions to provide it, and a Native Industrial School was erected and equipped near Maritzburg, but after five and a half years' unsatisfactory working, having failed to elicit any support from the native people, it was closed at the end of 1891.

It is, however, felt that the teaching of some handicrafts is absolutely necessary in any scheme of education for these people, and an amount of some £2,500 was last year placed on the Estimates for the purpose of making another attempt of the kind. The erection of workshops on a somewhat large scale was contemplated, and but for an unfortunate hitch in the arrangements this school would have been completed before now. It is hoped to have it in working order by the end of the year.

The present system of Native education is purely an aided one. Grants-in-aid are given by the Government to the schools in connection with the different mission bodies on condition of compliance with regulations laid down from time to time by the Department. The subjects taught include Reading and Writing in both English and Zulu, Arithmetic, Grammar, Geography and a little History. All the girls are taught sewing, and in the Boarding Schools they have lessons given in general housework, cookery and fancy work of several kinds, whilst the boys have two hours' instruction daily in some useful industrial work. Nothing of an industrial character is required from the boys in the day schools, experience having shown that the want of facilities in most day schools is such that the attempt to do industrial work would only be wasting time.

High-water mark was reached in 1901, in which year we had 196 schools with 11,071 pupils on registers, and an average daily attendance of 8,491. The Government's grants-in-aid amounted to £6,353 3s. 0d.

In 1904 our figures had receded to 156 schools with a registered attendance of 9,256 pupils, and an average attendance of 6,995, and the grants-in-aid amounted to £6,180 3s. 6d. This decrease was the direct result of stringent regulations being passed requiring all Native head teachers to possess certain higher qualifications. The supply of such qualified teachers being inadequate some fifty schools were temporarily closed. The probability is that in 1907 we shall have 250 schools with 14,000 or 15,000 in attendance. Of the 156 schools at present receiving grants-in-aid, twenty-six are boarding schools, the rest day schools. There are in all 278 teachers, of whom seventy-six are Europeans.

In nearly all the schools the payment of fees is enforced. These vary considerably in amount, but they are enough to ensure the recognition of the principle of paying for what is received.

Special emphasis is laid upon English speaking as distinct from reading and translating. All schools receiving grants-in-aid are inspected twice, and in most cases three times a year. Bonuses are given to the teachers for good discipline, general deportment of scholars, neatness and cleanliness of buildings, and general progress in school work. Examinations for Teachers' Certificates are held annually in the month of December, and July and January are holiday months.

Native Teachers' salaries vary from £36 to £60 per annum in the case of male teachers, and £24 to £40 per annum for females.

The whole work is supervised by three Inspectors, working under the direction of the Superintendent of Education.

Steady improvement on the part of the pupils and a growing interest on the part of the Native parents are distinctly evident.

The present high standard of education and its wide diffusion throughout the Colony are an enduring testimony to the wise foresight of Sir Henry Bulwer, by whom the Laws passed in 1878 were framed. Twenty-seven years ago it was very unusual to find in up-country districts any child who had ever been out of his native place. The teacher, however able and earnest, was circumscribed by his environment. It was next to impossible for him, for instance, to explain the greatness and extent of the Empire to children whose ideas were bounded by the horizon of their own hamlet, to whom the ox-wagon was the ideal means of locomotion, who had never seen a soldier, and to whom the mention of the ocean and ships conjured up no memories. His words could awaken no response. Now, the railway, that great educator, has changed, and is changing all that. The dull stare which so often greeted one's questioning has, except in remote corners, almost wholly disappeared; and both teachers and inspectors find the change in the keener interest and the more intelligent apprehension which the children bring to bear on the instruction imparted to them, and in the increased vivacity and responsiveness of their manner.

Natal is affiliated with the Cape of Good Hope University, and is represented on the Council of the University by three members—the Hon. J. X. Merriman, Mr. R. D. Clark, M.A., and the Superintendent of Education *ex officio*. Many advantages, direct and indirect, result from this educational union of the two Colonies.

Natal has the honour of nominating one Rhodes Scholar per annum, and two young men are now in residence at Oxford.

The Natal Government provides an Annual Exhibition to an English University of £150 a year for four years, and several other valuable scholarships and bursaries are given to pupils after competitive examination to enable them to proceed to higher work.

3. EDUCATION IN THE LATE SOUTH AFRICAN REPUBLIC AND IN THE TRANSVAAL.

By John Robinson, Secretary of the Technical Institute, Johannesburg.

I. Education in the South African Republic.

The first published Education Law of the South African Republic was Law No. 4 of 1874. In terms of this Law three classes of school were recognised—(1) Ward Schools, (2) District Schools, and (3) Gymnasium (at Pretoria). In practice the Ward School was described as a " Farm " School and the District School as a " Town " School. The Gymnasium was not realised till 1893. In terms of this Law, instruction was undenominational. The medium was Dutch or English at the will of the parents. Thus when the first School Inspector (Mr. van Gorkum) arrived in the Transvaal in 1876 there were eight Farm Schools. There were four schools in which the medium was wholly English, viz., Pretoria, Heidelberg, Lydenberg and Zeerust, with a total of seventy-one pupils. In three schools—Pretoria, Potchefstroom and Lydenburg, with fifty pupils, the medium was Dutch. One school, with twenty-nine pupils, had both English and Dutch as the medium.

The next educational legislation of significance is Law No. 1 of 1882. The distinctions between town and country schools ceased; Lower Education (Standards I.—III.) and Middle Education (Standards IV.—VI.) were recognised, and annual subsidies of £3 and £5 per pupil were paid on account of the respective groups. This law laid it down that schools were to be opened and closed by prayer, but that doctrinal instruction was to be left to the Churches. The medium of instruction was to be Dutch. The medium clause was not rigidly enforced and English schools, as a rule, had no difficulty in earning their subsidy. A reference to the number of pupils undergoing instruction furnishes evidence as to the liberal, or may be lax, spirit of the Administration. Thus in 1883, the year after the publication of the Law, numbers had nearly doubled, and in 1892 they had increased tenfold.

Inauguration of Retrogression Policy.—1892 onwards marks a new era in the history of education in the South African Republic. From the Volksraad discussion during the few years immediately prior to this there appeared to be uneasiness as to the effect education might have upon the spirit of nationality. Thus when the propriety of paying bursaries to students in Europe was under debate, a member urged that the boy would return as a stranger in the land. Another member put an end to the argument by pointing out that Moses was educated at a foreign court, and on his return he was not only a patriot but became the leader of his people. In reply to a member arguing against the English language, it was shown that many who had been educated at the Cape had fought in the War of Independence, and were therefore nothing the worse for knowing the language.

It was, however, reserved to Mr. Mansvelt to inaugurate what may fairly be called a period of educational repression and retrogression. Mr. Mansvelt, a teacher from the College in Stellenbosch, was appointed Superintendent of Schools in 1891. In the following year Law No. 8 of 1892 appeared. The more important provisions of this Law were as follows :—

1. All teachers must be members of a Protestant Church.
2. All lesson books must be written in Dutch. Not more than three hours per week in Standards I.—III. and four hours per week in Standards IV.—VI. may be devoted to instruction in a foreign language.

Under (2) all English-speaking children, including many from the Cape Colony, were excluded, and Roman Catholics and Jews were subject to a further disability under (1). That the Law was not merely a conservative measure, but was in its intent purely anti-English, need hardly be said, but if proof were wanting it is found in the arguments Mr. Mansvelt used to coerce recalcitrant Boers. "The use of English," he says, "is fraught with serious consequence to our national existence," and he inveighs bitterly against the parents who have sent their children to English schools," where they can get fuller scope to their short-sighted desires." As a result of two years' working of this Law attendance at schools fell off 27.7 per cent. throughout the Republic, and about 40 per cent. taking the Town schools alone.

The turning of some 2,261 children out of school brought about an agitation amongst those on the gold fields interested in education, and the result was a Volksraad Resolution purporting by a subsidy to meet the case of private schools. The subsidy was to be paid on account of those children who learnt Dutch, but the payment was so hedged round with conditions as to render it almost impossible for schools to earn it. At no period were there more than 200 children earning the subsidy under this resolution.

Staats Gymnasium and Staats Meisjes School.—In 1893 the Staats Gymnasium and the Staats Meisjes School were opened at Pretoria. The Gymnasium was modelled on the lines of the Gymnasia of Holland. In the Gymnasium Higher Education was to have four departments :—

(1) Modern language and literature.
(2) Science.
(3) Classics.
(4) Natural Science.

Holland. The Science department developed in 1897 into the School of Mines, which was brought to an untimely end by the war.

Witwatersrand Council of Education.—The dissatisfaction with Law 8 of 1892 and the subsequent Volksraad Resolution found expression in 1895 in the formation of the Witwatersrand Council of Education. This Council, of which Mr. H. S. Caldecott was the leading spirit, consisted of a number of influential Johannesburghers many of whom, by their contributions to the funds of the Council, gave proof of the keen interest they took in the welfare of the children who had been excluded from school under Mr. Mansvelt's regime; £7,000 was subscribed, which the Council by judicious investment converted into £10,000. A director was employed who was instructed to report on the condition of things. On investigation it appeared that in the mining area (excluding Johannesburg) there were some 2,000 children of school-going age. There was not a single efficient English school in the whole area, most schools being of the private adventure type presided over by a lady who had not succeeded in other walks in life. In Johannesburg and district there were 2,000 children of school-going age not attending school.

A scheme involving an expenditure of about £60,000, and having for its object the providing of schools on the mines and the subsidising of the more deserving schools in town, was approved. Fifty thousand pounds had been promised in donations from individuals and firms when the Jameson Raid, in the beginning of 1896, caused education to take a less prominent place in the public mind. The Council, however, went to work with the £10,000 it had in hand, and brought seven English schools into existence, in addition to subsidising in a small way several schools in town. This work was carried on from 1896 till the outbreak of the war. An attempt was made in 1897 to establish classes for the Cape University Matriculation together with science classes, these latter in the interests of employés on the mines. After about eighteen months this work was abandoned, as its cost, in view of the limited resources of the Council, threatened to jeopardise the primary educational work, which was deemed more important. Although the Council had the satisfaction of realising that it was getting good return for its outlay, it was obvious that only the outermost fringe of the difficulty was being dealt with, and during 1898 it was resolved to try and resuscitate the original scheme. The Director made another exhaustive inspection of the mines and district, and communicated the results of his investigations in a letter addressed to Mr. (now Sir Percy) Fitzpatrick. Mr. Fitzpatrick forwarded this letter, with an appeal, to the financial houses in London, and his action resulted in donations to the extent of £97,000. It was proposed to spend this sum in buildings, and the mines engaged to furnish £13,000 for a period of three years for salaries and maintenance. The Council had the whole of the Witwatersrand area mapped out and sites for schools located when the imminence and the final outbreak of war put a period to its operations.

Further Legislation for Uitlanders.—Meanwhile the activity of the Council of Education, circumscribed though it was by its limited means, gave rise to considerable perturbation at Pretoria. The problem was how to take the wind out of the Council's sails without departing too far from the policy laid down in 1892. About a year after the publication of the Council's Report, Law No. 15 of 1896 was evolved. The peculiar terms of this Law show that the situation was considered critical. The Volksraad empowered the Superintendent of Education and the Government to take steps to remedy the educational conditions on the gold fields where they were considered defective, thus making it possible to go as far as the exigencies of the case might demand and no further. It was soon apparent, when the Superintendent published his Regulation under this Law, that he did not intend to go very far. Though not explicitly stated, the Regulation in effect made it impossible for anyone but a Hollander to become headmaster of a school under the new law. A child during his first year at school was expected to devote one hour a day to instruction in Dutch, in the second year two hours, and in the third year three hours. In the fourth year he was to take the whole of his instruction through the medium of that language. In view of the short average school life of the class these schools proposed to reach it became obvious to the Government itself that the scheme was impossible, and the regulations were not strictly enforced, with the result that during 1898 there were as many as 540 children working under the Law.

Although State Schools were formally closed by Volksraad resolution of the 3rd of October, 1899, several State and State-subsidised Schools were carried on during the war. During the first months teachers paid a war tax of from ten to twenty per cent. on their salaries ; later fifty per cent. was charged.

II. Education in the Transvaal.

In January of 1901, exactly fifteen months after the declaration of war, Mr. E. B. Sargant, Director of Education for the Transvaal and Orange River Colony paid a visit to Johannesburg and Pretoria. Mr. Sargant returned to the Cape in January to organise his Camp School scheme leaving deputies in the two Transvaal towns with considerable powers of initiative in respect to educational work. Mr. Sargant's policy of delegating administrative powers to his subordinates was productive of the best results, so much so that at the end of 1901, whilst war was still going on, there were more children in schools in proportion to population than there had been at any time in the history of the Republic.

Concentration Camps.—The work of teaching in the Boer Concentration Camps was carried on vigorously, the number of pupils rising from 1,859 in May 1901, to 17,213 in the same month of 1902.

to go hurried off to their farms.

Farm and Country Schools.—Hitherto educational efforts had been confined to the towns along the lines of communication. Now education had to be provided on the farms and in the country. The difficulties the Department had to encounter in rendering this service were, in view of the scarcity of transport and the almost total lack of school accommodation, if possible, greater than attended the establishing of the Concentration Camp Schools.

Although continually occupied in the distracting efforts to meet the exigencies of each new situation as it arose, questions of educational policy and organisation with a view to the future were not overlooked.

In July of 1902 an Inspectors' and Teachers' Conference was held in Johannesburg, when resolutions affecting such questions as conditions of entrance to the Normal Schools, Evening Schools, Native education and other questions were approved.

Inter-Colonial Conference.—In January of 1903 an Inter-Colonial Conference of the heads of the Education Departments of the various Colonies was held at Bloemfontein, when questions of common interest were discussed. Conferences of Inspectors were frequently held to discuss problems arising out of their work.

Education Ordinance of 1903.—In February of 1903 the Educational Ordinance for the Transvaal was published. The main features of the Ordinance may be summarised as follows :—

1. Primary Education is free.
2. All teachers must be certificated.
3. Teachers to give instruction in Bible history. Ministers of Religion to have the right of entry to give "supplementary" religious instruction. The "conscience clause" is operative.
4. When required instruction may be given in or through the medium of the Dutch language, for not exceeding five hours per week.

Religious Difficulty.—The Religious Instruction Clause has been subjected to considerable criticism, as a result of which the Government appointed a special commission to enquire into its working. In the evidence the "right of entry" was most strongly opposed, whilst some witnesses were in favour of the secularisation of schools. The report of the Commission has not been published at the time of writing.

Language Question.—The Dutch are dissatisfied with the proportion of time allotted to the Dutch language. This is the more surprising as the time given is in excess of that allowed for the English language under Law 15 of 1892.

Code of Regulations for Elementary Schools.—An excellent Code of Regulations for instruction in Primary Schools was issued in October of 1903 by Mr. Ware, who succeeded to Mr. Sargant in the

Directorship in July of that year. It should be noted, however, that the Department has reverted to the old system of annual individual examination of scholars.

Secondary School Regulations.—Regulations for Government Secondary Schools consist almost wholly of syllabuses of two examinations, the Lower and Leaving Certificate. The intention of the Department that the Leaving Certificate should take the place of the Matriculation examination for several purposes is likely to be defeated, as the examination regulations preclude the possibility of any uniformity of test.

Normal School Regulations.—In August of 1903 Regulations for the Government Normal Schools of the Transvaal were published. The feature of these Regulations is the alternating of teaching work and professional study until the First-class Teacher's Certificate is obtained. The effect of the operation of these Regulations would be to keep the Colony supplied with a first-class teaching staff from its own resources, but hitherto it has not been the practice of Governments to provide for the training of teachers on so liberal a scale.

Technical Education.—In 1898 a law was passed in terms of which the Boer Government proposed to establish Technical Schools in the various districts of the Republic. It is, however, only interesting to note the fact as a matter of history, as practically nothing was done under the law.

In July of 1902 Mr. E. B. Sargant was successful in getting together a Committee to advise him on technical education. Immediately after printing its report a conference was arranged between the Committee and representatives of the South African College and the Kimberley School of Mines, at which the question of training in mining subjects was discussed.

Technical Education Commission.—In January of 1903 the Lieutenant-Governor appointed a Commission to report generally on Technical Education. The Commission made recommendations, briefly summarised as follows :—

1. That immediate provision for a four years' course in Mining Engineering be made.
2. That a central site be set aside in Johannesburg to provide accommodation for technical instruction, which should at the same time accommodate the State Scientific Laboratories and focus the scientific and literary work of the town.
3. That a site be acquired for the purpose of a South African Teaching University.

Transvaal Technical Institute.—To carry out recommendation (1) and report on (2) and (3) a representative body was appointed by the Lieutenant-Governor in August of 1903. This body was incorporated under the title of the Transvaal Technical Institute. The Council of the Institute secured the services of Professor Hele Shaw of Liverpool University, and the Institute commenced teaching in technical subjects were opened. The enrolment in these classes for the year was 349. This year the number of students in mining engineering is fifty-two. The enrolment for the first term's work in the evening classes for the present year is 460.

Inter-Colonial Co-operation.—During March of 1905 a Conference between the Council of the Institute and delegates from the Technical Education Commission of Natal and of the Orange River Colony took place at Johannesburg. Several resolutions were passed which point towards co-operation between the Colonies in regard to Technical and Higher Education.

Appended is a list showing number of schools and attendance, together with the cost to Government of teaching staff. A list of authorities wherein fuller information on the points touched on above may be derived is also attached.

Year.	Town School.	Farm School.	Aver. No. of Pupils.	Paid to Schools in subsidies. £	s.	d	Cost per Pupil. £	s.	d
1873	9	10	..	1,975	0	0	..		
1876	8	5	150	1,275	0	0	8	1	0
1877	9	..	306	3,500	0	0	11	8	9
1879	11	9	838	4,379	0	0	5	4	6
1882	9	34	872	2,753	0	0	3	4	8
1883	8	64	1,410	4,395	0	0	3	2	4
1884	14	45	1,280	5,974	0	0	4	13	4
1885	14	79	2,111	8,525	0	0	4	0	9
1886	18	78	2,600	9,261	0	0	3	11	3
1887	16	100	2,795	10,499	0	0	3	15	1
1888.	20	159	4,016	14,715	0	0	3	13	3
1889	28	197	5,475	24,907	0	0	4	11	3
1890	34	262	6,990	35,546	0	0	5	18	0
1891	99	453	8,170	43,823	11	0	5	7	3
1892	62	422	7,932	34,962	5	7	4	8	2
1893	59	353	5,909	26,916	4	4	4	11	2
1894	61	358	6,626	31,260	17	4	4	14	4
1895	422		7,217	39,813	2	8	5	10	4
1896	395		7,738	44,548	3	2	5	15	2
1897	457		10,777	65,656	2	6	6	1	10
1898	509		13,561	90,935	10	3	6	14	1
1903	388		24,021	221,226	14	0	9	4	2

Documents from which material has been collected for the purposes of this Memorandum :—

For Education in Z.A. Republic :—

Staats Courant of Z.A.R. Years 1887-1899.

Appendix I., Report on Education in the Transvaal. By E. B. Sargant. (Longmans and Co.)

For Education in the Transvaal:

Appendix I., Mr. Sargant's Report as above.

Reports, Witwatersrand Council of Education. By J. Robinson.

Report of Director of Education for the Transvaal for year 1903. (Government Printing Works, Pretoria.)

Report of Technical Education Commission, issued July, 1903. (Government Printing Works, Pretoria.)

4. EDUCATION IN THE ORANGE RIVER COLONY.

By Johannes Brill, Lit.D. (Utrecht and Cape),
Rector of Grey College, Bloemfontein.

To understand the problems that present themselves to those who, under the present conditions, seek to establish an efficient system of education in the Orange River Colony, it is necessary to be acquainted with the conditions prevailing in the country before the war, while it is both interesting and useful to cast a glance at what was done for education even in the midst of the war, and finally to give some account of the system which is being established at the present moment.

Our subject, therefore, naturally falls into three divisions :—

A. Education in the Orange Free State.

The Orange Free State was established in the year 1854. During the first twenty years of its existence difficulties of various kinds—Basuto wars (1856–'68), troubles about the possession of the Diamond Fields, the poverty of the young State and its struggling citizens—hindered the Government from seriously turning its attention to the organisation of education. Still it must not be supposed that the youth of the land, even under those adverse circumstances, grew up altogether illiterate. There has always existed among the Boers a strong sense of the value of education as marking the boundary line between civilisation and barbarism, coupled with a deep religious feeling, which caused them to submit readily to the salutary rule of their Church, according to which there could be no membership without some knowledge of reading and writing, Bible history and Church doctrine. Under these influences elementary schools existed not only in the little townships, but also on many of the farms scattered all over the country, where instruction was given by "wandering" schoolmasters of a peculiar type, most of them without any professional training, who drifted from one farm to another to "keep school," sometimes only for a few months, sometimes for longer periods.

In the townships schools were established by the inhabitants, enjoying some support from the Government in the form of contributions towards the salary of the teacher; and in the capital, Bloemfontein, a school of a somewhat higher type was founded, thanks to a generous gift of Sir George Grey, and, consequently, called "The

Grey College" after its founder. This state of affairs lasted till 1873, when, after the wars with barbarous neighbours, peace had been established for some years, and, on the discovery of diamond fields, prosperity had followed under the wise rule of President Brand. In that year the Volksraad adopted a scheme of national education, and invited the Rev. John Brebner, a Scottish teacher, who had come to South Africa twelve years before, and was then Professor of Classics in Gill College, Somerset East, to come to the Free State as Inspector of Education. He accepted the call, came to Bloemfontein in January, 1874, and from that time devoted himself to his work of organisation and supervision for more than twenty-five years with untiring energy and patience. The following are the main features of the system that Mr. Brebner introduced into the Free State, and which has often been pointed to as a model one for its time and for the requirements of the country.

I. SCHOOLS.—The "Grey College" for boys and the "Eunice Institute" for girls, both in Bloemfontein, provided a higher or secondary education, carrying their pupils as far as Matriculation or the Intermediate Arts Examination of the Cape University.

All the other schools were expected to give sound elementary instruction, but not to go beyond the Standard work.

These schools were classified under four heads :—

(*a*) DISTRICT SCHOOLS, in the larger towns or villages, with a school building and a teacher's dwelling provided by Government. The headmaster of such a school was required to hold a first-class teacher's certificate of the Free State, or an equivalent certificate of some other country; but the assistants were required only to hold a second-class teacher's diploma. Both Dutch and English had to be thoroughly taught throughout the school, while half the subjects were taught through the medium of Dutch, the other half through the medium of English. The headmaster received a fixed salary and a free house, and was entitled to all the school fees. He was expected to keep boarders, and his house was built with a view to this. The assistants' salaries were paid partly by Government and partly by the headmaster. An energetic and successful headmaster of such a school might have altogether an income of £500 or £600 a year.

(*b*) WARD SCHOOLS, in the smaller villages or in suitable situations in the country. The Government provided the necessary buildings as under (*a*) for the school, the teacher, and a certain number of boarders, but these schools were generally smaller than those of class (*a*), and a teacher holding a second-class or equivalent certificate might be appointed to them. The teacher also received a fixed minimum salary, free house, and all the school fees. Both Dutch and English had to be taught.

(*c*) ITINERANT SCHOOLS.—These could be established on a farm wherever sufficient and suitable accommodation was offered, and a sufficient number of children could be got to attend regularly. The Government paid a fixed rent for a schoolroom, and a room for an unmarried teacher, and also paid the teacher a salary of £100 or £120.

The proprietor, on whose farm the school was opened, was bound to board children from other farms who lived too far away to come to school daily from their homes. He also had to board the teacher at a reasonable rate. The school fees were fixed by Government, but drawn by the teacher, who sometimes, however, agreed to accept his board as an equivalent. The teacher was expected to hold a second-class certificate or some certificate of equal value. Dutch was the principal language in these schools, but English was also taught to the more advanced pupils. An itinerant school was started for a term of six months. After that time application might be made to continue the school on the same farm for another six months. If the Superintendent approved, the request was granted, otherwise the teacher was moved to another farm where a school was required, and sometimes a number of his former pupils went with him.

(*d*) Private Schools.—These might apply for Government aid under certain conditions. They must be situated on a farm not too near a Government school; they must be examined and reported on by some person appointed thereunto by the Superintendent of Education, and regular instruction according to the standards must have been given for at least six months previous to the examination. Government aid took the form of a capitation grant, the amount of which depended on whether or not the teacher held a certificate, and on the standard in which the child passed. The grant was equally divided between the teacher and the owner of the school. A minimum number of pupils was fixed, and it was also required that the teacher should bear a good character and be a member of some Protestant Church. As for the two latter conditions, they applied equally to all Government-aided teachers in the Free State.

Besides the schools falling under the above category, there also gradually came into existence a certain number of schools for children in Railway and Mining camps, Poor Schools, an Artillery School of young men serving time in the Free State Artillery, and an Industrial Home for children of poor parents, who were clothed, fed and instructed at Government expense, at the same time being apprenticed to learn some trade.

II. School Committees.—These were of two kinds, viz., District School Committees and Committees appointed over the Ward and Itinerant Schools. The Committees consisted of five members, two of whom were recommended by the Superintendent of Education and appointed by the President, while the other three were chosen by all the inhabitants of the district who were entitled to a vote. The Committees were appointed for three years. The

District Committees met once a month, the others once in three months.

They selected places convenient for opening a school, selected teachers, subject to the approval of the Superintendent and the President; visited and examined the schools under their control at stated intervals and reported on them to the Superintendent (such examinations, however, did not take the place of the annual inspections by Government Inspectors). Finally, they had to see that the school books and school materials prescribed by the Superintendent were procured for the schools under their supervision.

III. Inspection and Standards.—At the head of all the schools and School Committees in the State stood the Superintendent of Education, latterly with two Inspectors and a staff of clerks to assist him, himself responsible to the Volksraad and the President, to whom he submitted an annual report.

Every school receiving Government grants was inspected at least once a year, and these annual inspections were conducted on the lines of the seven standards fixed by the Department. Reading, writing, arithmetic, grammar, Bible history, geography and general history were the main subjects taught, some of them through the medium of Dutch, others in English. In Standard VII. a little literature and science was added. French, German, Latin and mathematics were optional, whereas drawing and (for girls) sewing were gradually made compulsory, and woodwork was taught as a special subject in some of the schools. A special grant of 2s. 6d. was made to the teacher for each pupil who passed in sewing, drawing, gymnastics or woodwork.

IV. Examinations.—An examining body for all public examinations in the Free State was constituted in Bloemfontein, consisting of nine members under the Superintendent of Education as chairman. It was divided into three Committees for examining in literature, in science, and in law. Examinations for the purpose of granting teachers' certificates were held twice a year. A competitive school examination, open under certain restrictions to all schools in the State, was held once a year, and those candidates (boys or girls) who obtained the highest marks were awarded bursaries of £50 each per annum for two and a half years on condition that the Bursar continued his or her education at a school approved of by the Superintendent, during the time for which the money was granted.

A system providing for pupil teachers was introduced, their apprenticeship lasting three years, with grants of £15, £25 and £60 respectively, and in 1899 a beginning was made with a Normal Training College in Bloemfontein.

In 1895 a modified form of compulsory education was adopted by the Volksraad, making it binding on every white child living at a distance of not more than two miles from a Government school, and being between ten and sixteen years of age, either to attend such school for one or two consecutive years or to pass a simple examination in reading, writing, arithmetic, history and geography of the Free State, and Bible history. In the case of poor children no school fees were demanded, and, if necessary, clothing was provided. Parents not complying with this law were to be fined or otherwise punished.

V. Statistics.—In 1874, the year the above-mentioned system of education was introduced, there were in the State only ten Government schools, with twelve teachers and 348 pupils. In 1898 the number of Government schools was 199, with 293 teachers and 8,157 pupils.

Besides these there were 42 private schools with 753 pupils that received Government aid.

B.—Education during the War.

The outbreak of hostilities in October, 1899, naturally involved the complete disorganisation of the educational system so ably established and conducted by the late Dr. Brebner, and even after the British occupation it was some time before much could be accomplished.

Under the Military Governor, indeed, a considerable number of schools along the railway line and elsewhere were opened, as it seemed possible at the time that the country would soon settle down. Subsequent events, however, proved otherwise, and many schools that had been re-established were compelled to close down again when the towns were evacuated.

Mr. Sargant, who had arrived in Cape Town in November to assume the position of Director of Education for the two new Colonies, after a tour of observation, returned to the Cape, feeling, as he says, "very uncertain as to whether it would be possible to make any satisfactory beginning of the work for months to come." In Cape Town, however, he found a school established in the Prisoner of War Camp at Green Point, and while visiting this school he formed the idea of establishing schools in the Concentration Camps, which were then being formed. With characteristic energy he commenced the work in person at Norval's Pont, and from the opening of this school in February, 1901, the history of the Camp schools is a record of success amidst difficulties which at first sight appeared insuperable. Under the Director for both Colonies (Mr. Sargant), Mr. W. A. Russell held the position of Assistant Director of Education for the Orange River Colony from the 27th July, 1901, to the 31st January, 1904, and it is to his indefatigable labours under most trying circumstances that, to a great extent, is due what ever was accomplished during this period of transition.

In May of the year 1901 the number of children in attendance at the Camp schools of the Orange River Colony was 2,001, as compared with 1,692 in the Town schools, while in May, 1902, there were 12,066 in the Camp schools as compared with 2,691 in the Town schools.

There was naturally much in these Camp schools to provoke the criticism of an educationist, but if all the circumstances are taken into consideration it is surprising that so much efficient work was done. For this result both the Dutch and English teachers who volunteered for the work deserve credit. It is interesting to recall the fact that the work done in these schools received commendation from the Ladies' Commission sent from England to enquire into the condition of the Camps.

C. Education after the Declaration of Peace.

As the Concentration Camps began to be broken up the attendance at these schools declined with great rapidity. For several months after peace was declared the towns were crowded with families who were unable to return to their farms until the damage done by the war had to some extent been repaired, and accordingly the hands of the Department were fully occupied in re-establishing the Town schools and providing the additional accommodation required by the influx of population into the towns.

When the country became more settled, the most difficult work of all began—the bringing of educational facilities within the reach of children living on remote farms. The applications for new schools increased in number month by month, and in dealing with them the attention of the Department was first directed to the larger schools—the so-called Ward schools, at which a minimum attendance of twenty-five pupils was expected. In the year June, 1903 to June, 1904, nearly 100 of these schools were established, and the number of children in attendance rose from 480 to 3,388. To meet the needs of the more isolated parts the so-called Farm schools were established, with a minimum attendance of twelve pupils, in which a capitation grant is paid to the teacher. While the latter type of school must necessarily form part of a complete system of State education under existing conditions, the Department has always endeavoured to encourage the establishment of larger schools, adequately staffed, where greater efficiency can accordingly be secured.

In the early days of the new administration there was much to militate against anything like the formation of a definite system, and it is doubtful whether attempts in this direction would have been altogether desirable. It was, therefore, not until June, 1903, that the Education Ordinance was passed. From that time, however, events moved quickly. Towards the end of 1903 Local Education Committees were appointed with certain defined powers. In December, 1903, a Code of Regulations and a Syllabus of Instruction was put into force. The principle of free education, which in practice had been recognised since the British occupation, was in January, 1904, formally approved by Government. In February of the same year Mr. E. B. Sargant, who had been Director of Education for both the Transvaal and Orange River Colony, was made Education Adviser to the High Commissioner, and Mr. Hugh Gunn was appointed Director for the Orange River Colony. He became henceforth directly responsible to the Local Government, and holds a seat in the Legislative Council of the Colony.

Under the system as now established, special provision for Higher education is made at the Grey College and the Girls' High School, Bloemfontein, and in the north of the Colony at the Kroonstad High School. In the Grey College students are prepared for the degrees of the Cape University, and a staff of lecturers has been carefully selected for this work. There is a B.A. class at present in existence, and the intention of the Government is to develop the Grey College on University lines. At all the remaining schools, both town and country, education is free, and in the case of the more important towns there is attached to the Elementary school a higher department in which pupils may receive free education up to the standard of matriculation.

A Normal school was established in August, 1902, for the purpose of preparing students for the teaching profession, and a large number have already passed through a course of training. The work of Technical education and the establishment of Evening schools have also been taken in hand in different parts of the Colony.

The town of Bloemfontein is under the charge of the Chief Inspector, and the rest of the Colony is divided into four inspectorial districts. Though the work of creating new schools has not been allowed to lapse, the energies of the Inspectors can now be devoted more to their natural duties than was possible when the country was passing through its various and eventful phases alluded to above.

5. THE GROWTH OF SOUTH AFRICA: HISTORICAL AND SOCIOLOGICAL DATA.

By Rev. William Flint, D.D., Librarian of Parliament, Cape Colony.

The work, of which the chapters in this volume are a record and a review, does not necessarily invite competitive comparison with that accomplished in the name of Science in older lands. It does claim, however, to have a value of its own, but its worth can only be appraised on a careful weighing of the conditions under which research and investigation have been carried on.

The accompanying tables of events, linked as they are with estimates and censuses of the population at different periods, will afford data out of which a true background may be found for the work and workers in science.

The events which have contributed to the making of the comparatively brief history of South Africa need only a cursory examination in order to reveal the fact that many of the varied experiences and developments of older countries, which have extended over long eras, have here been compressed into two or three brief centuries. The conquest of barbaric tribes, the peopling of the land, the establishing of law and order, the development of natural resources, the opening up of communication over vast distances, the provision of the means of education, the uniting into one commonwealth of peoples of diverse origins and varying ideals, have necessarily absorbed the chief energies and time and thought of the makers of the country.

In the 250 years which have elapsed since the landing of Van Riebeek not less than fifty wars, great and small, have been waged, an average of one every five years, and many of these have entailed a large expenditure of money, and great sacrifices of life and property on the part of the populations of the different colonies and territories.

As one of the results of these conflicts the boundaries of the Colonies have frequently been extended. Now and again the territorial advance has been necessitated by the exigencies of danger to the white population caused by the close proximity of warlike and irresponsible tribes. At times the rights of conquest after battle have led to annexation. On more than one occasion tribes which have learned to respect the guarantees of safety for life and property which accompany the white man's rule have sought the protection of the British Flag. Here and there the discovery of mineral wealth has attracted the European, and in opening the ground for gold or diamonds he has found it convenient to erect a flagstaff for his national colours.

Slowly through the periods covered by these wars and extensions the methods of governing the various peoples have developed, from the simple enforcement of the gubernatorial will of Van Riebeek and his successors to the complete self-government of the older colonies of the Cape and Natal, and the recently granted Constitution for the younger Colony of the Transvaal.

In 1825 the Cape Colony was accorded the right of influencing its Governor through a Council of Advice consisting of six members, to whom all ordinances were to be submitted before promulgation. In 1834 another step towards a Parliament was taken, and a Legislative Council consisting of six officials and six colonists chosen by the Governor was created. For twenty years that semblance of popular government had to suffice, when in 1854 Parliamentary institutions were granted and two Chambers were created, a Legislative Council and a House of Assembly, but the old Executive Council, whose members were appointed by the Home Government, was retained for purposes of administration, much to the chagrin of those who made the laws and voted the money for carrying out the will of the people. Ultimately in 1872 Responsible Government was granted, and in 1874 made more effectively operative by the division of the Colony into seven electoral circles for the election of the Upper House.

A reference to the historical data which immediately follows this will reveal the development of self-government in Natal upon somewhat similar lines, but will show that even now responsible government is only twelve years old, and it may be noted that the Legislative Council is still a nominated Chamber.

Hints at more ancient history will be found in the paper on Rhodesian Ruins, and light will be thrown upon the relations between the Native races by articles in the Anthropological Section. The somewhat chequered career of the recently-acquired Colonies may also be discerned in the chronological table inserted hereafter.

Not a little light is thrown on many aspects of the country's growth by the tables giving an outline of the history of railway extension. How recently the ox-wagon and the stage-coach have given place to the locomotive is not always realised, but he who reads the figures aright, will find a key to many of the problems which have affected development, as well in the realm of science as in the social and political life of the people.

A.D. HISTORICAL DATA.

1486. Discovery of the Cape of Good Hope by Diaz.
1497. Cape rounded and Natal named by Vasco da Gama.
1503. Table Bay discovered by Antonio de Saldanha.
1505. Arab dhows laden with gold from interior found at Sofala.
1510. Indian Viceroy slain in fight with Hottentots.
1552. Zimbabwe mentioned by De Barros.

1580. Drake returned from East by Cape.
1588. Monomotapa described by Livio Sanuto.
1591. English ships first visited Table Bay.
1595. First Dutch fleet in South African waters.
1602. Dutch East India Co. formed.
1607. Armed alliance between King of Monomotapa and Portuguese.
1620. Sovereignty of King James proclaimed in Table Bay.
1632. Tete founded by Portuguese.
1652. Arrival of Van Riebeek and beginning of Settlement.
1655. Introduction of the Vine.
1657. Inland exploration commenced.
1658. Importation of Slaves.
1659. First War with Hottentots.
1672. Territory formally purchased from Hottentots.
1673. Second Hottentot War commenced.
1679. Stellenbosch founded by Van der Stel.
1685. Discovery of Namaqualand copper.
1686. Wreck of Stavenisse on Natal coast.
1688. Arrival of first Huguenot settlers.
1691. Commander raised to dignity of Governor.
1693. Portuguese forces driven by Natives from Zimbaoe.
1700. Extension of settlement to Tulbagh.
1702. First encounter with the Kafirs.
1713. Outbreak of small-pox at the Cape.
1720. Makalangas, forced South by Zulus, enter Natal.
1746. Foundation of Swellendam.
1752. Exploration eastwards to Kei River.
1761. Northern exploration to Namaqualand.
1778. Orange River discovered.
1778. Fish River made the Frontier line.
1779. First Kafir War commenced.
1781. French troops arrived to defend Colony against English.
1789. Second Kafir War commenced.
1793. Commission of Enquiry into Cape grievances.
1795. Graaff Reinet and Swellendam rebellions.
1795. Surrender of Cape Colony to English.
1797. Earl of Macartney, first English civil governor, appointed.
1799. Rebellion of Eastern farmers.
1799. Third Kafir War commenced.
1799. London Missionary Society started operations.
1801. Southern Bechuanaland explored.
1803. Cape Colony restored to the Dutch.
1804. Van Riebeek's heraldic arms granted to the Cape.
1806. Cape Colony again surrendered to the English.
1806. Last public sale of imported slaves.
1807. Court of Appeal for civil cases appointed.
1809. Hottentots made subject to colonial laws.
1812. Fourth Kafir War.
1815. Slachter's Nek rebellion.

1818. Chaka's reign of terror commenced.
1818. Fifth Kafir War.
1820. Port Elizabeth founded.
1820. Arrival of British settlers in Albany.
1823. Lieut. Farwell's visit to Natal.
1824. First settlement of English in Natal.
1825. Governor's power limited by Council of Advice.
1825. First steamer arrived at Table Bay.
1828. Chaka killed by Dingaan.
1829. South African College opened.
1834. Emancipation of slaves.
1834. Fingoes released from bondage.
1834. Dutch Farmers entered Natal.
1834. Legislative Council established in Cape Colony.
1835. Sixth Kafir War.
1835. Capt. Allen Gardiner's mission to Natal.
1835. Durban founded.
1835. American mission in Natal commenced.
1836. Emigration of Dutch farmers beyond Orange River.
1837. Matabele crossed to the north of the Limpopo.
1837. Dutch emigrants enter Natal.
1838. Dutch emigrants murdered by Dingaan.
1838. Natal visited by British troops.
1839. Dutch proclaimed republic of Natalia.
1839. Coal discovered in Natal.
1839. Transvaal Republic founded.
1839. Establishment of Public School system in Cape Colony.
1841. Wesleyan Mission in Natal commenced.
1842. British supremacy in Natal proclaimed.
1843. Griqua and Basuto treaties.
1844. Pondoland made a treaty State.
1845. First Lieut.-Governor of Natal appointed.
1846. Seventh Kafir War commenced.
1847. Province of British Kaffararia created.
1848. Orange River Sovereignty proclaimed.
1848. Andries Pretorious crossed the Vaal.
1848. Legislative Council for Natal established.
1849. Anti-Convict agitation.
1850. Eighth Kafir War commenced.
1851. First Basuto War commenced.
1852. Sand River Convention.
1852. Sugar planting commenced in Natal.
1854. Orange Free State established.
1854. Parliamentary institutions granted to Cape Colony.
1854. Angora goats introduced into Cape Colony.
1856. Natal created a colony with representative institutions.
1857. Pretorious and Kruger invade the Free State.
1858. Cattle-killing mania of the Ama Xosa.
1858. Second Basuto War.
1860. First telegraph line from Cape Town to Simon's Town.

1860. Coolie labour introduced into Natal.
1865. Kei River made eastern boundary of Cape Colony.
1866. Natal extended to Pondoland border.
1867. Discovery of Diamonds.
1868. Annexation of Basutoland to British dominions.
1871. Creation of Province of Griqualand West.
1872. Burgers elected President of Transvaal.
1872. Responsible Government granted to Cape Colony.
1873. Cape University established.
1873. Revolt of Langalibalele.
1874. Legislative Council for Cape Colony elected by 7 Circles.
1877. Annexation of South African Republic.
1877. Ninth Kafir War commenced.
1879. War with Cetewayo.
1880. War with the Basutos.
1880. Annexation of Griqualand West to Cape Colony.
1880. Transvaal War of Independence.
1881. Restoration of South African Republic.
1882. Kruger elected President.
1884. Basutoland made a Crown Colony.
1884. Barolong Territory annexed to Free State.
1884. German Protectorate in South-West Africa.
1885. Bechuanaland made British territory.
1886. Opening of Transvaal goldfields.
1887. Zululand declared British Territory.
1889. Customs Union formed.
1889. Charter to British South Africa Company granted.
1890. Mashonaland occupied.
1893. Responsible government granted to Natal.
1893. Lobengula overthrown.
1894. Pondoland annexed to Cape Colony.
1895. Swaziland annexed to the Transvaal.
1895. The Raid into the Transvaal.
1896. War with the Matabele.
1896. Annexation of Amatongaland.
1897. Zululand annexed to Natal.
1898. Rebellion of Bechuana chiefs.
1899. Great Boer War commenced.
1900. Transvaal and Orange River Colony proclaimed British territory.
1901. Visit of Prince and Princess of Wales.
1902. Death of Cecil Rhodes.
1902. Peace signed at Pretoria.

Population Data.

Cape Colony.

	Population.
1806	77,055
1811	87,018
1816	88,486

Cape Colony (continued).

	Population.
1821	112,147
1826	121,497
1831	126,848
1836	152,240
1841	155,324
1846	180,594
1851	297,113
1856	267,096

These figures are probably rough enumerations, but are sufficiently consistent period by period to give a fairly accurate idea of the number and growth of the population up to the time when the census proper was instituted. The relative proportions to be allotted to the different races may be gathered from the following figures taken at different times. In 1806 the races are thus divided :—

Christians	26,768
Hottentots	20,426
Slaves	29,861

Fifteen years later, in 1821, two new classes appear, the figures being :—

Christians	47,280
Free Blacks	1,871
Hottentots	29,023
Negro Apprentices	1,571
Slaves	32,402

In a return presented to the House of Commons showing the population in 1849, the proportions are given as 88,490 white and some 196,790 coloured, the numbers being approximate.

First Census.

The first actual census was taken in 1865, with the following results :—

Europeans	181,592
Hottentots	81,598
Kafirs	100,536
Others	132,655
Total Population	496,381

In 1875 a

SECOND CENSUS

produced the following figures :—

Europeans	236,783
Malays	10,817
Hottentots	98,561
Fingoes	73,506
Kafirs and Bechuanas	214,133
Mixed and others	87,184
Total Population	720,984

It should be noted that the territory then known as British Kaffraria was not reckoned in the census of 1865. By the inclusion of that territory in Cape Colony some 8,183 Europeans and 78,018 Natives were added, and these must be reckoned with their natural increase during the decade for the purpose of comparison.

THE THIRD CENSUS

was not taken until 1891, the intention of the longer interval being doubtless to bring the numbering of the people into line with the year fixed for the United Kingdom and other parts of the Empire. The results are set forth in the following table :—

Europeans or Whites	376,987
Malays	13,907
Hottentots	50,388
Fingoes	229,680
Kafirs and Bechuanas	608,456
Mixed and Others	247,806
Total Population	1,527,224

Again it must be borne in mind that additional territories had been included since the previous census, these comprising the Province of Griqualand West which brought in 29,670 Europeans and 53,705 Native and coloured, and the Native Territories of East Griqualand, Tembuland, Transkei and Walfish Bay with 10,379 Europeans and 476,985 Natives.

THE FOURTH CENSUS

which, in the ordinary course, should have been taken in 1901, but owing to the war had to be deferred, was not taken until 1904, that being the earliest date for which the arrangements could be completed after the country districts had settled down, and the towns resumed their normal condition.

The results are set forth in racial detail in the following figures :—

European or White	579,741
Malays	15,682
Hottentots	91,260
Fingoes	310,720
Kafirs and Bechuanas	1,114,067
Mixed and Others	298,334
Total Population	2,409,804

Once more annexed territories have to be taken into account when comparisons of results are instituted, British Bechuanaland and Pondoland being together responsible for the addition of 10,300 Europeans and 276,522 Native and other peoples.

Natal.

For the population of Natal there are no accurate figures for the early years, and resorting to estimates the following figures will be found to afford at least an idea of racial proportions and growth :—

1859.	Europeans	11,580
	Zulu Kafirs	150,000
	Total	161,580
1865.	Europeans	17,000
	Zulu Kafirs	140,000
	Total	157,000
1871.	Whites	17,886
	Coolies	5,070
	Natives	266,817
	Aliens, &c.,	4,059
	Total	293,832
1881.	Whites	28,483
	Coolies	20,196
	Natives	367,540
	Total	416,219

1891.	Whites	46,788
	Coolies	41,142
	Natives	455,983
	Total	543,913

1904.	Whites	97,109
	Indians	100,918
	Natives in Service	79,978
	Mixed and Others	6,686
	Natives	824,063
	Total Population	1,108,754

Transvaal.

The earlier estimates of the population in the Transvaal appear to have been less carefully made than those in other parts of South Africa, and the Native population, especially, seems to have been over-estimated. The figures available do not cover a very extended period. During the first British occupation the following statement was given :—

1880.	Whites	45,000
	Natives and others	774,930
	Total	819,930

1891.	Whites	85,000
	Natives and others	715,000
	Total	800,000

1904.	Whites	300,255
	Natives	1,030,029
	Other Coloured	23,946
	Total Population	1,354,200

In the numbers for the 1904 census Swaziland is included, another instance of expanding territory which has so frequently to be borne in mind in South Africa when comparisons are instituted.

Orange River Colony.

The estimates of population in the early days of the Orange Free State do not form very satisfactory data upon which to work, but the population was at no time very large, nor did it very rapidly increase. In later years the development has been more rapid.

In 1870 the following figures were given out :—

	Whites	33,000
	Natives and others	17,000
	Total	50,000
1880.	Whites	61,022
	Natives and others	72,496
	Total	133,518
1890.	Whites	77,716
	Natives and others	129,787
	Total	207,503
1904.	Whites	143,419
	Natives and others	241,626
	Total	385,045

Southern Rhodesia.

1904.	Mashonaland Europeans	4,917
	Matabeleland Europeans	7,706
	Whites	12,623
	Natives and others	593,141
	Total	605,764

Bechuanaland Protectorate.

1904.	Whites	1,004
	Natives and others	119,772
	Total	120,776

Basutoland.

1904.	Whites	895
	Natives and others	347,953
	Total	348,848

British South Africa, 1904.

	European or White.	Natives and others.	Total.
Cape Colony..	579,741	1,830,063	2,409,804
Natal..	97,109	1,011,645	1,108,754
Transvaal	300,225	1,053,975	1,354,200
Orange River Colony ..	143,419	241,626	385,045
Southern Rhodesia	12,623	593,141	605,764
Bechuanaland Protectorate	1,004	119,772	120,776
Basutoland	895	347,953	348,848
Grand Total ..	1,135,016	5,198,175	6,333,194

Railway Communication.

Cape Colony (*Western.*)

A.D.
1863. Cape Town to Wellington (Main Line).
1864. Cape Town to Wynberg.
1875. Cape Town to Docks.
1876. Main Line extended to Worcester.
1877. Malmesbury Branch.
1878. Main Line extended to Matjesfontein.
1880. Main Line extended to Beaufort West.
1883. Wynberg to Kalk Bay.
1884. Main Line extended to De Aar.
1885. Main Line extended to Kimberley.
1890. Sir Lowry's Pass Branch.
1890. Kalk Bay to Simon's Town.
1890. Main Line extended to Vryburg.

Cape Colony (*Midland*).

1875. Port Elizabeth to Addo.
1875. Port Elizabeth to Uitenhage.
1877. Main Line opened to Alicedale.
1879. Uitenhage Line extended to Graaff-Reinet.
1879. Grahamstown Branch.
1881. Main Line opened to Cradock.
1883. Extension to Colesberg.
1884. Linked with Western at De Aar.
1890. Norval's Pont reached.
1898. Graaff-Reinet Line extended to Rosmead.

Cape Colony (*Eastern*).

1877 East London to King William's Town.
1877. East London to Kei Road.
1880. Extended to Queenstown.

1883. Extended to Sterkstroom.
1885. Extended to Aliwal North.
1892. From Albert to Orange River.

Later the Sir Lowry's Pass Line has been extended to Caledon, the Malmesbury line to Hopefield and Eendekuil, and other branches are in course of construction from the Western Line to Carnarvon and Prieska.

From the Graaff-Reinet Line the South-Western Districts have been tapped, and the coast district west of Port Elizabeth.

The King William's Town Line has been extended to Cookhouse, and from the latter place a branch reaches to Somerset East.

The Eastern Line has also been supplied with a feeder on its western side from Tarkastad, and on its eastern side branches are being made in the direction of Butterworth from Amabele, and to Maclear from Sterkstroom, and Gairtney from Aliwal North.

At different periods private enterprise has joined Grahamstown with Port Alfred; and from Worcester an extension has been made which will shortly reach Mossel Bay; while from the west coast Namaqualand has been supplied.

Natal.

1860. Point to Durban (First Railway in Africa).
1876. Main Line commenced.
1880. Opened to Maritzburg.
1886. Extended to Ladysmith.
1891. Completed to Charlestown.
1892. Opened to Harrismith.

Branch Lines have been been opened at different periods on the northern coast through the sugar and tea districts reaching the Lower Tugela in 1898, and Empangeni in Zululand in 1902. On the southern coast the line was completed to North Shepstone in 1901, and a branch to Umzinto was opened in 1900. A local line Clairmont to Wests was completed in 1898. On the Western side of the main line Richmond branch was opened in 1897 and Maritzburg to Greytown on the east in 1900. Glencoe to Dundee was completed in 1889, and last year was opened to Vryheid. Portions of most of these lines were opened as completed.

Orange River Colony.

1890. Cape Lines reached Bloemfontein.
1892. East London Line linked at Springfontein.
1892. Extension to Vaal River.

More recently branch lines have been opened to Jagersfontein, Ladybrand, Winburg and Heilbron, and the Natal line from Harrismith has reached Bethlehem.

Transvaal.

1892. Cape Lines extended to Johannesburg and Pretoria.
1895. Natal Line linked with Johannesburg.
1895. Delagoa Bay Line linked in at Pretoria.

Branch lines have since been made to Barberton, to Pietersburg, to Springs and to Klerksdorp.

Rhodesia.

A decade covers the railway history of Rhodesia, which includes extension from Vryburg to Beira, with branch lines to Matopos, West Nicholson, Selukwe and the Ayrshire Mines, and during the present year the Zambesi has been crossed at the Victoria Falls.

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