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THE GEOLOGICAL SOCIETY OF AMERICA®

VOL. 32, NO. 6 | JUNE 2022

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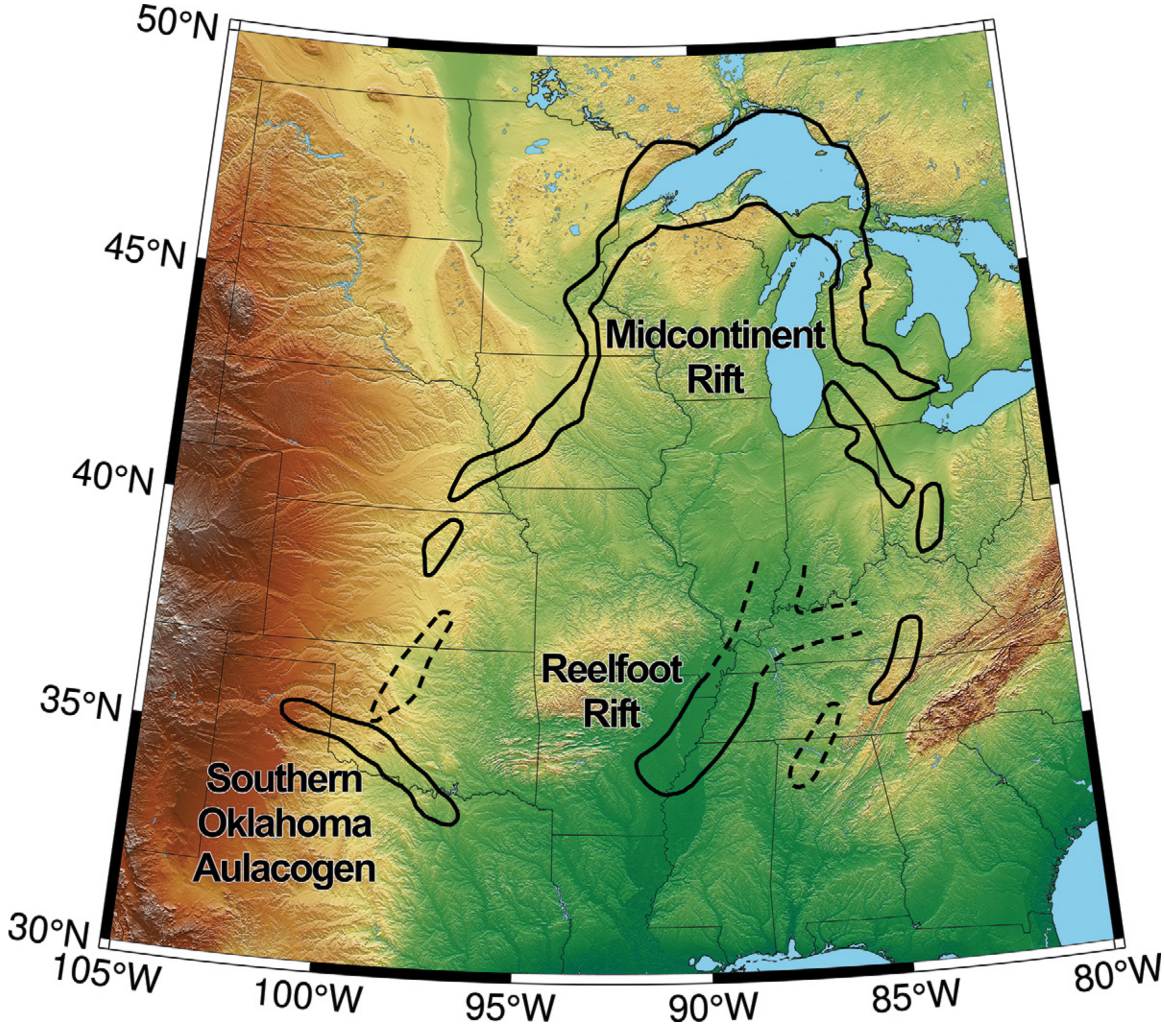

JUNE 2022 | VOLUME 32, NUMBER 6

GSA TODAY

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Executive Director and Publisher: Vicki S. McConnell

Science Editors: Peter Copeland, University of Houston, Department of Earth and Atmospheric Sciences, Science & Research Building 1, 3507 Cullen Blvd., Room 314, Houston, Texas 77204-5008, USA, copeland@uh.edu; **James Schmitt,** Dept. of Earth Sciences, Montana State University, Bozeman, Montana 59717, USA, jschmitt@montana.edu.

Managing Editor: Kristen “Kea” Giles, kgiles@geosociety.org, gsatoday@geosociety.org

Graphics Production: Emily Levine, elevine@geosociety.org

Advertising Manager: Ann Crawford, +1-800-472-1988 ext. 1053; +1-303-357-1053; Fax: +1-303-357-1070; advertising@geosociety.org

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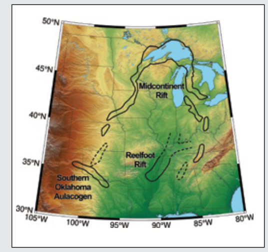

Cover: Topographic map of central North America outlining the extent of its three major failed rifts: the Mesoproterozoic Midcontinent Rift, and the Ediacaran-Cambrian Southern Oklahoma Aulacogen and Reelfoot Rift. Dashed lines indicate possible extensions of rift arms. See related article, p. 4–11.

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Three Major Failed Rifts in Central North America: Similarities and Differences

Reece Elling, Seth Stein, *Earth & Planetary Sciences, Northwestern University, Evanston, Illinois 60208, USA;* ***Carol A. Stein, Kerri Gefeke,*** *Earth & Environmental Sciences, University of Illinois, Chicago, Illinois 60607, USA*

ABSTRACT

The North American craton preserves nearly two billion years of geologic history, including three major rifts that failed rather than evolving to continental breakup and seafloor spreading. The Midcontinent Rift (MCR) and Southern Oklahoma Aulacogen (SOA) show prominent gravity anomalies due to large volumes of igneous rift-filling rock. The Reelfoot Rift (RR), though obscure in gravity data, is of interest due to its seismicity. The ca. 1.1 Ga MCR records aspects of the assembly of Rodinia, whereas the ca. 560 Ma SOA and RR initiated during the later breakup of Rodinia and were inverted during the assembly of Pangea. Comparative study of these rifts using geophysical and geological data shows intriguing similarities and differences. The rifts formed in similar tectonic settings and followed similar evolutionary paths of extension, magmatism, subsidence, and inversion by later compression, leading to similar width and architecture. Differences between the rifts reflect the extent to which these processes occurred. Further study of failed rifts would give additional insight into the final stages of continental rifting and early stages of seafloor spreading.

INTRODUCTION

Plate tectonics shapes the evolution of the continents and oceans via the Wilson cycle, in which continents rift to form new oceans. Many rifts evolve to passive continental margins. However, some rifts fail before continental breakup and remain as fossil features within continents, which are largely buried beneath the surface and studied primarily with gravity and seismic surveys. Failed rifts preserve a snapshot of the rifting process before the beginning of seafloor spreading and thus give insight into late stages of continental rifting and formation of passive continental margins (S. Stein et al., 2018; Stein et al., 2022).

North America contains multiple impressive, failed rifts (Fig. 1), preserving important aspects of the fabric of nearly two billion years of geologic history in Laurentia, its Precambrian core (Whitmeyer and Karlstrom, 2007; Marshak and van der Pluijm, 2021). We focus on three major failed rifts, covering ~10% of central North America (defined for these purposes as the area shown in Fig. 1A). One, the Midcontinent Rift (MCR), is a prominent feature in geophysical maps of the region. Due to its size and the availability of geophysical and geological data, the MCR has been the focus of many studies giving insight into its evolution, role in the assembly of Rodinia, and processes of rifting and passive margin evolution (e.g., Green et al., 1989; C. Stein et al., 2018; Swanson-Hysell et al., 2019). Two other failed rifts, the Southern Oklahoma Aulacogen (SOA) and Reelfoot Rift (RR), have also been subjects of much interest. Parts of the SOA lie within the basement near and below the Anadarko Basin, a major oil- and gas-producing basin. Thus, its oil-bearing upper crust is well studied (Brewer et al., 1983; Keller and Stephenson, 2007; Hanson et al., 2013), but the deeper structures in the lower crust and uppermost mantle are rarely the primary target of study. The RR and its northern extensions, on the other hand, have little interest for the energy industry but are of interest due to their active seismicity (Hildenbrand and Hendricks, 1995; Calais et al., 2010).

These three failed rifts are grossly similar, with similar tectonic origins and structural features, but with interesting differences highlighting aspects of their evolution. These are shown by gravity data that are uniformly sampled across the central U.S. (Fig. 1). In contrast, other data available differ from area to area. In particular, high-quality seismic reflection data giving detailed structure at depth that allows modeling of the rift's evolution are available only across the part of the MCR below Lake Superior. Conversely, EarthScope local seismic array data showing structure beneath the rift are available only across parts of the MCR's west arm and the RR.

Using gravity data from the PACES (Keller et al., 2006) and TOPEX data sets (Sandwell et al., 2013), we extracted profiles 150 km long and ~50 km apart across each rift (Fig. 1B). Figure 1C shows each rift's mean Bouguer anomaly and standard deviation. The mean profiles show differences between rifts, reflecting their tectonic origin and subsurface structure. The MCR's west arm shows large gravity highs (~80 mGal) bounded by ~20 mGal lows on either side of the rift basin. In contrast, the MCR's east arm has a positive anomaly half that of the west arm and lacks bounding lows. The Southern Oklahoma Aulacogen has an ~60 mGal positive anomaly, similar to the MCR, whereas the RR shows only a minor (~10–15 mGal) positive anomaly despite forming about the same time as the SOA.

The profiles are generally similar in width and form, but differ in amplitude, suggesting general similarities in crustal and uppermost mantle structure between the rifts. We use the mean gravity profiles augmented with seismic and other data, combined with results from earlier studies, to model the rifts' general subsurface structures. We start with the hypothesis that the rifts are similar, and so when needed use inferences from one rift to gain insight into the others, to the extent that the data permit. Although models from gravity data alone are non-unique, augmenting them with information from seismic, aeromagnetic, surface mapping, and drill-hole data lets us characterize average structure along the rifts and illustrate similarities and differences between them. The similarities and differences reflect the combined effects of a

GSA Today, v. 32, https://doi.org/GSATG518A.1.

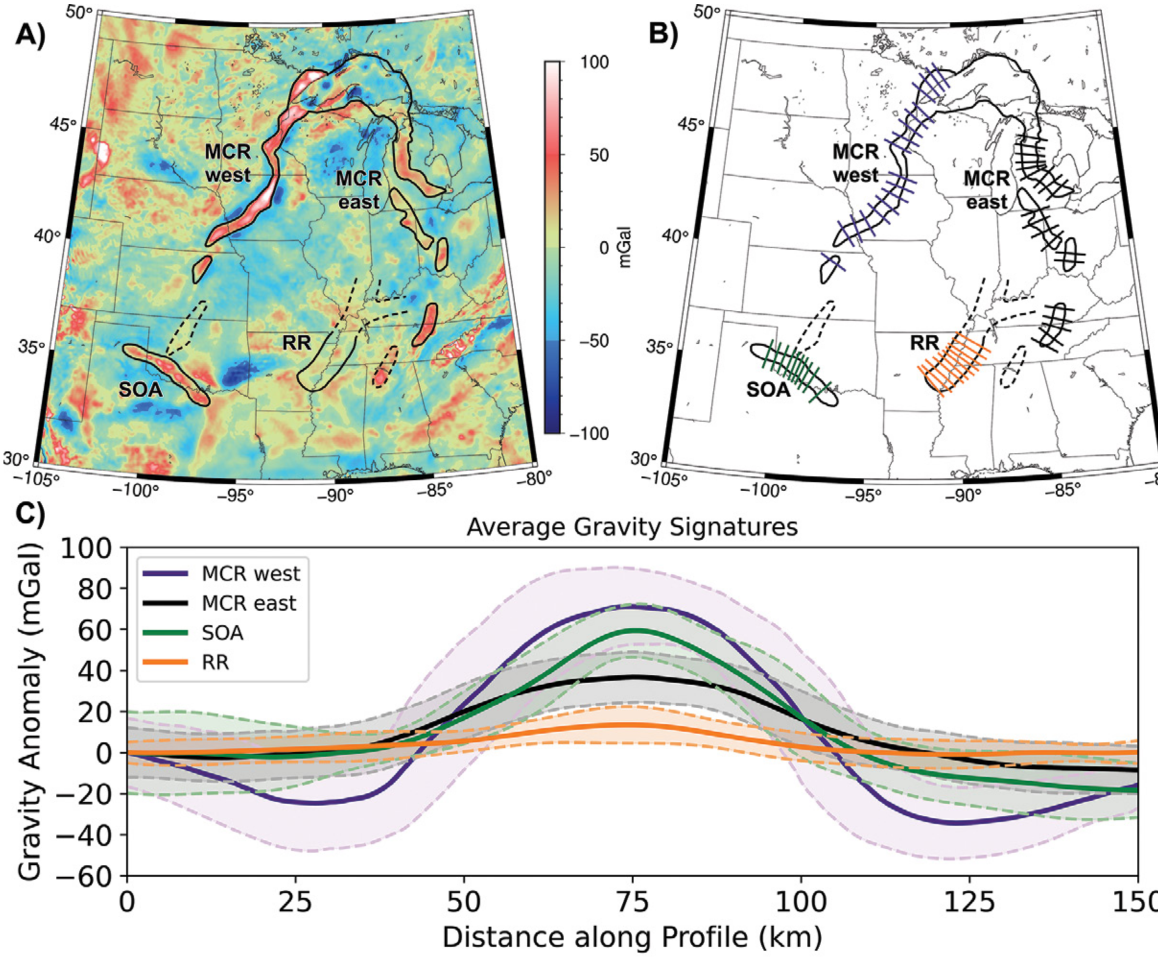

Figure 1. (A) Bouguer gravity anomaly map for central North America. Anomalies related to the Midcontinent Rift (MCR), Southern Oklahoma Aulacogen (SOA), and Reelfoot Rift (RR) are outlined. Dashed lines outline possible extensions of rift arms not included in analysis. (B) Profiles used in calculating the average gravity anomalies. (C) Mean anomalies and standard deviations for rifts.

sequence of rifting, volcanism, sedimentation, subsidence, compression, erosion, and later effects (Stein et al., 2015; Elling et al., 2020). They give insight into how rifts evolve and are useful when studying other failed or active rifts elsewhere.

MIDCONTINENT RIFT

The Midcontinent Rift (MCR), a 3000-km-long band of more than 2 million km^3 of buried igneous and sedimentary rocks that outcrop near Lake Superior, has been extensively studied, as reviewed by Ojakangas et al. (2001) and S. Stein et al. (2018). To the south, it is buried by younger sediments, but easily traced because the rift-filling volcanic rocks are dense and highly magnetized. The western arm extends southward to Oklahoma, as shown by positive gravity anomalies and similar-age diffuse volcanism (Bright et al., 2014). The eastern arm extends southward to Alabama (Keller et al., 1983; C. Stein et al., 2014, 2018; S. Stein et al., 2018; Elling et al., 2020). The MCR likely formed as part of rifting of the Amazonia craton (now in northeastern South America) from Laurentia, the Precambrian core of North America at 1.1 Ga, after the Elzeverian and Shawinigan orogenies and before the Grenville Orogeny (C. Stein et al., 2014, 2018; S. Stein et al., 2018). Surface exposures, seismic data, and gravity data delineate rift basins filled by thick basalt layers and sediments, underlain by thinned crust and an underplate unit, presumably the dense residuum from the magma extraction (Vervoort et al., 2007; S. Stein et al., 2018). The rift was later massively inverted by regional compression, uplifting the volcanic rocks so that some are exposed at the surface today. The MCR has little seismicity along most of its length, but portions in Kansas and Oklahoma experienced seismicity and Phanerozoic deformation (Burberry et al., 2015; Levandowski et al., 2017).

We developed models for each arm (Figs. 2A and 2B), following Elling et al. (2020), because the west arm's larger gravity anomaly indicates differences in magma volume and tectonic evolution. For simplicity, the models use average densities of the sediment, igneous rift fill, underlying crust, underplate, and mantle. We began with GLIMPCE seismic reflection profiles across Lake Superior that give the best available image of structure at depth in the MCR (Green et al., 1989) and permit detailed modeling of its evolution (Stein et al., 2015). We also considered prior gravity models across parts of the MCR (Mayhew et al., 1982; Shay and Trehu, 1993). EarthScope data (Zhang et al., 2016) provided values for the depth and thickness of the volcanics and underplate along the west arm that were used to update the models. These data showed that structure below the west arm resembles that below Lake Superior, suggesting that the structure along the entire MCR is similar. On either side of the central rift basin, basins ~5 km thick resulting from post-rift sedimentation

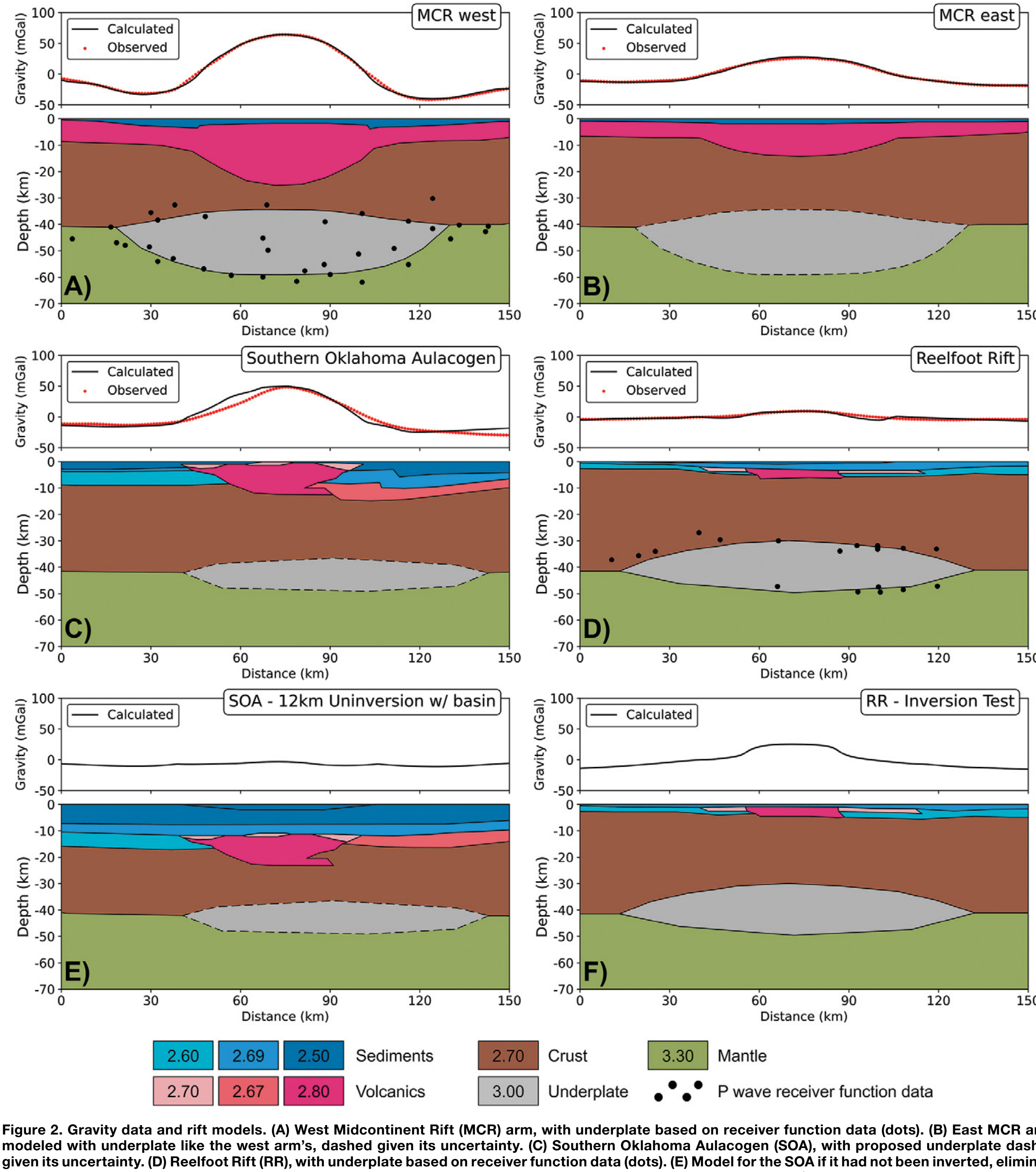

Figure 2. Gravity data and rift models. (A) West Midcontinent Rift (MCR) arm, with underplate based on receiver function data (dots). (B) East MCR arm, modeled with underplate like the west arm's, dashed given its uncertainty. (C) Southern Oklahoma Aulacogen (SOA), with proposed underplate dashed given its uncertainty. (D) Reelfoot Rift (RR), with underplate based on receiver function data (dots). (E) Model for the SOA if it had not been inverted, eliminating the positive anomaly. (F) Model for the RR if it had been inverted, producing a positive anomaly. Densities in g/cm^3.

produce bounding gravity lows. The sediments are much thinner over the central basin as a result of inversion, uplift, and erosion after rift failure.

We model the east arm as similar to the west. Because the east arm does not show bounding gravity lows, the model does not include bounding basins. We include an underplate like that below the west arm, although seismic data needed to resolve it are lacking, because such underplates are also seen below the RR, have been proposed below the SOA, are common in rifts worldwide (Thybo and Artemieva, 2013; Rooney et al., 2017), and are expected given the igneous rift fill (Vervoort et al., 2007). The largest difference between the models is the thickness of rift-filling volcanics; the west arm contains 20–25 km of volcanics, whereas the east arm contains 10–15 km. The dense igneous rocks affect the gravity anomaly much more than the underplate, so the geometry of the volcanics in the east arm was adjusted to match the gravity profiles.

SOUTHERN OKLAHOMA AULACOGEN

The Southern Oklahoma Aulacogen (SOA) (Walper, 1977) is a linear alignment of extensively inverted rift structures perpendicular to the southern tip of the MCR's west arm. Its main structures are the Wichita uplift (and associated igneous provinces) and Anadarko Basin. Both the SOA and RR (discussed shortly) initiated as the Cuyania block, also known as the Argentine Precordillera, rifted away from Laurentia (Thomas, 2011; Whitmeyer and Karlstrom, 2007). Rifting is thought to have begun in latest Precambrian, but the oldest dates come from SOA igneous rocks dated at ca. 540 Ma (Wall et al., 2021).

The SOA's geologic and tectonic history has three major phases. The first involved emplacement of the Wichita Igneous Province during development of a rift beginning in the Ediacaran to mid-Cambrian (Brewer et al., 1983; Perry, 1989; Wall et al., 2021). Extensional and transtensional tectonism within the SOA developed during the latest Precambrian–Cambrian opening of the southern Iapetus Ocean as part of Rodinia's breakup (Robert et al., 2021). Following rift failure, thermal subsidence allowed deposition of thick sedimentary sequences, marking the onset of the Anadarko Basin formation (Perry, 1989; Johnson, 2008). Finally, Late Mississippian through Pennsylvanian compression inverted the SOA and formed a NE-trending fold-thrust belt containing the Wichita and Arbuckle Mountains (Keller and Stephenson, 2007). The compression is believed to be related to North America's collision with Africa and South America during the Alleghenian Orogeny (Kluth and Coney, 1981) or tectonic activity along North America's western and southwestern margins (Lawton et al., 2017; Leary et al., 2017). The SOA exposes only a fraction of its extent in the Wichita Mountains and contains more than 210,000 km^3 of buried mafic rocks up to 10 km thick along the entire rift (Hanson et al., 2013), along with a large volume of felsic igneous rocks, including granitic intrusions and interbedded rhyolites. Emplacement and subsequent inversion of the igneous rocks yielded a positive gravity anomaly of ~60 mGal, similar to the average of the MCR arms.

Our SOA model is modified from Keller and Stephenson's (2007) model based on gravity, seismic, aeromagnetic, surface mapping, and drilling data. Seismic reflection data were used to constrain the location and thicknesses of the gabbroic and felsic intrusions producing the large positive anomaly. We simplified their model for comparison with the other rifts. Sedimentary basin rocks were averaged into a few units, and bodies within the gabbroic intrusion that increased in density with depth in the original model were averaged to a single density. Keller and Baldridge (1995) proposed the presence of an underplate, which is consistent with the gravity data and included in our model, though seismic data adequate to confirm (or disprove) its presence are not available.

REELFOOT RIFT

The Reelfoot Rift (RR) underlies the Upper Mississippi Embayment, a broad trough with a complex history of rifting and subsidence (Catchings, 1999). The NE-trending graben of the RR is 70 km wide and more than 300 km long. Reflection profiles and mafic alkalic plutons suggest several episodes of faulting and intrusive activity (Mooney et al., 1983). The RR is believed to have experienced multiple phases of subsidence (Ervin and McGinnis, 1975), with the earliest rifting in the Ediacaran associated with widespread rifting along North America's margins during the breakup of Rodinia. The rift basin primarily developed during this Cambrian event. Later subsidence, perhaps as late as the Cretaceous, is associated with emplacement of mafic igneous intrusives inside the rift and deposition of several kilometers of sediments that bury them (Hildenbrand and Hendricks, 1995; Cox and Van Arsdale, 2002). Relative to the MCR and SOA, the RR experienced significantly less volcanic activity during rifting, and its subsidence influenced the sedimentation and subsequent development of the drainage basins of major rivers, such as the Mississippi. Climate-controlled erosion and unloading of sediments that fill the rift basin have been proposed to have triggered the present seismicity (New Madrid seismic zone) on faults remaining from the rifting (Calais et al., 2010).

We developed our model by modifying one by Liu et al. (2017) based on their work and earlier models constrained by seismic refraction, gravity, and magnetic data (Mooney et al., 1983; Braile et al., 1986; Nelson and Zhang, 1991). Earlier studies identified an underplate, or "rift pillow," whose location is constrained by Liu et al.'s (2017) results. An underplate has also been observed along the RR's northeastern extension (Aziz Zanjani et al., 2019). A feature of our model, required to replicate the lack of a large gravity anomaly, is that the RR contains far less high-density volcanics than the other rifts, perhaps because it extended less. Low-density Quaternary sediments of the Mississippi River basin overlying the rift rocks also contribute to the minimal anomaly.

SIMILARITIES AND DIFFERENCES

Comparing the three rifts' average gravity profiles and subsurface structures inferred in part from them illustrates similarities and differences between the rifts.

Tectonic Setting

All three formed during rifting associated with Laurentia's interactions within the supercontinent of Rodinia. The MCR formed after the Elzeverian and Shawinigan orogenies and before the Grenville Orogeny that assembled Rodinia (e.g., Hynes and Rivers, 2010). Its formation was likely associated with rifting between Laurentia and Amazonia during a plate boundary reorganization (S. Stein et al., 2014, 2018) (Fig. 3A), although details of Amazonia's location and motion are not well constrained at this time because of limited paleomagnetic data (Tohver et al., 2006; Li et al., 2008).

Additional evidence for this view comes from a change in Laurentia's absolute plate motion around the time of the formation of the MCR. A global plate model (Scotese and Elling, 2017), updated with a global compilation of paleomagnetic poles (McElhinny and Lock, 1996; Torsvik et al., 2008, 2012; Merdith et al., 2017; Scotese and Van der Voo, 2017; Veikkolainen et al., 2017), was inverted to generate synthetic apparent polar wander (APW) paths that match the plate model. Comparison with global mean poles (GMP) revealed these synthetic APW paths produce a good fit within the α95 error of the GMPs. Laurentia's APW path has a major cusp, called the Logan Loop, recorded in part by the MCR's volcanic rocks (Fig. 3C). Cusps in APW paths have been observed elsewhere when continents rift apart (Gordon et al., 1984). A similar cusp appears ca. 600 Ma in this model (Fig. 3C), during opening of the Iapetus Ocean as the Argentine Precordillera microcontinent rifted from the Wichita embayment on Laurentia's SE margin (Whitmeyer and Karlstrom, 2007; Thomas, 2011). Both the SOA and RR

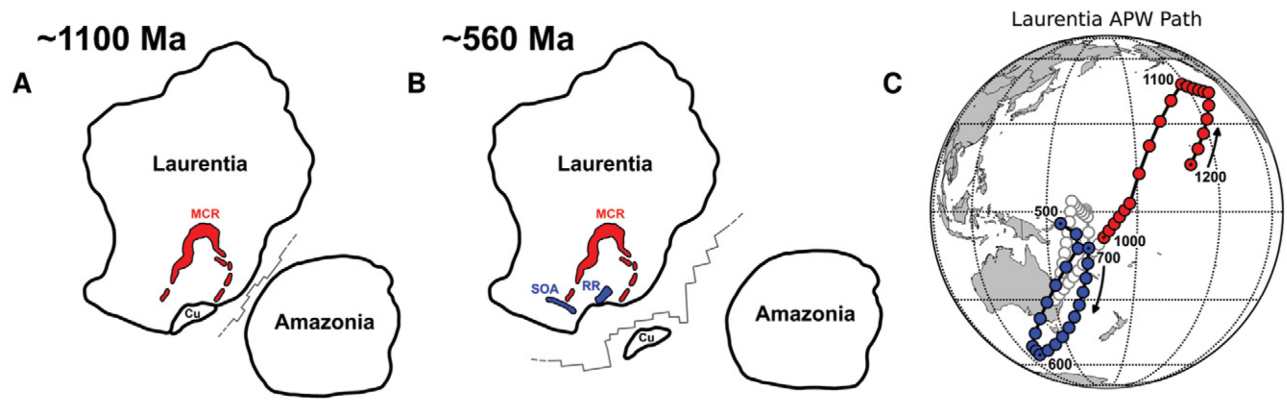

Figure 3. (A) Schematic reconstruction of plate positions relative to Laurentia ca. 1100 Ma during formation of Rodinia. After the Elzeverian and Shawinigan orogenies, but before the Grenville orogeny, spreading likely initiated between the major plates. Following failure of the Midcontinent Rift (MCR), Amazonia shifted north along the margin before recolliding. (B) Similar reconstruction at ca. 560 Ma as Rodinia was breaking up. Cuyania (Cu) block rifted off Laurentia, leaving the Southern Oklahoma Aulacogen (SOA) and Reelfoot Rift (RR) as failed arms. (C) Apparent polar wander (APW) path of Laurentia, plotted in present-day coordinates, at 10-m.y. increments. Red cusp (1200–1000 Ma) is related to formation of the MCR, and blue cusp (700–500 Ma) is related to initial rifting of the SOA and RR. Path between these events plotted in gray.

opened as arms of this triple junction but ultimately failed (Fig. 3B).

Spatial Scale and Architecture

The three rifts have similar spatial scales and structures that seem to characterize failed rifts. Their central grabens, filled with volcanic and sedimentary rocks, are bounded by faults that presumably had normal fault motion during extension. Despite structural differences, all three rifts are ~60–80 km wide, suggesting that failed rifts are consistent with observations that presently spreading rifts had initial widths controlled by crustal thickness rather than the extension history (Allemand and Brun, 1991).

For the MCR and SOA, the rifting faults were reactivated as reverse faults during subsequent inversion. The SOA's gravity high reflects structural inversion of basaltic and gabbroic material in the Wichita Mountains, but significant amounts of rift-fill remain buried beneath the Anadarko Basin (Keller and Stephenson, 2007). Although the RR looks similar overall, it was not significantly reactivated by later inversion. This left its rift-filling volcanics deeper in the subsurface, causing the absence of a positive gravity anomaly. This effect is illustrated by a model showing the gravity anomaly at different stages in the MCR's evolution (Fig. 4), derived from cross-section–balanced reconstructions from GLIMPCE data (Stein et al., 2015). During rifting, dense volcanics near the surface would have caused a large positive anomaly. Subsequent deposition of low-density sediments and subsidence that depressed the volcanics would have caused a gravity low. Eventually, inversion of the rift and erosion and removal of low-density sediments brought the volcanics closer to the surface, causing today's gravity high. Without this inversion, a positive anomaly would not have developed.

We explored the hypothesis that inversion is crucial for producing a positive gravity anomaly using the SOA and RR. The SOA experienced up to 15 km of inversion in the late Paleozoic (Keller and Stephenson, 2007). "Uninverting" the rift by re-burying the gabbroic fill 12 km below a sedimentary basin eliminates the positive anomaly (Fig. 2E). Hence the SOA's gravity high largely reflects the inversion. Conversely, because the RR did not experience significant inversion, its rift basin is buried beneath low-density sediments. Inverting the RR by 3 km and removing sediments overlying the basin (Fig. 2F) produces a positive anomaly due to the high-density igneous rift fill being much nearer to the surface.

Igneous Rock Volumes

There are interesting differences in the volumes of rift volcanics. The MCR is ~3000 km long and contains more than 2 million km^3 of buried igneous rocks, while the SOA and RR are both roughly 1/10 the length of the MCR and contain significantly less volcanics. Although the SOA's volcanic package produces a large positive gravity anomaly, it contains only ~1/10 as much volcanics as the MCR (Hanson et al., 2013).

The differences appear in the cross sections. Volcanics in MCR's west and east arms have average cross-sectional areas of 1100 km^2 and 680 km^2, the SOA has an average cross-sectional area of 470 km^2, whereas the RR's cross-sectional area is much smaller (160 km^2). How these differences arose is unclear. The volumes of igneous rocks produced in rifting can reflect two effects. The first is passive rifting in which extension due to far-field forces causes lithospheric thinning and inflow of hot asthenosphere, such that greater extension produces more melt (Koptev et al., 2015). The second, active rifting, involves an upwelling thermal plume, such that melt is generated by elevated mantle temperatures beneath the lithosphere (Burov and Gerya, 2014). The relative roles of these and other possible rifting processes (King, 2007) are extensively debated but remain unclear (Foulger, 2010). Both active and passive rifting have been invoked to explain the volumes of volcanic rocks at rifted continental margins (White and McKenzie, 1989; Richards et al., 1989; van Wijk et al., 2001). Gallahue et al. (2020) find evidence for both processes on continental margins, with passive rifting having a stronger effect.

A plume contribution for the MCR has been inferred from petrologic and geochemical data (Nicholson et al., 1997; White, 1997; Davis et al., 2021), consistent with the enormous volume of volcanic rocks making it a Large Igneous Province (Green, 1983; Stein et al., 2015). The large volume of MCR rocks also likely reflects Precambrian mantle temperatures higher than today's (Korenaga, 2013). The difference between the west and east arms likely reflects a difference in the amount of extension during rifting (Merino et al., 2013; Elling et al., 2020). The smaller cross-sectional areas of volcanics in the SOA and RR probably do not require assuming a plume. Hence, in our view, the simplest

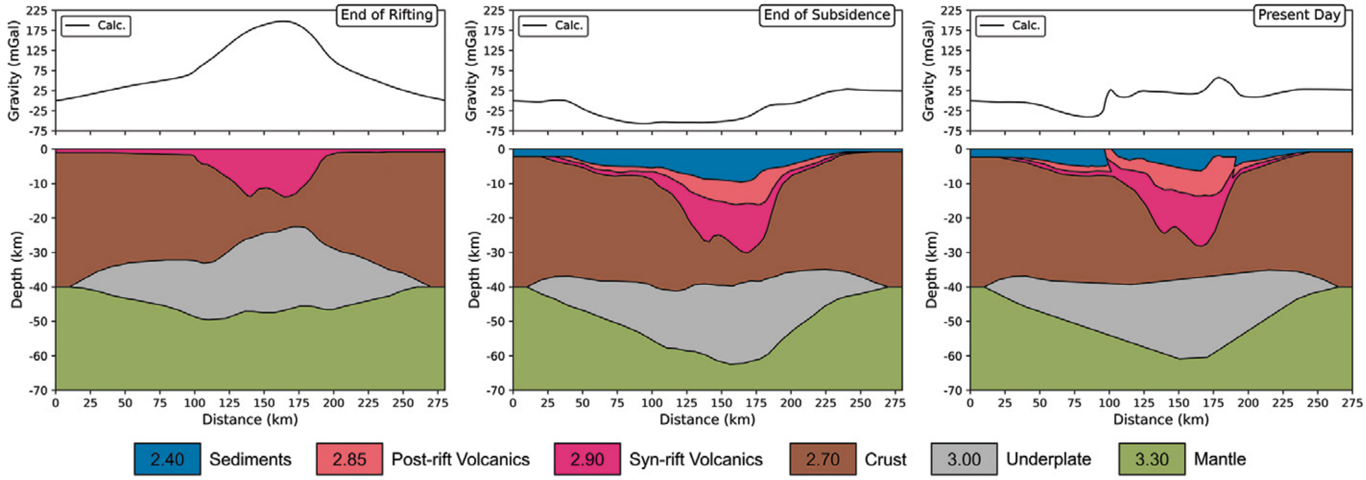

Figure 4. Gravity anomalies expected at various stages in rift evolution, based on model for the Midcontinent Rift under Lake Superior. During rifting, dense volcanics cause a large positive anomaly. Subsequent deposition of low-density sediments and associated subsidence cause a gravity low. Inversion of the rift and erosion of low-density sediments cause the high observed today. Densities in g/cm³. (After Elling et al., 2020.)

explanation of the differences between the SOA and RR, which formed about the same time in similar events, is that the RR had less extension and inversion.

Although models without underplates could fit the gravity data, we include underplates because seismic data both from the MCR (below Lake Superior and on its west arm) and RR show them, and underplates are typically observed at presently spreading rifts. Furthermore, underplates are thought to form from residual melt after extraction of low-density lavas and would be expected given the volume of volcanic material in these rifts. We expect their size to be proportional to the volume (cross-sectional area) of volcanics, as observed for rifted continental margins (Gallahue et al., 2020). Hence, the similar underplates beneath the western MCR and RR are surprising, given that the MCR has roughly ten times more volcanics in cross section. One possible explanation is that in addition to the volcanics in our RR model, another volcanic unit, a mafic high-density upper crustal layer, also exists. Liu et al. (2017, p. 4581) suggest this possibility while noting that such a layer is not required by the data and would be "rare, if not previously unrecognized, for continental rifts." Another possibility is that during the mid-Cretaceous, as the area passed over the Bermuda plume (Cox and Van Arsdale, 2002), plume-derived material may have augmented the underplate. An improved understanding of the relation between the volcanics and underplate would be helpful in understanding the transition between the final stages of continental rifting and early stages of seafloor spreading.

CONCLUSIONS

Traditionally, studies have considered the major failed rifts in central North America separately. However, it is useful to consider them as similar although not identical entities and to view them in the context of both failed and active rifts worldwide. Although they are grossly similar, with similar tectonic origins and structural features, interesting differences between them reflect the extent to which extension, magmatism, subsidence, and inversion by later compression occurred. Further study of these and other failed rifts would provide additional insight into how many rifts transition from the final stages of continental rifting to the early stages of seafloor spreading.

ACKNOWLEDGMENTS

We thank our many collaborators during a decade of rift studies synthesized here. In particular, Randy Keller provided his broad knowledge and deep insight about continental rifting both in North America and elsewhere. We also thank Nick Swanson-Hysell and anonymous reviewers for helpful suggestions, along with Jim Schmitt for constructive discussions and timely editorial processing of this manuscript.

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Manuscript received 8 June 2021
Revised manuscript received 11 Nov. 2021
Manuscript accepted 19 Feb. 2022

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GSA is committed to providing a safe, inclusive, and professional environment for all our events, including meetings, field trips, short courses, mentorships, and other GSA-supported programs. Maintaining safe, inclusive events is critical to GSA's success because it promotes full participation and a sense of belonging, which in turn fosters open dialogue, networking, and the productive exchange of scientific ideas.

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Several GSA Divisions and Associated Societies will hold breakfasts, lunches, receptions, and awards presentations that require tickets and/or advance registration (see the meeting website for a complete list). Ticketed events are open to everyone, and tickets can be purchased in advance when you register. If you are not attending the meeting but would like to purchase a ticket to one of these events, please contact the GSA meetings department at meetings@geosociety.org.

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Please wait until you sign up as a volunteer to register for the meeting, unless you want to reserve a space in a Field Trip or Short Course. Check the website at **https://community.geosociety.org/gsa2022/registration/volunteers** for more information.

Call for Papers

Abstracts deadline: 19 July

SUBMITTING AN ABSTRACT

Abstracts form open: 1 May
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- **Abstract non-refundable submission fee:** GSA MEMBERS: professionals: US$60; students: US$25. NON-MEMBERS: professionals: US$80; students: US$50.
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TWO-ABSTRACT RULE

- You may submit two volunteered abstracts, *as long as one of the abstracts is for a poster presentation*.
- Each submitted abstract must be different in content.
- If you are invited to submit an abstract in a Pardee Keynote Symposium or a topical session, the invited abstracts do not count against the two-abstract rule.

POSTER PRESENTERS

- You will be provided with one horizontal, free-standing 8-ft-wide by 4-ft-high display board and Velcro for hanging your display at no charge.
- Electricity is available for a fee.
- AM Session: Posters will be displayed 9 a.m.–1 p.m., with presenters present 11 a.m.–1 p.m.
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The normal length of an oral presentation is 12 minutes plus three minutes for questions and answers. You *must* visit the Speaker Ready Room at least 24 hours before your scheduled presentation. All technical session rooms will be equipped with a PC Windows 10/MS Office 2013. Presentations should be prepared using a 16:9 screen ratio.

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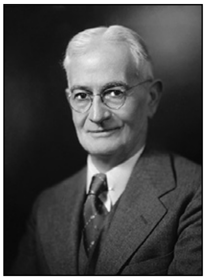
GSA is planning an in-person meeting in Denver, Colorado, USA. We will be offering an online component to all technical sessions, in addition to the GSA Presidential Address, Pardee Keynote Symposia, and noontime lectures.

ABSTRACTS SUBMISSION: EXPECTED BEHAVIOR

The submission of an abstract implies a sincere intent to present the submitted research during the meeting. Authors and presenters are expected to display integrity in disseminating their research; adhere to the content and conclusions of abstracts, as submitted and reviewed; remain gracious by offering collaborators the opportunity for recognition as a co-author; make sure that listed co-authors have made a bona fide contribution to the project, are aware of their inclusion, and have accepted that recognition; and be diligent in preparing a polished product that conveys high quality scholarship. GSA strives to promote diversity among conveners and presenters when organizing panels, keynotes, and other invitational sessions.

Pardee Keynote Symposia



Joseph Thomas Pardee

Pardee Keynote Symposia are named in honor of GSA Fellow and benefactor Joseph Thomas Pardee (1871–1960) via a bequest from Mary Pardee Kelly. Pardee is perhaps best known for his work on Glacial Lake Missoula. These symposia consist of invited presentations covering a broad range of topics.

P1. **Geoheritage: Connecting Our Stories to Earth's History**

Endorsers: *GSA History and Philosophy of Geology Division; History of Earth Sciences Society; GSA Energy Geology Division; GSA Geoscience Education Division; GSA Karst Division; GSA Hydrogeology Division*
Disciplines: History and Philosophy of Geology, Geoscience Education, Geoscience Information/Communication
Advocates: Christina DeVera; Renee M. Clary; William Andrews Jr.; Timothy Connors

Geoheritage communicates the story about Earth's geologic history shaping our diverse cultures. Your stories and perspectives ARE important. Join us to share ideas about best practices for collecting information, developing mapping and metadata standards, and disseminating knowledge about how the unique landscapes that we inhabit have impacted our societies. We want to hear your stories about geoheritage projects within your community and how they have increased public awareness and conservation efforts through effective, inclusive, and accessible communication. This session provides inspiration, empowerment, and the foundational elements needed to develop geoheritage efforts in our professional, public, and personal communities.

P2. **Looking to the Future of Environmental and Engineering Geology: EEGD 75th Anniversary**

Endorsers: *GSA Environmental and Engineering Geology Division; GSA Geology and Society Division; GSA Quaternary Geology and Geomorphology Division; GSA Environmental and Engineering Geology Division—Landslide Committee; U.S. Geological Survey Landslide Hazards Program; GSA Geology and Society Division*
Disciplines: Engineering Geology, Environmental Geoscience, Geoscience Information/Communication
Advocates: Matthew Crawford; Ann Youberg; Francis Rengers; William Burns; Stephen Slaughter; Anne Witt

Celebrating the 75th anniversary of the Environmental and Engineering Geology Division, this session will discuss the past, present, and exciting future of many applied geology disciplines. The focus will be cutting-edge research and communication related to geologic hazards, geotechnical engineering, mining geology, remote sensing, geophysics, hydrogeology, and soil and rock mechanics. The session will contribute to a better understanding of these complex topics and processes, support hazard mitigation, improve human health and safety, and help build resilience under changing climatic conditions.

P3. **The Proterozoic-Phanerozoic Transition: Laying the Foundation for the Modern Earth System**

Endorsers: *Paleontological Society; GSA Geobiology and Geomicrobiology Division; GSA Sedimentary Geology Division; SEPM (Society for Sedimentary Geology); Geochemical Society; GSA Continental Scientific Drilling Division; GSA Geochronology Division*
Disciplines: Geomicrobiology, Paleontology, Diversity, Extinction, Origination, Sediments, Carbonates
Advocates: Emily F. Smith; David A.D. Evans; C. Brenhin Keller; Kimberly Lau; Alan Rooney; Justin V. Strauss; Shuhai Xiao

The Proterozoic-Phanerozoic transition represents one of the most profound geobiological events in Earth's history, marking the diversification of major animal groups that unmistakably mark the Phanerozoic eon. Key advances have been made in recent years using an integrative and interdisciplinary approach to shed novel insights into biological, environmental, and tectonic changes during this transition. This symposium will showcase some of these advances from sedimentological, stratigraphic, paleontological, geochronological, geochemical, geophysical, and science-communication perspectives. Parallel topical session(s) and a science-communication panel discussion will be arranged.

Special Session

From the Mantle to the Mesosphere: Diversified Approaches Toward Understanding the Cataclysmic January 2022 Eruption of Hunga Tonga–Hunga Ha'apai Volcano
Endorsers: *GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Geophysics and Geodynamics Division; GSA Geology and Society Division*
Disciplines: Volcanology, Geophysics/Geodynamics, Petrology, Igneous
Advocates: Melissa Scruggs; Frank J. Spera

The 15 January 2022 eruption of Hunga Tonga–Hunga Ha'apai Volcano was the most powerful volcanic eruption in the past ~30 years, and the first of its kind recorded on modern scientific instruments. Gaining insight into the events surrounding this eruption will require input from researchers in all areas of earth science—from magma origin and transport, eruption dynamics, seismicity, tsunami and atmospheric waves, to evaluating societal impacts. *We hope to receive abstracts that will fulfill this subject.*

Saturday Icebreaker Keynote

Saturday, 8 Oct., 5–6 p.m.

Wanjiku "Wawa" Gatheru, Environmental Justice Warrior, Rhodes Scholar, and Founder of Black Girl Environmentalist

Wanjiku "Wawa" Gatheru is an environmental justice advocate, writer, and current graduate student at the University of Oxford. She is a first-generation American of Kenyan descent and the first Black person in history to receive the Rhodes, Truman, and Udall Scholarships.

The founder of the organization Black Girl Environmentalist, Gatheru is motivated to uplift the voices of those most adversely impacted by environmental inequities through changing conservation conversations. For her work in collaboration with other activists and thought leaders, Gatheru has been recognized as a 2020 Young Futurist by *The Root*, a 2020 Grist 50 FIXER, a 2020 *Glamour* College Woman of the Year, and has spoken on her work across the country.

Noontime Lectures

Monday, 10 Oct., 12:15–1:15 p.m.

Marjorie A. Chan, David Mogk: "Culture and Ethics of Geologic Sampling Town Hall." *Cosponsored by MSA (Mineralogical Society of America) and IAPG (International Association for Promoting Geoethics).*

Wednesday, 12 Oct., 12:15–1:15 p.m.

Katie Stack Morgan, "The Mars 2020 Perseverance Rover in Jezero Crater"

Special Lectures

Sunday, 9 Oct., noon–1:30 p.m.

Mark Little, GSA Presidential Address: "On Science, Power, and the Future of Our Earth."

Tuesday, 11 Oct., 12:15–1:15 p.m.

Jani Ingram, 2022 Michel T. Halbouty Distinguished Lecture: "Environmental Health Investigations on the Navajo Nation."

Hotels

GSA has selected several hotels within close proximity of the Colorado Convention Center (CCC). Below are our headquarters hotels. A full list of hotels is available on our website. Rates are in U.S. dollars and *do not include* the current applicable tax of 15.57% per room per, per night. Complimentary basic Internet will be provided in all guest rooms booked through GSA/Orchid Events (OE).

Hotel	Rate (single/double)	Each Add'l Adult (3rd & 4th person)	Distance to CCC	Parking Daily (24-hr)
Hyatt Regency Denver at CCC (HQ)	US$249	US$25	Across the street	US$52 Valet/US$42 Self
Grand Hyatt Denver (Co-HQ)	US$244	US$25	4 blocks	US$52 Valet/US$38 Self

ALERT: The official GSA housing bureau is OE. To receive the GSA group rate at each hotel, reservations must be made through OE and not directly with the hotels. GSA and OE will NOT contact attendees directly to solicit new reservations. If you are contacted by a vendor who claims to represent GSA, please notify the GSA meetings department at meetings@geosociety.org. Please do not make hotel arrangements or share any personal information through any means other than a trusted, reliable source.

Travel & Transportation

It’s easier than ever to get around Denver! Denver International Airport (DEN) is one of the best and easiest to navigate airports in the country. Once in Denver, you can easily access the city by the public transport system (RTD), airport rail, taxi, uber/lyft, and more. For more information on each form of transportation, such as fares, ticket purchase, and schedules go to **https://www.denver.org/about-denver/transportation/.**

A Line train at Denver International Airport. Photo courtesy of Denver International Airport.

Non-Technical Event Space Requests

Deadline for first consideration: **6 June**

Please let us know about your non-technical events via our online event space & event-listing database connect via **https://community.geosociety.org/gsa2022/connect/events/plan.** Space is reserved on a first-come, first-served basis; in order to avoid increased fees, you must submit your request by MONDAY, 6 JUNE. Event space/event listing submissions should be used for business meetings, luncheons, receptions, town halls, etc.

- For events held at the Colorado Convention Center (CCC) or Hyatt Regency Denver at CCC (HQ Hotel)
- For off-site events (events that are being held at another location in Denver that you have arranged on your own)
- For online events being held 7–13 October 2022

Meeting room assignments will be sent out in July.

Childcare by KiddieCorp

Location: Colorado Convention Center

Hours: Sun.–Wed., 7 a.m.–6 p.m. daily

Ages: Six months to 12 years

Cost: US$10 per hour per child for children 2 years or older and US$12 per hour per child for children under 2 with a 1-hour minimum per child. At least one parent must be registered for the meeting. This is a discounted rate as GSA subsidizes 85% of the total cost for this service to attendees.

Late pick-up fee: US$5 per child for every five minutes the parent is late.

More info: www.kiddiecorp.com/parents.html

Register securely at https://form.jotform.com/KiddieCorp/gsakids

Reserve Childcare in Advance: To ensure that the center is properly staffed and to facilitate planning of games and other activities for the children, advance registration is required. On-site registration may be possible, at a slightly higher cost, if space is available. The deadline for advance child-care registration is 9 September.

Cancelations: For a full refund, cancelations must be made to KiddieCorp prior to 9 September. Cancelations made after 9 September will incur a 50% fee. No refunds after 23 September.

About: KiddieCorp is a nationally recognized company that provides onsite children’s activities for a comfortable, safe, and happy experience for both kids and parents. Childcare services are a contractual agreement between each individual and the childcare company. GSA assumes no responsibility for the services rendered.

Contact: KiddieCorp, +1-858-455-1718, info@kiddiecorp.com

Scientific Field Trips

401. **Black Hills and Badlands: A Synopsis of Geological Time.** Thurs.–Sat., 6–8 Oct. US$681. Endorser: *Edmunds Central School District*. Leader: Spencer Cody, Edmunds Central School District.

402. **PC^2 = PreCambrian Colorado: The Role of the Mesoproterozoic Picuris Orogeny in Colorado.** Fri.–Sat., 7–8 Oct. US$362. Endorsers: *GSA Structural Geology and Tectonics Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; Colorado Scientific Society (CSS); Denver Regional Exploration Geologists' Society (DREGS); Escalante Resources Group*. Leaders: Ruth F. Aronoff, Furman University; Yvette Kuiper; Christopher G. Daniel.

403. **PC^2 = PreCambrian Colorado: Geology and Economic Geology of the Colorado Central Front Range; Field Observations and Perspectives Bearing on the Growth and Metallogeny of the North American Craton.** Fri.–Sat., 7–8 Oct. US$670. Endorsers: *Colorado Scientific Society Denver Regional Exploration Geologists' Society; Escalante Resources Group*. Leaders: Lisa Fisher, Colorado Scientific Society; Lewis Kleinhans.

404. **A Bike Tour: Geology, Geochronology, and Geochemistry of the Table Mountain Shoshonite, Golden, Colorado.** Sat., 8 Oct. US$194. Endorsers: *GSA Geochronology Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division*. Leaders: Leah Morgan, Geology, Geophysics, and Geochemistry Science Center; Alexie Millikin.

405. **Dinosaur Tracks and Microbial MAT in Photogrammetric 3D Relief: The Classic Trace Fossils of the Dinosaur Ridge Area.** Sat., 8 Oct. US$205. Endorser: *Dinosaur Ridge*. Leaders: Martin Lockley, Dinosaur Trackers Research Group; Nora Noffke; Brent Breithaupt.

406. **World-Class Geologic Heritage Sites of the Metropolitan Denver, Colorado, Area (pre-meeting).** Sat., 8 Oct. US$128. Endorsers: *Colorado Scientific Society; GSA Geology and Society Division*. Leader: Tim Connors.

407. **Accessible Tour of Colorado Geoscience for Students & Faculty.** Sat., 8 Oct. US$148. Endorser: *UNAVCO-NSF GAGE*. Leaders: Anika Knight, UNAVCO; Kelsey Russo-Nixon.

408. **Mountain Highs and Valley Lows: An Accessible Introduction to the Geology of the Pikes Peak Area.** Wed.–Thurs., 12–13 Oct. Apply at https://theiagd.org/2022-gsa-field-trip-geology-of-pikes-peak/. Endorser: *International Association for Geoscience Diversity (IAGD)*. Leaders: Anita Marshall, University of Florida; Christine Siddoway; Michele Cooke; Nancy R. Riggs; Chris Atchison.

409. **PC^2 = PreCambrian Colorado: Peraluminous Gold Deposits Emplaced above a 1.75 Ga Flat Subduction Zone in South-Central Colorado.** Wed.–Thurs., 12–13 Oct. US$470. Endorsers: *PC2 = Precambrian Colorado; Denver Region Exploration Geologists' Society (DREGS); Colorado Scientific Society (CSS); MagmaChem Research Institute; Escalante Resources Group*. Leaders: Monte Swan, MagmaChem Research Institute; Lewis Kleinhans; Stanley B. Keith.

410. **PC^2 = PreCambrian Colorado: Paleoproterozoic Tectonics of the Northern Colorado Front Range.** Thurs., 13 Oct. US$120. Endorsers: *GSA Structural Geology and Tectonics Division; The Colorado Scientific Society (CSS); Denver Regional Exploration Geologists' Society (DREGS); Escalante Resources Group*. Leaders: Graham Baird, University of Northern Colorado; Timothy Grover, Kevin H. Mahan.

411. **World-Class Geologic Heritage Sites of the Metropolitan Denver, Colorado, Area (post-meeting).** Thurs., 13 Oct. US$128. Endorsers: *Colorado Scientific Society; GSA Geology and Society Division*. Leader: Tim Connors.

412. **Exploring Morrison: Jurassic Morrison Formation at Dinosaur Ridge and Beyond.** Thurs.–Fri., 13–14 Oct. US$396. Leaders: Matthew Mossbrucker, Morrison Natural History Museum; Erin Rose LaCount, Dinosaur Ridge; Robert Bakker, Paul Murphey.

INDUSTRY TRACKS

GSA's program offers field trips relevant to applied geoscientists.
Look for these icons, which identify trips in the following areas:

Economic Geology | **Energy** | **Engineering** | **Hydrogeology and Environmental Geology**

Short Courses

Learn and explore a new topic. Build your skills.

Early registration deadline: 6 Sept. Early registration is highly recommended to ensure that courses will run.
Registration after 6 Sept. will cost an additional US$30.
Cancelation deadline: 12 Sept.

Can I take a short course if I am not registered for the meeting? YES! You're welcome to—just add the meeting nonregistrant fee (US$55) by 6 Sept. to your course enrollment cost. Should you then decide to attend the meeting, your payment will be applied toward meeting registration.

GSA K–12 teacher members: You are welcome to take short courses without registering for the meeting or paying the non-registrant fee.

Continuing education units (CEUs): Most professional development courses and workshops offer CEUs. One CEU equals 10 hours of participation in an organized continuing education experience under responsible sponsorship, capable direction, and qualified instruction.

See **https://community.geosociety.org/gsa2022/program/short** or contact Jennifer Nocerino, jnocerino@geosociety.org, for course abstracts and additional information.

ONLINE COURSES

501. **NSF Graduate Research Fellowship Program (GRFP) Proposal Preparation Course.** Mon., 26 Sept., 8 a.m.–noon MDT. US$20. Limit: 30. CEU: 0.4. **Instructors:** Kristina Butler, University of Texas at Austin; Sarah George, University of Arizona. **Course Endorser:** *GSA Geoscience Education Division.*

502. **Climate Adaptation Planning for Emergency Management.** Tues., 27 Sept., 10 a.m.–2 p.m. MDT *and* Wed., 28 Sept., 10 a.m.–2 p.m. MDT. FREE. Limit: 50. CEU: 0.8. **Instructors:** Jeff Rubin, semi-retired emergency manager; Monica Gowan, independent consultant. **Course Endorsers:** *GSA Geology and Health Division; GSA Geology and Society Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; National Disaster Preparedness Training Center (NDPTC) at the University of Hawai'i; Federal Emergency Management Agency (FEMA).*

503. **Resistivity Surveying: Getting the Best and Making the Most from Electrical Resistivity Tomography and Induced Polarization Data.** Thurs., 29 Sept., 8 a.m.–noon MDT. US$40. Limit: 50. CEU: 0.4. **Instructors:** Morgan Sander-Olhoeft, Guideline Geo Americas Inc.; Harry Higgs, Guideline Geo Americas Inc. **Course Endorser:** *Guideline Geo.*

504. **Introduction to Geostatistical Modeling of Geochemical Data.** Thurs., 29 Sept., 8 a.m.–noon MDT *and* Fri., 30 Sept., 8 a.m.–noon MDT. US$50 professionals; US$25 students. Limit: 50. CEU: 0.8. **Instructors:** Abani Samal, GeoGlobal LLC; Sankar Sasidharan, Harte Research Institute.

505. **How to Create Your Own 3D Videogame-Style Geologic Field Trip and Host it Online: Accessible, Immersive Data Visualization for Education and Research.** Fri., 30 Sept., 9:30 a.m.–5 p.m. MDT. US$40. Limit: 40. CEU: 0.7. **Instructors:** Mattathias (Max) Needle, University of Washington; John Akers, University of Washington; Juliet Crider, University of Washington. **Course Endorser:** *GSA Structural Geology and Tectonics Division.*

FRIDAY COURSES

506. **Geological Modeling and Uncertainties Using Multiple Point Statistics.** Fri., 7 Oct., 8 a.m.–5 p.m. US$115. Limit: 20. CEU: 0.8. **Instructors:** Mats Lundh Gulbrandsen, I-GIS; Tom Martlev Pallesen, I-GIS. **Course Endorser:** *I-GIS.*

507. **Exploring Surface Processes with the CSDMS Workbench: Building Coupled Models.** Fri., 7 Oct., 9 a.m.–5 p.m. US$60. Limit: 40. CEU: 0.8. **Instructors:** Mark Piper, University of Colorado Boulder; Benjamin Campforts, University of Colorado Boulder. **Course Endorser:** CSDMS@HydroShare.

508. **Multiphysics Modeling for the Geosciences.** Fri., 7 Oct., 8 a.m.–5 p.m. US$160. Limit: 30. CEU: 0.8. **Instructors:** Susan Sakimoto, Space Science Institute; Heidi Haviland, NASA Marshall Space Flight Center. **Course Endorsers:** *GSA Planetary Geology Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; COMSOL Inc.*

509. **Methods and Geological Applications in Geo-Thermo-Petro-Chronology I.** Fri., 7 Oct., 9 a.m.–5 p.m. US$40. Limit: 50. CEU: 0.7. **Instructors:** Sarah George, University of Arizona; George Gehrels, University of Arizona; Kurt Sundell, Idaho State

INDUSTRY TRACKS

GSA's program offers short courses relevant to applied geoscientists.
Look for these icons, which identify sessions in the following areas:

Economic Geology | **Energy** | **Engineering** | **Hydrogeology and Environmental Geology**

University; Mauricio Ibanez, University of Arizona; Kendra Murray, Idaho State University; Allen Schaen, University of Arizona.

FRIDAY–SATURDAY COURSES

510. **Field Safety Leadership.** Fri.–Sat., 7–8 Oct., 8 a.m.–5 p.m. US$45 professionals; US$25 students. Limit: 24. CEU: 1.6. **Instructors:** Kevin Bohacs, ExxonMobil (retired); Kurt Burmeister, California State University, Sacramento; Greer Barriault, ExxonMobil Technology and Engineering Company. **Course Endorser:** *ExxonMobil Technology and Engineering Company.*

511. **Teaching SfM and GNSS Methods to Undergraduates in the Field.** Fri.–Sat., 7–8 Oct., 8 a.m.–5 p.m. US$40. Limit: 30. CEU: 1.6. **Instructors:** Beth Pratt-Sitaula, UNAVCO; Benjamin Crosby, Idaho State University; Bruce Douglas, Indiana University; Christopher Crosby, UNAVCO. **Course Endorsers:** *GEodesy Tools for Societal Issues (GETSI) Field Project; UNAVCO; National Association of Geoscience Teachers (NAGT); OpenTopography.*

512. **Sequence Stratigraphy for Graduate Students.** Fri.–Sat., 7–8 Oct., 8 a.m.–5 p.m. US$25 (those who complete the course will receive three free GSA ebooks of their choice—a US$25 value). Limit: 55. CEU: 1.6. **Instructors:** Morgan Sullivan, Chevron Energy Technology Company; Bret Dixon, Tall City Exploration. **Course Endorser:** *Chevron Energy Technology Company.*

513. **Introduction to the Paleobiology Database.** Fri.–Sat., 7–8 Oct., 8 a.m.–5 p.m. US$100 professionals; free for students. Limit: 100. CEU: 1.6. **Instructor:** Mark D. Uhen, George Mason University. **Course Endorsers:** *Society of Vertebrate Paleontology; Paleontological Society.*

514. **Improve Your Computational Petrology Skills: Designing and Executing a Computational Petrology Research Project and an Introduction to the Magma Chamber Simulator.** Fri., 7 Oct., 1–5 p.m. *and* Sat., 8 Oct., 8 a.m.–5 p.m. US$163. Limit: 40. CEU: 1.2. **Instructors:** Wendy Bohrson, Colorado School of Mines; Frank Spera, University of California Santa Barbara; Valerie Strasser, Colorado School of Mines; Monike Distefano, Colorado School of Mines; Paula Antoshechkina, Caltech. **Course Endorsers:** *GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Planetary Geology Division; GSA Geophysics and Geodynamics Division.*

SATURDAY COURSES

515. **Machine Learning for Small, Uncertain, and Sparse Datasets.** Sat., 8 Oct., 8 a.m.–5 p.m. US$116. Limit: 40. CEU: 0.8. **Instructors:** Velimir Vesselinov, Los Alamos National Laboratory; Bulbul Ahmmed, Los Alamos National Laboratory. **Course Endorsers:** *Computational Earth Science Group; Los Alamos National Laboratory.*

516. **Digital Petrography: Bringing Petrologic Imaging into the Modern Era with Automation, Robotics, Image Analysis, and AI.** Sat., 8 Oct., 8 a.m.–5 p.m. US$60. Limit: 40. CEU: 0.8. **Instructors:** Matthew Andrew, Carl Zeiss X-ray Microscopy; Kitty Milliken, The University of Texas; Brice Lacroix, University of Kansas; Mingyue Yu, University of Illinois. **Course Endorser:** *Carl Zeiss X-ray Microscopy.*

517. **Foundations in the Design and Teaching of Geoscience Courses Using Active Learning Strategies.** Sat., 8 Oct., 8 a.m.–5 p.m. US$25 (Those who complete the course will receive three free GSA ebooks of their choice—a $25 value). Limit: 40. CEU: 0.8. **Instructors:** Leilani Arthurs, University of Colorado Boulder; Chu-Lin Cheng, University of Texas Rio Grande Valley; Ming-Tsan Lu, University of Texas Rio Grande Valley; Patrick Shabram, Front Range Community College.

518. **Introduction to Drones (sUAS) in the Geosciences.** Sat., 8 Oct., 8 a.m.–5 p.m. US$126. Limit: 40. CEU: 0.8. **Instructor:** Gregory Baker, Colorado Mesa University. **Course Endorsers:** *GSA Hydrogeology Division; GSA Geoarchaeology Division; GSA Quaternary Geology and Geomorphology Division; GeoAvatar LLC.*

519. **Three-Dimensional Geological Mapping and Modeling.** Sat., 8 Oct., 8 a.m.–5 p.m. US$106. Limit: 60. CEU: 0.8. **Instructors:** Richard Berg, Illinois State Geological Survey; Harvey Thorleifson, Minnesota Geological Survey; Kelsey MacCormack, Alberta Geological Survey.

520. **On To the Future Professional Development Workshop: Looking Forward to a Career in Geosciences.** Sat., 8 Oct., 8 a.m.–5 p.m. By invitation only to On To the Future participants and alumni; workshop fee for invitees will be provided from NSF #1801569. Limit: 150. CEU: 0.8. **Instructors:** Stephen Boss, University of Arkansas; Kathy Ellins, University of Texas (retired); Susan Eriksson, Eriksson Associates. **Course Endorser:** *National Science Foundation (Award #1801569).*

521. **Talking Science: A Communicating Science Workshop.** Sat., 8 Oct., 8 a.m.–5 p.m. US$30 professionals; US$15 students. Limit: 40. CEU: 0.8. **Instructor:** Steven Jaret, American Museum of Natural History. **Course Endorsers:** *GSA Planetary Geology Division; National Science Foundation Integrated Earth Science project EAR-1814051.*

522. **Ground-Penetrating Radar—Principles, Practice, and Processing.** Sat., 8 Oct., 8 a.m.–5 p.m. US$95 professionals; US$50 students. Limit: 25. CEU: 0.8. **Instructor:** Greg Johnston, Sensors & Software Inc. **Course Endorser:** *Sensors & Software Inc.*

523. **AGeS Geochronology Workshop.** Sat., 8 Oct., 8 a.m.–5 p.m. US$40. Limit: 100. CEU: 0.8. **Instructors:** Rebecca Flowers, University of Colorado Boulder; Ramon Arrowsmith, Arizona State University; James Metcalf, University of Colorado Boulder. **Course Endorser:** *GSA Geochronology Division.*

524. **Hydrogeological Layered Modeling—Use of Data, How to Build, and How to Use Output for Informed Decision Making.** Sat., 8 Oct., 8 a.m.–5 p.m. US$115. Limit: 20. CEU: 0.8. **Instructor:** Tom Martlev Pallesen, I-GIS. **Course Endorser:** *I-GIS.*

525. **Introduction to Planetary Image Analysis with ArcGIS.** Sat., 8 Oct., 8 a.m.–5 p.m. US$40. Limit: 40. CEU: 0.8. **Instructor:** Zoe Learner Ponterio, Cornell University. **Course Endorsers:** *Spacecraft Planetary Image Facility; Cornell University.*

526. **Applying Virtual Microscopy to Geoscience.** Sat., 8 Oct., 8 a.m.–5 p.m. US$100 professionals; US$50 students. Limit: 25. CEU: 0.8. **Instructors:** Christopher Prince, PetroArc International; Suzanne Kairo, Indiana University. **Course Endorser:** *PetroArc International.*

527. **Volcanic Crisis Awareness.** Sat., 8 Oct., 8 a.m.–5 p.m. FREE. Limit: 40. CEU: 0.8. **Instructors:** Jeff Rubin, semi-retired emergency manager; Monica Gowan, independent consultant. **Course Endorsers:** *GSA Geology and Health Division; GSA Geology and Society Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; National Disaster Preparedness Training Center (NDPTC) at the University of Hawai'i; Federal Emergency Management Agency (FEMA).*

528. **Head, Shoulders, Knees, and Toes: Medical Geology Fundamentals.** Sat., 8 Oct., 8 a.m.–5 p.m. US$84. Limit: 40. CEU: 0.8. **Instructors:** Laura Ruhl, University of Arkansas at Little Rock; Robert Finkelman, University of Texas at Dallas; Reto Gieré, University of Pennsylvania; Malcolm Siegel, University of New Mexico. **Course Endorsers:** *GSA Geology and Health Division; International Medical Geology Association.*

529. **Quantitative Analysis, Visualization, and Modeling of Detrital Geochronology Data.** Sat., 8 Oct., 8 a.m.–5 p.m. US$75 professionals; US$50 students. Limit: 40. CEU: 0.8. **Instructors:** Joel Saylor, University of British Columbia; Kurt Sundell, Idaho State University; Glenn Sharman, University of Arkansas.

530. **Cave and Karst Research on Federal Lands.** Sat., 8 Oct., 8 a.m.–5 p.m. US$75. Limit: 40. CEU: 0.8. **Instructors:** Patricia Seiser, National Park Service; Limaris Soto, U.S. Forest Service; Kyle Rybacki, Bureau of Land Management. **Course Endorsers:** *National Cave and Karst Research Institute; National Park Service; U.S. Forest Service; Bureau of Land Management.*

531. **Using the StraboSpot and StraboMicro Data Systems for Geology.** Sat., 8 Oct., 8 a.m.–5 p.m. US$25. Limit: 40. CEU: 0.8. **Instructors:** Doug Walker, University of Kansas; Julie Newman, Texas A&M University. **Course Endorsers:** *GSA Structural Geology and Tectonics Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Geoinformatics and Data Science Division.*

532. **Methods and Geological Applications in Geo-Thermo-Petro-Chronology II.** Sat., 8 Oct., 9 a.m.–5 p.m. US$40. Limit: 50. CEU: 0.7. **Instructors:** Sarah George, University of Arizona; George Gehrels, University of Arizona; Kurt Sundell, Idaho State University; Mauricio Ibanez, University of Arizona; Kendra Murray, Idaho State University; Allen Schaen, University of Arizona.

HALF-DAY SATURDAY COURSES

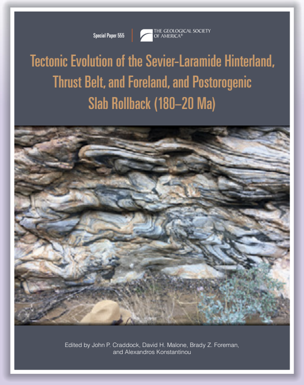
533. **Inclusive Educational Outreach with NASA SCoPE.** Sat., 8 Oct., 8 a.m.–noon. US$25. Limit: 40. CEU: 0.4. **Instructors:** Jessica Swann, Arizona State University; David Williams, Arizona State University. **Course Endorsers:** *National Aeronautics and Space Administration; Arizona State University.*

534. **Improv to Improve the Geoscience Community.** Sat., 8 Oct., 1–5 p.m. US$20. Limit: 20. CEU: 0.4. **Instructor:** Erik Haroldson, Austin Peay State University. **Course Endorsers:** *Austin Peay State University College of STEM; National Association of Geoscience Teachers (NAGT); National Association of Geoscience Teachers (NAGT) Teacher Education Division (TED).*

535. **Using Geophysics to Address Societally Relevant, Urban and Environmental Real-World Questions in Introductory-Level Geoscience Courses.** Sat., 8 Oct., 1–5 p.m. US$10. Limit: 40. CEU: 0.4. **Instructors:** John Taber, Incorporated Research Institutions for Seismology (IRIS); Andrew Parsekian, University of Wyoming; Sarah Kruse, University of South Florida; Carol Ormand, Carleton College.

536. **Advances in Applications of Laser Ablation to the Geosciences.** Sat., 8 Oct., 8 a.m.–5 p.m. US$132. Limit: 40. CEU: 0.8. Instructors: Ian Ridley, U.S. Geological Survey; Michael Pribil, U.S. Geological Survey; Alan Koenig, Newmont Mining Co.; Jay Thompson, U.S. Geological Survey.

Browse the Latest at the GSA STORE



Tectonic Evolution of the Sevier-Laramide Hinterland, Thrust Belt, and Foreland, and Postorogenic Slab Rollback (180–20 Ma)
Edited by John P. Craddock, David H. Malone, Brady Z. Foreman, and Alexandros Konstantinou
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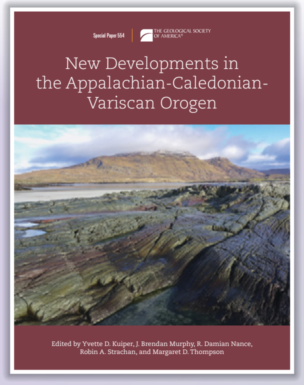

New Developments in the Appalachian-Caledonian-Variscan Orogen
Edited by Yvette D. Kuiper, J. Brendan Murphy, R. Damian Nance, Robin A. Strachan, and Margaret D. Thompson
SPE554, 436 p., ISBN 9780813725543
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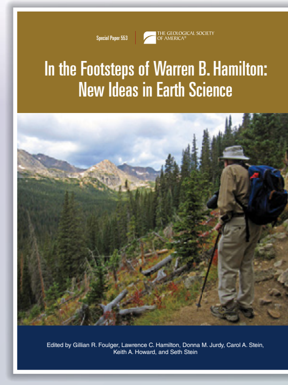
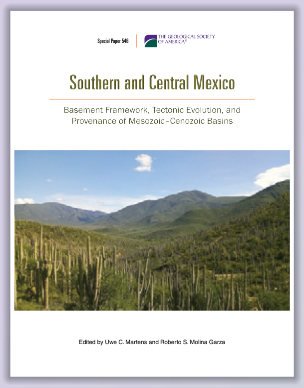


In the Footsteps of Warren B. Hamilton: New Ideas in Earth Science
Edited by Gillian R. Foulger, Lawrence C. Hamilton, Donna M. Jurdy, Carol A. Stein, Keith A. Howard, and Seth Stein
SPE553, 434 p., ISBN 9780813725536
$95.00 | **member price $66.00**



Southern and Central Mexico: Basement Framework, Tectonic Evolution, and Provenance of Mesozoic–Cenozoic Basins
Edited by Uwe Martens and Roberto S. Molina Garza
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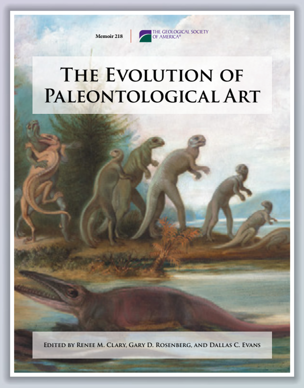
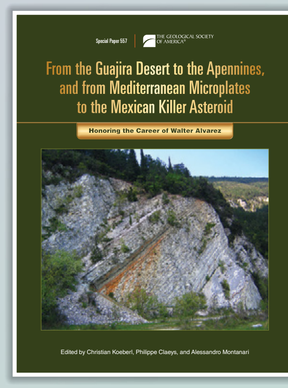
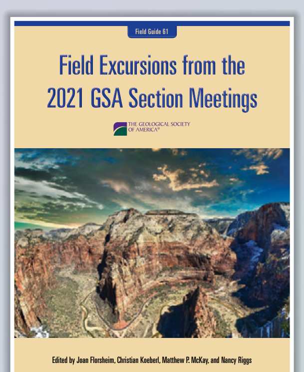
$120.00 | **member price $84.00**



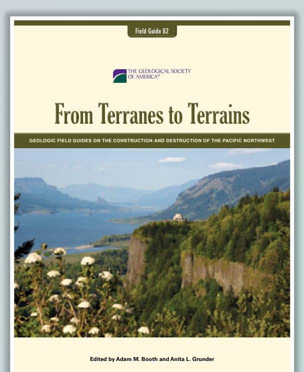
The Evolution of Paleontological Art
Edited by Renee M. Clary, Gary D. Rosenberg, and Dallas C. Evans
MWR218, 275 p., ISBN 9780813712185
$60.00 | **member price $42.00**



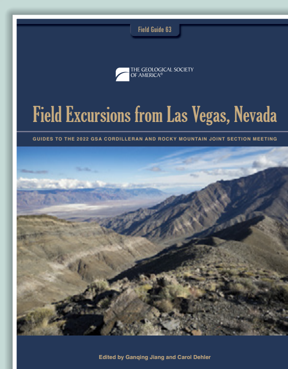
From the Guajira Desert to the Apennines, and from Mediterranean Microplates to the Mexican Killer Asteroid: Honoring the Career of Walter Alvarez
Edited by C. Koeberl, P. Claeys, and A. Montanari
SPE557, 600 p., ISBN 9780813725574 | IN PRESS



Field Excursions from the 2021 GSA Section Meetings
Edited by Joan Florsheim, Christian Koeberl, Matthew P. McKay, and Nancy Riggs
FLD061, 289 p., ISBN 9780813700618
$60.00 | **member price $42.00**



From Terranes to Terrains: Geologic Field Guides on the Construction and Destruction of the Pacific Northwest
Edited by Adam M. Booth and Anita L. Grunder
FLD062, 352 p., ISBN 9780813700625
$60.00 | **member price $42.00**



Field Excursions from Las Vegas, Nevada: Guides to the 2022 GSA Cordilleran and Rocky Mountain Joint Section Meeting
Edited by Ganqing Jiang and Carol Dehler
FLD063, 125 p., ISBN 9780813700632
$40.00 | **member price $28.00**

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Envision your future career in the geosciences, and learn about how to make it a reality by attending these events.

GEOCAREERS DAY

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Direct access to company representatives

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(Sunday–Wednesday)
Career Guidance and Information

- Career Presentations
- Résumé Review Clinic
- Drop-In Mentoring
- Early Career Professional Coffee
- Geology Club Meet Up
- Networking Event
- Women in Geology Program
- Post or View Jobs

If you're not attending the meeting, consider registering for an upcoming webinar or viewing past career exploration webinars at **www.geosociety.org/webinars.**

Go to **https://community.geosociety.org/gsa2022/geocareers** for event details, dates, and times.

Share Your Experience—Be a Mentor

Become a mentor and help students navigate the meeting, introduce them to contacts, discuss career paths, and offer advice. Graduate students, early career professionals, professionals, and retirees are all welcome!

Drop-in Mentor. This one-on-one mentoring activity takes place in the GeoCareers Center. Students have 30 minutes to ask questions and seek advice. About 28 mentors are needed.

Networking Reception Mentor. The networking reception is a gathering of students, early career professionals, and mentors. About 40 mentors are needed to answer questions, offer advice about careers plans, and comment on job opportunities within their fields.

On To the Future Mentor. About 75 On To the Future (OTF) mentors are needed. Each will be paired with a student who is part of the OTF program, which supports students from diverse groups to attend their first GSA Connects meeting. Mentors will meet with their mentee each day of the meeting, introduce the mentee to five contacts, and share their professional experiences in the geosciences. Matching will be completed using an online platform. To learn more, go to **https://www.geosociety.org/OTF** and click on "mentorships."

Résumé or CV Mentor. Résumé mentors are matched with a student on-site to review the student's résumé or CV. Consultations take place for 30 minutes in the GeoCareers Center in a one-on-one format. About 28 mentors are needed.

Women in Geology Mentor. About 30 mentors from a variety of sectors are needed to answer career questions and offer advice during the Women in Geology Reception.

To serve as a mentor, please complete the mentor interest form at **https://community.geosociety.org/gsa2022/mentor.**

Exhibit in the Resource & Innovation Center

BENEFITS OF EXHIBITING

- Two Resource & Innovation Center badges per 10-ft × 10-ft booth.
- Complimentary listing on the conference website and on the conference app.
- One complimentary full-meeting registration.
- Preferential booth selection for GSA Connects 2023 in Pittsburgh, Pennsylvania, USA.

Multiple rates are available to reflect the diverse range of GSA Connects 2022 exhibitors. For booth pricing and a floor plan, go to **https://community.geosociety.org/gsa2022/showcase/exhibitors.**

If you have questions or want to reserve your booth, please contact Gavin McAuliffe. Exhibit Manager–GSA 2022, Corcoran Expositions Inc., +1-312-265-9649, gavin@corcexpo.com.

EXHIBITOR MOVE IN & MOVE OUT HOURS*

Move in: Sat., 8 Oct., 8 a.m.–5 p.m.
Sun., 9 Oct., 8–11 a.m.

Move out: Wed., 12 Oct., 2–8 p.m.
*Hours subject to change

RESOURCE & INNOVATION CENTER HOURS

Sun., 9 Oct., 5–7 p.m.
Exhibits Opening & Reception begins at 5 p.m.

Mon., 10 Oct., 10 a.m.–6:30 p.m.
Collaborations and Conversations Reception: 4:30–6:30 p.m.

Tues., 11 Oct., 10 a.m.–6:30 p.m.
Collaborations and Conversations Reception: 4:30–6:30 p.m.

Wed., 12 Oct., 10 a.m.–2 p.m.

Advertising & Sponsorship Opportunities

Don't miss the opportunity to reach a broad cross section of geoscientists.

All advertising inquiries: Ann Crawford, GSA Advertising Manager, +1-303-357-1053, advertising@geosociety.org, **www.geosociety.org/advertising.**

All sponsorship inquiries: Debbie Marcinkowski, Executive Director, GSA Foundation, +1-303-357-1047, dmarcinkowski@geosociety.org, **https://community.geosociety.org/gsa2022/showcase/sponsors.**

Meet Us on Social Media

Follow hashtag #GSA2022

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https://community.geosociety.org

Local Organizing Committee

Jeffrey Lee,
General Co-Chair,
Colorado School of Mines,
lee1@mines.edu

Cal Barnes,
General Co-Chair,
Texas Tech University,
Cal.Barnes@ttu.edu

Lynne Carpenter,
Field Trip Co-Chair,
Geologic Hazards Coordinator,
lynne.chastain-carpenter@usda.gov

Kevin Mahan,
Field Trip Co-Chair,
University of Colorado Boulder,
mahank@colorado.edu

Robinson Cecil,
Technical Program Chair,
California State University, Northridge,
robinson.cecil@csun.edu

Patrick Burkhart,
Vice Technical Program Chair,
Slippery Rock University,
patrick.burkhart@sru.edu

Lindsay Powers,
Special Events Chair,
U.S. Geological Survey Program Manager and Director of USGS Core Facility, lpowers@usgs.gov

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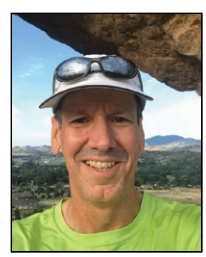
U.S. Geological Survey,
danielle.olinger@gmail.com



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Sponsorship Chair,
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timothy.grover@unco.edu

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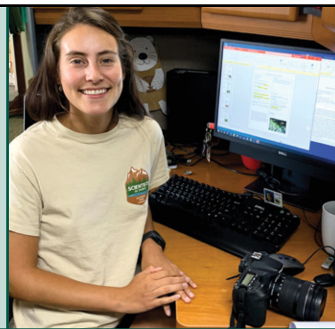
Grand Valley State University,
callahca@gvsu.edu

SCIENTISTS IN PARKS
NATIONAL PARK SERVICE



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Scientists in Parks provides all aspiring professionals—especially those underrepresented in science—with a unique opportunity to work on important real-world projects while building professional experience and a life-long connection to America's national parks.

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www.geosociety.org/sip

Learn more from NPS about the program and related opportunities
https://go.nps.gov/scientistsinparks

Questions? Contact us at sip@geosociety.org

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Make the Most of Your Vacation with GSA Books

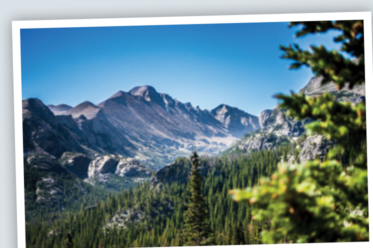
Before heading off on your summer vacation, stop by the GSA Store for ideas and inspiration.

Is camping on your itinerary? Explore central California from Yosemite National Park to the Sierra Nevada foothills with *A Tour of California's Iconic Geology*. If you'll be pitching your tent in Colorado, download *Through the Generations: Geologic and Anthropogenic Field Excursions in the Rocky Mountains from Modern to Ancient.* Each of these eBooks is available for just US$9.99.

Looking for a vacation to a historical destination? Pick up your copy of *Geology Field Trips in and around the U.S. Capital*. When you're ready to take a break from the museums and monuments, the four field trips in this guide will help you explore various locations in Virginia, Maryland, and West Virginia.

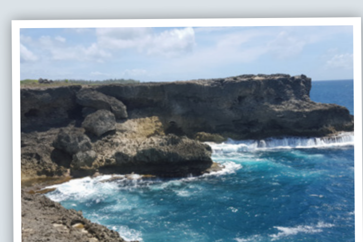
Want to spend some time at the beach? Be sure to pack a copy of Special Paper 491, *Geology and Geomorphology of Barbados*, for your trip to the Caribbean, or download *From the Islands to the Mountains: A 2020 View of Geologic Excursions in Southern California* before heading to the Golden State.

Start exploring at **https://rock.geosociety.org/store/**



Longs Peak, Colorado, USA.

Shenandoah National Park, Virginia, USA.



Animal Flower Cave, St. Lucy, Barbados.

GSA Committee Vacancies Available for Nominations by 15 June 2022

Go to **https://rock.geosociety.org/Nominations/CS.aspx** to volunteer or nominate. Open positions and qualifications are detailed online at **https://rock.geosociety.org/forms/viewopenpositions.asp** or see the January issue of *GSA Today*.
Terms begin 1 July 2023 unless stated otherwise.

COMMITTEE NAME	NO. OF VACANCIES	POSITION TITLE & SPECIAL REQUIREMENTS	TERM (YEARS)
Academic and Applied Geoscience Relations Committee	1	Member-at-Large Industry	3
Annual Program Committee	3	Members-at-Large	4
		Member-at-Large Student	2
Arthur L. Day Medal Award Committee	2	Members-at-Large	3
Bascom Mapping Award Committee	3	Member-at-Large Government	3
		Member-at-Large Industry	3
		Member-at-Large	3
Council Officers	5	President-Elect	3
		Treasurer	1
		Councilor	4
Diversity in the Geosciences Committee	4	Members-at-Large	3
		Member-at-Large Industry	3
		Member-at-Large Student	3
Education Committee	3	4-Year College Faculty Representative	4
		Members-at-Large	4
		Graduate Student Representative	2
Geology and Public Policy Committee	3	Members-at-Large	3
		Member-at-Large Student	3
GSA International	4	Chair	4
		International IIG Chair	4
		Member-at-Large	4
		Secretary	4
Membership and Fellowship Committee	3	Members-at-Large Industry	3
		Members-at-Large Student	3
Nominations Committee	2	Members-at-Large	3
North American Commission on Stratigraphic Nomenclature	1	GSA Representative	3
Penrose Conferences and Thompson Field Forums Committee	1	Member-at-Large	3
Penrose Medal Award Committee	2	Members-at-Large	3
Professional Development Committee	2	Members-at-Large	3
Public Service Award Committee	1	Member-at-Large	3
Publications Committee	1	Member-at-Large	4
Research Grants Committee	11	Members-at-Large (various specialties)	3
Young Scientist Award (Donath Medal) Committee	3	Members-at-Large	3

Penrose Circle Membership Takes a Leap with Your Growing Support

For many years, the GSA Foundation provided about US$1M annually in support of GSA programs and priorities. We are delighted to inform you that this has risen to between $1.25M and $1.5M annually. We deeply appreciate the generous members who make contributions through the Foundation.

In the early 2000s, the GSA Foundation created the Penrose Circle to recognize donors who give US$500 and above. This honors R.A.F. Penrose, GSA's president in 1930, who left a generous bequest of nearly US$4M, which continues to provide support for GSA. While this Penrose Circle minimum contribution has remained the same for nearly 20 years, both program costs and the number of GSA programs keep increasing. In recognition of this changing landscape, the Penrose Circle will now start with US$1,000 contributions. As always, Penrose Circle levels may comprise cumulative gifts within a calendar year. More than half of Penrose Circle members already give US$1,000 or more. We thank you for your generosity.

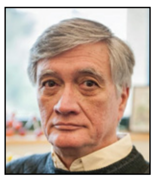
By maintaining Penrose-level giving, you will help provide an even stronger foundation for the GSA programs you passionately support year after year. An additional incentive is the opportunity to strengthen GSA's ongoing accessibility, diversity, equity, and inclusion (DEI) initiatives. For the next three years (July 2022–July 2025), donors who give US$1,000 and above will have the option to direct US$250 of their gift to GSA's DEI efforts to build a superlative workforce for the future. If you give via credit card, just check the box that says, "Please direct $250 of my gift to GSA's diversity, equity, and inclusion efforts." If you give via check or other methods, please include a note indicating that you would like US$250 of your gift to be directed to GSA's DEI efforts, or contact Cliff Cullen at ccullen@geosiociety.org or +1-303-357-1007.

Thank you for keeping GSA strong and prepared for the challenges and opportunities of tomorrow.

NEW GSAF BOARD MEMBERS

Last year the GSA Foundation welcomed three new members to our Board of Trustees, and another three will join us this July. We are grateful for the breadth of experience and expertise each new member brings to the board.

Rebecca Caldwell, Research Geoscientist, Chevron Energy Technology Company



Rodney C. Ewing, Frank Stanton Professor in Nuclear Security; Co-Director of the Center for International Security and Cooperation in the Freeman Spogli Institute for International Studies; Professor, Dept. of Geological Sciences, School of Earth Sciences, Stanford University

Alberto Gutierrez, President, CEO, and Geologist, Geolex Inc.

Terry Briggs, Chief Development Officer, AngloGold Ashanti

Katy Sementelli, Exploration Technical Services, BHP

George Davis, Regents Professor (Emeritus), Provost Emeritus, The University of Arizona; GSA Past President

Celebrate *GEOLOGY's* 50th Anniversary Science Editor Word Search

Hidden in the puzzle are the names of science editors who have served on the journal GEOLOGY from 2010 to today. Their tireless efforts have contributed greatly to the journal's quality and reputation, and we thank them immensely for their service.

R	O	N	A	D	H	C	O	X	E	O	X	M	S	U	K	E	G	R	R	G	J
N	J	T	N	W	O	R	B	S	I	N	N	E	D	A	R	D	E	E	O	L	U
E	A	C	L	R	E	A	R	I	R	E	D	K	T	O	S	Y	R	G	B	K	D
S	Y	M	G	S	G	W	V	W	L	H	E	H	B	G	M	L	A	G	S	O	I
V	U	S	R	W	D	T	V	L	W	S	L	E	X	A	I	C	L	E	T	Z	T
N	P	Z	Y	O	K	A	E	W	N	E	R	H	R	H	T	M	D	T	R	B	H
E	R	S	P	S	N	N	U	I	E	T	A	K	O	T	J	A	D	L	A	E	T
C	D	P	Z	Y	T	D	L	N	H	K	C	V	I	T	F	I	I	A	C	K	O
I	O	J	X	H	B	L	C	O	V	Q	R	M	S	S	Y	L	C	H	H	Y	T
P	Z	K	O	X	O	B	L	R	U	O	H	A	O	O	Y	L	K	C	A	D	M
W	A	M	A	C	E	D	R	I	A	C	O	G	L	G	S	I	E	S	N	P	A
M	A	T	L	N	S	J	G	F	S	M	M	E	A	C	X	W	N	S	W	O	N
S	P	L	I	W	J	L	H	S	E	R	H	C	N	H	S	U	S	R	O	Y	P
S	I	S	O	E	E	H	E	H	O	D	P	W	D	O	W	I	A	U	K	E	A
B	O	R	C	Y	N	M	E	O	U	Q	O	Z	R	W	G	Q	R	D	X	L	R
N	T	Q	I	H	A	C	K	K	U	F	N	H	E	H	H	F	W	H	M	D	R
H	F	J	R	J	K	C	E	V	W	L	E	Y	W	B	G	S	N	A	C	A	I
A	V	O	Q	V	U	W	B	C	M	C	Z	S	B	C	U	F	Z	O	G	R	S
Z	L	S	T	X	P	D	Y	N	O	B	Z	I	A	P	P	Q	S	Z	A	B	H
V	Q	M	G	Q	M	C	D	L	Y	W	J	A	R	D	N	A	S	O	N	U	K
Q	A	P	H	Z	B	H	Z	T	W	O	I	S	T	H	S	O	G	E	Z	C	T
J	A	M	E	S	S	P	O	T	I	L	A	E	H	E	A	H	V	N	E	F	E
G	U	E	I	O	Y	H	P	R	U	M	N	A	D	N	E	R	B	P	G	B	P

Find the editors' names! They are hidden forward, backward, up, down, and diagonally.

Andrew Barth
Kathleen C. Benison
Dennis Brown
Chris Clark
William Clyde
Bill Collins
Rónadh Cox
Patience Cowie
Gerald Dickens
Robert Holdsworth
Brendan Murphy
Marc D. Norman
Bradley Opdyke
Judith Totman Parrish
Mark C. Quigley
Urs Schaltegger
James Schmitt
James Spotila
Rob Strachan
Ellen Thomas
Sandra J. Wyld

Bookmark the Geoscience Job Board at **www.geosociety.org/jobs** for up-to-the-minute job postings. Job Board ads may also appear in a corresponding monthly print issue of *GSA Today*. Send inquiries to advertising@geosociety.org, or call +1-800-427-1988 ext. 1053 or +1-303-357-1053.

POSITIONS OPEN

Faculty Position in Solid Earth Science, The University of Tokyo

The Dept. of Earth and Planetary Science of the University of Tokyo is seeking to fill a vacancy in the solid earth science group at the level of Associate Professor. Fields of expertise we are interested in strengthening are igneous petrology, volcanology and magma processes; solid earth geochemistry; mineralogy and crystallography; and neotectonics and fault mechanics. The ideal candidate should be able to incorporate observations of natural systems in their research either as part of their own activities or in collaboration with other workers. Strong preference will be given for candidates with a nationality other than Japanese although relevant experience in non-Japanese environments will also be taken into consideration for candidates of Japanese nationality. The Application deadline is Wednesday, 15 June 2022. More information is available at https://www.eps.s.u-tokyo.ac.jp/en/job20220324/.

Hiring?

Find those qualified geoscientists to fill vacancies. Use GSA's Geoscience Job Board (geosociety.org/jobs) and print issues of *GSA Today*. Bundle and save for best pricing options. That unique candidate is waiting to be found.

OPPORTUNITIES FOR STUDENTS

Thesis research opportunities and graduate assistantships at Sul Ross State University in West Texas. The Geology Program at Sul Ross State University has positions open for students to pursue a Master of Science degree beginning Fall 2022. The SRSU Geology Program emphasizes field research in surface and groundwater, paleontology, sedimentary petrology, igneous petrology, and structural geology.

The program is looking for students to undertake the following research projects:

- Petrogenesis and tectonic association of Miocene mafic lavas in the Santana graben, Trans-Pecos Texas (Prof. Kevin Urbanczyk)
- A field-based kinematic analysis of Laramide structures in Trans-Pecos Texas: Was crustal shortening oblique or orthogonal? (Prof. Jesse Kelsch)
- Paleozoic stratigraphy and petrology of carbonates and clastics (Prof. Liz Measures)
- The stratigraphy and paleontology of Upper Cretaceous–Paleogene strata of the Big Bend and northern Mexico (Prof. Thomas Shiller)
- A study of the geomorphology and flood history of the Rio Grande in the Colorado Canyon area, Big Bend Ranch State Park (Prof. Kevin Urbanczyk)

Graduate students are funded as teaching assistants for undergraduate geology or chemistry labs, or by tutoring positions in mathematics. These graduate positions pay $1,000/month for the first two semesters and $1,250/month thereafter. Out-of-state tuition is also waived for non-residents.

Sul Ross is a small university in the mountainous region of far west Texas, near three national parks and in proximity to the geology faculty's research areas. Our faculty are committed to providing individual attention and excellent resources to each student.

Qualified individuals are encouraged to learn more at https://www.sulross.edu/courses/m-s-geology/ and to reach out to a faculty member about the program, their thesis-research projects, and the application process. Applications are accepted through the spring semester.

GSA Today Science Editor Opening for 2023

GSA seeks applications for a science co-editor for *GSA Today*. The four-year term begins 1 January 2023. Duties include ensuring stringent peer review and expeditious processing of manuscripts; making final acceptance or rejection decisions after considering reviewer recommendations; and, along with your co-editor, setting the editorial tone of the journal and maintaining excellent content through publication of a diverse range of papers.

The editors of *GSA Today*, one of the most widely read earth-science publications in the world, must have a wide range of interests and expertise along with the ability to identify research topics of both high quality and broad appeal. Prior editing experience and a publication record in a wide range of journals is key.

Editors work out of their current locations at work or at home. The positions are considered voluntary, but GSA provides an annual stipend and funds for office expenses.

Evaluation Process: The GSA Publications Committee will evaluate applications and make its recommendations to GSA Council based on the combination of how a candidate's disciplinary expertise fits with the needs of the journal and on the candidate's application, which should provide documentation of the required and preferred qualifications listed here. GSA affirms the value of diverse scientific ideas and the connection between diverse scientific ideas and a diverse group of contributors of those ideas. Accordingly, GSA welcomes applications from all qualified persons and encourages applications that highlight diversity.

To Apply: In a single PDF, submit your curriculum vitae and a letter of application that demonstrates how your interests and experience fulfill the required and preferred qualifications listed below to editing@geosociety.org. **Deadline: 1 September 2022.**

REQUIRED QUALIFICATIONS

- Experience as an editor or associate editor for a geoscience journal. Include details of the duties and duration of the position(s) held.
- Demonstrated expertise in two or more fields in the geosciences or in interdisciplinary fields broadly related to the geosciences.
- Demonstrated experience handling a significant editorial workload and ability to make timely decisions.
- Because of the breadth of topics covered in GSA journals, applicants must clearly express willingness to handle papers outside of their main disciplines.
- Demonstrated ability to communicate clearly and be responsive to author needs.

PREFERRED QUALIFICATIONS

- Experience with a GSA journal as a reviewer, associate editor, or editor.
- Breadth of interdisciplinary experience to complement that of existing editors; demonstrated interest in interdisciplinary research.
- International reputation and connections with the geoscience communities.
- Interest in encouraging innovation; willingness to take risks.
- Ability to support a positive team dynamic; ability to work with GSA staff and other editors to enhance the reputation of the journal.

TAKING ON 21ST CENTURY CHALLENGES
CREATING 21ST CENTURY LEADERS

From the Earth's core to outer space, research at The University of Texas at Austin's Jackson School of Geosciences is advancing the understanding of our world and beyond for the benefit of humankind.

PHOTO: NASA/JPL-CALTECH