The Faint Young Sun Problem Revisited
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SCIENCE

4 The Faint Young Sun Problem Revisited
Jon Spencer

Cover: Composite of two images, one of the solar corona as seen during the total solar eclipse of 21 Aug. 2017, the other of the solar disk at ultraviolet frequencies as imaged by the Solar Dynamics Observatory satellite. Streamers from polar regions are areas where solar wind flows outward along magnetic field lines. At lower solar latitudes, arcing magnetic-field lines are associated with sunspots and other surface activity that can yield explosive coronal mass ejections. Both solar wind and mass ejections carry away mass and angular momentum. This type of solar activity was much greater during the Sun’s fast-spinning youth. Image provided by Miloslav Druckmüller, Institute of Mathematics, Faculty of Mechanical Engineering, Brno University of Technology, Czech Republic. See related article, p. 4–10.
The Faint Young Sun Problem Revisited

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ABSTRACT
Earth and Mars should have been frozen worlds in their early history because of lower solar luminosity but were not, which challenges our understanding of early atmospheres and surface conditions and/or our understanding of solar evolution. This is known as the “faint young Sun problem.” One resolution to the problem is that the Sun was more massive and luminous in its youth before blowing off mass. Astrophysical studies of stellar evolution and behavior, however, including recent analysis of Kepler space-telescope data, indicate that mass loss is insufficient and occurs too early to allow for a more luminous Sun after ca. 4 Ga. Alternatively, greenhouse gases were surprisingly effective at warming young Earth and Mars. High concentrations of CO₂ with the possible addition of biogenic CH₄ are likely dominant factors promoting open-water conditions on Archean Earth. Evidence of precipitation and flowing water on young Mars, including river valleys thousands of kilometers long, is more problematic. Recent studies indicate that 3–4 Ga river valleys and delta deposits in crater lakes could have been produced in ~10⁷ years. Highly transient warm periods during times of favorable orbital parameters possibly led to brief melting under otherwise icy conditions. Seasonal melting and runoff would be more likely with ~1%–10% atmospheric H₂ and CH₄, perhaps derived from serpentinization of olivine in the martian crust and released from frozen ground by impacts and volcanism, and/or derived directly from volcanic outgassing. The recently recognized effectiveness of hydrogen and methane at absorbing infrared radiation in a thick CO₂-dominated atmosphere, in a process known as “collision-induced absorption,” is probably essential to the solution to the faint young Sun problem for Mars.

INTRODUCTION
The basic concepts involved in stellar-energy generation were known by the 1950s and include the insight that stellar luminosity gradually increases over time because of increasing density in stellar cores resulting directly from thermonuclear fusion (e.g., Burbidge et al., 1957) (Fig. 1). Solar luminosity at birth was calculated to be ~70% of modern luminosity. The idea that Earth should have geologic evidence of its presumably frozen youth was gradually determined to be inconsistent with growing evidence for liquid water at the surface of Archean Earth. The problem was first addressed by Sagan and Mullen (1972), who proposed that atmospheric ammonia was crucial to early warming. More recent robotic exploration of Mars similarly indicates surprisingly warm and wet conditions during its early geologic history. The discrepancy between low solar-energy production and warm early Earth and Mars is known as the “faint young Sun problem” (Ulrich, 1975; Feulner, 2012). This article is a brief review of solar evolution and the faint young Sun problem for Earth and Mars that highlights recent developments.

STELLAR ENERGY PRODUCTION
Stars form by gravitational contraction of clouds of interstellar gas dominated by hydrogen. During contraction and adiabatic heating, increasing stellar energy production by nuclear fusion of hydrogen into helium eventually terminates gravitational contraction (e.g., Haxton et al., 2013). Over millions of years, helium produced by fusion of hydrogen accumulates in the cores of stars and increases core density, causing gravitational contraction and adiabatic heating which, in turn, raise fusion rates and energy generation. This process occurs gradually and continuously, resulting in increasing core temperature and total luminosity (Fig. 1) (Bahcall et al., 2001). The Sun began with ~71% hydrogen...
greater insolation for orbiting planets

than ca. 2.7 Ga and ages and names of glacial deposits older than ca. 2.0 Ga. Archean glacial deposits from Young et al. (1988; Mozaan), Ojakangas et al. (2014; Talya), and de Wit and Furnes (2016; Noisy) (cg—conglomerate). (E) Some events in Mars history. Pre-Noachian magnetization of the martian crust ended before formation of the Hellas impact basin. Noachian to early Hesperian highland valley networks formed after the large impact basins.

A BRIGHT YOUNG SUN?

Difficulties in identifying the causes of warm climates on young Earth and Mars provoked consideration of a more massive and therefore more luminous young Sun. Specifically, if the Sun was 4%–5% more massive at its birth, before blowing off mass as solar wind and coronal mass ejections, it could have provided elevated luminosity to warm the young planets to approximately modern temperatures (Fig. 2C) (Whitmire et al., 1995; Sackmann and Boothroyd, 2003). This is plausible because stellar luminosity is very sensitive to stellar mass. For a roughly solar-mass star, absolute luminosity scales to almost the fifth power of solar mass, while the greater gravitational attraction of a more massive star reduces orbital radius proportional to mass. These factors together result in insolation at Earth and Mars that scales to almost the seventh power of solar mass such that a 1% greater solar mass would result in ~7% greater insolation for orbiting planets (1.01 raised to the 6.75 power =1.07; Minton and Malhotra, 2007).

The angular momentum of spinning stars is gradually carried away by stellar winds. This is effective because rotating stellar magnetic fields sweep through stellar winds and accelerate the winds circumferentially, thereby flinging the winds away and transferring angular momentum from the star to the wind.
Loss of angular momentum is more effective when stars spin faster, because magnetic fields are generally stronger and sweep through stellar winds faster, and because coronal mass ejections are more common (e.g., Gallet and Bouvier, 2015).

Studies of star populations in clusters in which all the stars have similar age indicate that most stellar spindown, and by inference mass loss, occurs during the first few hundred million years of a star’s life (Fig. 2A) (Skumanich, 1972; Ayres, 1997). This interpretation was strengthened by recent studies using data from the Kepler planet-finder satellite mission (active 2009–2018). The Kepler telescope was designed to detect changes in stellar luminosity resulting from passage of planets in front of stars but also identified luminosity variations due to transit of starspots on stellar surfaces. This allowed determination of rotation periods for thousands of stars and accurate representation of stellar spindown rates (Fig. 2A) (Meibom et al., 2011, 2015; Rebull et al., 2017). It appears from these studies that, if the Sun did have greater mass during its youth, it would have lost most of that additional mass during rapid spindown before deposition of Archean algal stromatolites on Earth and Noachian river-channel incision and lake-delta deposition on Mars (Figs. 2C–2E).

SOLAR RADIATION OVER TIME

Short-wavelength solar radiation was stronger during the Sun’s youth, which further complicates warming scenarios because some greenhouse gases such as methane are readily photolyzed (broken down) by such radiation or by free radicals produced by photolysis of other gases (Catling and Kasting, 2017). Six nearby stars similar in mass to the Sun, but with a range of ages, were identified by Ribas et al. (2005) and used to estimate radiation characteristics of the Sun over time (Fig. 2B). Short-wavelength radiation, especially far ultraviolet and X-ray, is significantly more intense for younger stars because their faster rotation rate increases the accumulation of magnetic-field energy in stellar envelopes, which in turn results in greater short-wavelength radiation from stellar surfaces and coronae.

EARTH

Solar luminosity is calculated to have been ~77%–79% of its current value at 3.2–3.5 Ga, when at least four different rock units were deposited during open-water, probably sunlit conditions (Figs. 2C and 2D). If Earth absorbed and retained solar energy with modern effectiveness, water at ancient Earth’s surface would have been largely if not entirely frozen during this time, except where heated by magmatic and hydrothermal activity or beneath hundreds to thousands of meters of ice. Geologic evidence of ancient warm conditions is outlined below, followed by possible explanations for effective surface warming with a faint young Sun.

Archean strata deposited in shallow water with evidence of sunlit conditions indicate surface temperatures above freezing. These rock units include calcareous and siliceous strata interpreted as fossil microbial mats and mound-forming algal stromatolites that harbored, or were produced by, photosynthetic bacteria (e.g., Grotzinger and Knoll, 1999; Noffke, 2008; Tice et al., 2011). One of the oldest examples of aquatic microbial life is the 3.42 Ga Buck Reef Chert in South Africa, which contains carbonaceous layers, filaments, and grains deposited within fine-grained, wave-agitated, siliceous sediments (Tice and Lowe, 2004) (Fig. 2D). The 3.35–3.43 Ga Strelley Pool Formation in the Pilbara Supergroup of northwestern Australia (Wacey et al., 2010) contains abundant evidence of microbial biofilms that precipitated carbonate and/or trapped fine detrital grains to form laminated stromatolites (Allwood et al., 2009; Wacey, 2010; Duda et al., 2016). Multiple associated sedimentary features in the Strelley Pool Formation, including rare desiccation cracks, indicate deposition in shallow-water, tidally affected, marine environments (e.g., Allwood et al., 2006). Fossil microbial mats and stromatolites resemble much younger and modern microbial mats, photosynthetic stromatolites, and cyanobacterial mounds (Suosaari et al., 2016).

The abundance of sedimentary and fossil indicators of liquid water at Earth’s surface during the Archean indicates the effectiveness of warming mechanisms that are still not well understood. CO₂, CH₄, and H₂O concentration, absolute pressure, and abundance of cloud-condensation nuclei. Warm, open-water conditions not unlike modern conditions were calculated for a 1-bar atmosphere with 1% CO₂ and 0.2% CH₄ at 2.5 Ga (Charnay et al., 2013); 1.2% CO₂ and 0.1% CH₄ at 3.5 Ga (Le Hir et al., 2014); and 0.1–0.36 bar CO₂ partial pressure with 1 bar N₂ at 3.8 Ga (Charnay et al., 2017). A variety of other factors influence global temperature, including sea-ice dynamics and the abundance of cloud-droplet condensation nuclei. Appropriate values of multiple variables appear to be capable of warming Archean Earth to approximately modern temperatures, but the relative significance of these factors in supporting warm conditions under a faint young Sun has not been clearly identified.

MARS

The heavily cratered Noachian highlands of equatorial and southern Mars, and by sulfur isotopes in sedimentary rocks that were fractionated independent of mass by ultraviolet photolysis of SO₂ in an anoxic atmosphere (Farquhar and Wing, 2003; Claire et al., 2014; Dauphas and Schauble, 2016). CH₄ and H₂ are potential greenhouse gases but would be slowly oxidized in such an atmosphere due to various reactions involving H₂O and CO₂ that are triggered by ultraviolet radiation, a process that would be more effective with more intense short-wavelength radiation in the Archean (Pavlov et al., 2001; Catling and Kasting, 2017). Methane could have been an important greenhouse gas, however, if methane-generating bacteria were abundant and if bacterial growth was not inhibited by cooling due to sunlight-shielding organic haze produced by photochemical reactions involving CH₄ and CO₂ (Domagal-Goldman et al., 2008). Effective warming by reducing greenhouse gases is suggested by the coincidence of earliest Proterozoic glaciations with the great oxidation event (“GOE”) of Earth’s atmosphere (Holland, 2006) (Fig. 2D). The GOE would have destroyed atmospheric CH₄ and H₂, thereby causing the temperature drop (Pavlov et al., 2000; Haqq-Misra et al., 2008).

Three-dimensional climate models of Archean Earth’s atmosphere have been used to evaluate the effectiveness of several atmospheric variables that are important for a warm climate, including CO₂, CH₄, and H₂O concentration, absolute pressure, and abundance of cloud-condensation nuclei. Warm, open-water conditions not unlike modern conditions were calculated for a 1-bar atmosphere with 1% CO₂ and 0.2% CH₄ at 2.5 Ga (Charnay et al., 2013); 1.2% CO₂ and 0.1% CH₄ at 3.5 Ga (Le Hir et al., 2014); and 0.1–0.36 bar CO₂ partial pressure with 1 bar N₂ at 3.8 Ga (Charnay et al., 2017). A variety of other factors influence global temperature, including sea-ice dynamics and the abundance of cloud-droplet condensation nuclei. Appropriate values of multiple variables appear to be capable of warming Archean Earth to approximately modern temperatures, but the relative significance of these factors in supporting warm conditions under a faint young Sun has not been clearly identified.
which are the oldest exposed part of the martian crust, contain abundant evidence of erosion by water. Mars is freezing cold now and, with similar surface and atmospheric conditions, should have been even colder at 3–4 Ga. Some drainages are thousands of kilometers long and were fed by numerous tributaries that reached drainage divides in headwater regions (Howard et al., 2005; Hynek et al., 2010). Many rivers flowed into or through crater lakes, and some left delta deposits (Irwin et al., 2005; Fassett and Head, 2008b; Goudge et al., 2016). Calculations based on canyon width and depth indicate that canyons reflect ~10⁶–10⁷ years of erosion and were not incised by catastrophic outflows (Barnhart et al., 2009; Hoke et al., 2011; Rosenberg and Head, 2015). Precipitation, drainage incision, and crater-lake filling are inferred at ca. 3.3–3.9 Ga based on crater density in affected terrains (Fassett and Head, 2008a; Hoke and Hynek, 2009) (Fig. 2E).

Several factors would have supported warmer Noachian environmental conditions, although maybe not enough for precipitation and flowing water. The pressure of the modern martian atmosphere, at 6–10 millibars, is ~1% that of Earth, but the ancient atmosphere was much thicker. The size and abundance of the smallest martian impact craters can be used to determine atmospheric pressure because the smallest meteorites are slowed or destroyed during passage through the atmosphere and so do not create impact craters. Size-frequency distributions for craters in fluvial deposits near Gale crater indicate that Noachian atmospheric pressure was in the range of ~1–2 bars during heavy Noachian bombardment (Kite et al., 2014). Atmospheric pressure greater than a few hundred millibars results in a vertical temperature profile that approximates an adiabatic gradient (Wordsworth, 2016). Under such conditions, surface temperatures are lower at higher elevation, with potential accumulation of snow and ice at high elevations. Even if the atmosphere was pure CO₂, however, this would not be adequate to warm early Mars to the point of supporting running water, especially in highland regions (Kasting, 1991; Forget et al., 2012).

Orbital factors relevant to early Mars climate are the variable tilt of its spin axis relative to the normal to the orbital plane (the obliquity) and the variable eccentricity (ellipticity) of the orbit. Earth’s obliquity is currently 23°, but because of stabilizing tidal forces associated with the Moon, obliquity varies geologically by <± 2° (Laskar et al., 1993). Mars, with current obliquity of 25°, does not have a massive moon, and its obliquity is not similarly stabilized. Because of tidal forces exerted on Mars by the Sun and planets, obliquity varied chaotically over millions of years to >60° (Figs. 3A and 3B) (Touma and Wisdom, 1993; Laskar et al., 2004). At obliquities >~45°, polar regions receive more sunlight than equatorial regions, potentially resulting in seasonal sublimation and evaporation at high latitudes and snow at low latitudes at times near summer solstices (Fig. 3C) (Ward, 1974; Jakosky and Carr, 1985; Wordsworth, 2016). High-latitude evaporation would be especially effective if the summer solstice coincided with greater proximity to the Sun during a period of high orbital eccentricity, which also varies chaotically (Fig. 3D).

Figure 3. (A) Obliquity of Mars at 2–6 Ma as calculated by Touma and Wisdom (1993). Note that obliquity exceeded 40° at 5–6 Ma. (B) Probability of reaching high obliquities during the chaotic obliquity evolution of Mars over a range of time periods, with initial 25° obliquity (from Laskar et al., 2004). (C) Total annual insolation versus latitude for obliquity variation of 0°–90°. Insolation units are relative to the solar constant at 1.52 AU (from Ward, 1974). (D) Normalized density function for chaotic eccentricity variation for Mars (from Figure 18d of Laskar et al., 2004). At present eccentricity, solar insolation at perihelion (orbital point closest to the Sun) is 45% greater than at aphelion.
runoff from frozen martian highlands (Wordsworth et al., 2017).

Multispectral imaging, lander observations, and the content of meteorites derived from Mars indicate that olivine is common on Mars (e.g., McSween et al., 2006; Koeppen and Hamilton, 2008; Ody et al., 2013). Hydrous alteration (serpentinization) of olivine and pyroxene by groundwater should have been common if not pervasive early in martian history (Oze and Sharma, 2005, 2007). Serpentinization yields H$_2$, which in turn reacts with CO$_2$ to produce CH$_4$, as is seen in hydrothermal fluids associated with ultramafic rocks on Earth (Bradley and Summons, 2010). Cooling of the young martian crust in the presence of groundwater would result in formation of a near-surface cryosphere of frozen groundwater. Downward propagation of the boundary between frozen ground and deeper groundwater would trap dissolved methane in methane clathrate, which is water ice with ~6% methane trapped within the cage-like molecular structure of the clathrate ice (e.g., Kvenvolden, 1993; Prieto-Ballesteros et al., 2006). As a result of clathrate genesis, the early martian cryosphere could have become a global methane reservoir (Lasue et al., 2015). Furthermore, the cryosphere would become an impermeable cap for trapped gaseous H$_2$ and CH$_4$ as on Earth (Kvenvolden, 1993).

Methane and hydrogen liberated to the atmosphere by cryosphere disruption and melting from magmatism, impacts, and perhaps outburst floods, would result in minor to perhaps significant transient planetary warming. Such warming might have been sufficient to cause snow and ice melting and runoff from Noachian highlands for perhaps tens to hundreds of thousands of years (Chassefière et al., 2016; Wordsworth et al., 2017), especially if it occurred during favorable orbital parameters (Palumbo et al., 2018). Such warming could melt more methane clathrate in a positive feedback cycle (Wordsworth et al., 2017). Finally, the 10$^3$–10$^4$ years needed for river valley incision was perhaps the cumulative result of numerous short-lived warming episodes, each triggered by a different geologic event over hundreds of millions of years. It remains uncertain, however, if all these factors are adequate for melting and river-valley incision on Mars.

**CONCLUSIONS**

1. Total solar-energy production is increasing gradually due to well-understood physics controlling rates of thermonuclear fusion in the solar core (Bahcall et al., 2001). A more massive and luminous young Sun is not supported by recent astrophysical studies.

2. Archean sedimentary rocks on Earth include many indicators of liquid water at Earth’s surface, including sedimentary rocks containing evidence of microbial life that in turn indicate open water with sunlight. The warm Archean Earth resulted from high atmospheric concentrations of CO$_2$, with possible additional warming from methane and hydrogen, lower cloud albedo, a low ratio of land to water at Earth’s surface, and other factors. It is not clear which additional factors were dominant or if we are missing something fundamental.

3. Abundant evidence of martian river channels and crater lakes at ca. 3.3–3.9 Ga indicates warm conditions in otherwise icy highlands of equatorial and southern Mars. Although transient melting might occur under favorable orbital parameters, augmentation of such warming by a few percent atmospheric H$_2$ and CH$_4$ released from crustal or mantle reservoirs may be a viable solution to the faint young Sun problem for Mars.

**ACKNOWLEDGMENTS**

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**REFERENCES CITED**


Duda, J.-P., Van Kranendonk, M.J., Thiel, V., Ionescu, D., Strauss, H., Schäfer, N., and


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GSA has also been a place where the many geoscientists I have met from around the world regularly gather to share our science. It’s very exciting to know that we are part of a much larger community, and it is gratifying to find the connections between our different disciplines as well as to see the value in each other’s work.

Darryl Reano
Postdoctoral Associate
STEM Transformation Institute
Florida International University

“GSA has also been a place where the many geoscientists I have met from around the world regularly gather to share our science. It’s very exciting to know that we are part of a much larger community.”

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TECHNICAL PROGRAM

T1. Insights into Processes of Proterozoic Crustal Growth, Modification, and Stabilization in the North-Central U.S. Continental Interior. Daniel Holm, Kent State University, dholm@kent.edu; David Malone, Illinois State; John Craddock, Macalester.

T2. Intrusive Rocks of the Midcontinent Rift. Joshua Feinberg, University of Minnesota Twin Cities, feinberg@umn.edu; Nicholas Swanson-Hysell, University of California Berkeley; Mark Severson, University of Minnesota Duluth Natural Resources Research Institute.

T3. Precambrian Geology of the Lake Superior Region. Robert Lodge, University of Wisconsin–Eau Claire, lodgerw@uwec.edu; Mark Jirsa, Minnesota Geological Survey.

T4. Petrology, Mineralogy, and High-Temperature Geochemistry. Fred Davis, University of Minnesota Duluth, fdavis@umn.edu.

T5. Novel Approaches to Studying Earth’s Earliest Terrestrial Ecosystems: From Biogeochemistry to Astrobiology. Erik Gulbranson, Gustavus Adolpbus College, erikgulbranson@gustavus.edu; Rebecca Dzombak, University of Michigan; Nathan Sheldon, University of Michigan.

T6. Deciphering the Record of Lake Superior Iron Formations. Athena Eyster, Massachusetts Institute of Technology, aeyster@mit.edu; Latisa Brengman, University of Minnesota Duluth; Chad Wittkop, Minnesota State University.


T8. Structural Geology and Tectonics. Melissa Lamb, University of St. Thomas, malamb@stthomas.edu.


T11. Glaciation and Deglaciation along the Southern Margin of the Laurentide Ice Sheet: Bringing Multiple Tools to Bear. Cosponsored by GSA Quaternary Geology and Geomorphology Division. Jennifer McDonald, Minnesota Geological Survey, jmhorton@umn.edu; David Ullman, Northland College; Kenneth Lepper, North Dakota State University.

T12. All Things Aeolian. Cosponsored by GSA Quaternary Geology and Geomorphology Division. Phillip Larson, Minnesota State University Mankato, philip.larson@mnsu.edu; Randall Schaetzl, Michigan State University; Garry Running, University of Wisconsin–Eau Claire.

T13. Geoarchaeology: Exploring the Connections between Humanity and Geology. Michele D. Stillinger, University of St. Thomas, mdstillinger@stthomas.edu.
T14. Magnetism from the Infinitesimal to the Planetesimal. Michele D. Stillinger, University of St. Thomas, mdstillinger@stthomas.edu; Joshua M. Feinberg, University of Minnesota Institute for Rock Magnetism.


T16. Subsurface Imaging within the Geosciences. Harry Jol, University of Wisconsin–Eau Claire, jolhm@uwec.edu.

T17. Geochemical Cycling of Environmentally Relevant Elements. Cara M. Santelli, University of Minnesota Department of Earth Sciences, BioTechnology Institute & MnDRIVE, santelli@umn.edu; Tingying Xu, University of Minnesota Department of Earth Sciences, BioTechnology Institute & MnDRIVE; Jacqueline Mejia, University of Minnesota Department of Earth Sciences, BioTechnology Institute & MnDRIVE.

T18. It's a Small (Microbial) World. Elizabeth Swanner, Iowa State University, eswanner@iastate.edu; Jeff Havig, University of Minnesota Twin Cities; Cody Sheik, University of Minnesota Duluth.

T19. Applications of 3D Modeling Using Structure from Motion or Terrestrial Laser Scanning. Stephanie S. Day, North Dakota State University, stephanie.day@ndsu.edu; Zachary Phillips, North Dakota State University.


T21. Flash Floods, Landslides, and Debris Flows in the Midcontinent. Cosponsored by GSA Quaternary Geology and Geomorphology Division. Carrie E. Jennings, Freshwater Society, cjennings@freshwater.org; Karen Gran, University of Minnesota Duluth; Thomas Oomen, Michigan Technological University.


T24. Lakes as Sentinels of Environmental Change. Byron A. Steinman, University of Minnesota Duluth, bsteinma@d.umn.edu; Kathryn M. Schreiner, University of Minnesota Duluth; Matthew Finkenbinder, Wilkes University.

T25. Land-Lake Connections: The Importance of Hydrologic Processes on Aquatic Ecosystems. Christopher T. Filstrup, University of Minnesota Duluth, filstrup@d.umn.edu; John A. Downing, University of Minnesota Duluth.


T27. The Hydrogeology of Fracture and Karst Bedrock Aquifers. E. Calvin Alexander Jr., University of Minnesota, alexat001@umn.edu; Anthony Runkel, Minnesota Geological Survey.

T28. Caves and Karst of the Midwest. Cosponsored by GSA Karst Division. Erik Larson, Shawnee State University, elarson@shawnee.edu; Maurice Testa, University of Arkansas–Fort Smith.

T29. Addressing Habitat, Water, Ecosystem, and Sustainability Issues through Interdisciplinary Work. Cosponsored by GSA Geobiology and Geomicrobiology Division; GSA Hydrogeology Division; GSA Environmental and Engineering Geology Division; GSA Soils and Soil Processes Division. Lisa Lamb, University of St. Thomas, malamb@stthomas.edu; Scott Clark, University of Wisconsin–Eau Claire; Richard Kiesling, U.S. Geological Survey; Eric Chapman, University of St. Thomas.


T32. Unique Geology and Geoheritage of the Lake Superior Region. Erika Vye, Michigan Technological University, ecvye@mtu.edu; William L. Rose, Michigan Technological University; Jim Miller; James M. DeGraff, Michigan Technological University.

T33. Highlighting Indigenous-Centered Geoscience Research and Education. Wendy Smythe, University of Minnesota Duluth, wsmythe@d.umn.edu; Christie Poitra, Michigan
State University, Native American Institute; Judi Brown Clarke, Michigan State University, BEACON Center.

T34. **Strategies to Address Barriers to Learning in Classroom, Lab, and/or Field.** Prajukti (Juk) Bhattacharyya, University of Wisconsin–Whitewater, bhattacj@uww.edu; Caitlin Callahan, Grand Valley State University.

T35. **Encouraging New Scientists: What Works in STEM Recruitment and Retention.** Cosponsored by GSA Geoscience Education Division; NAGT Geo2YC Division. Joy Branlund, Southwestern Illinois College, joy.branlund@swic.edu; Sheldon Turner, Triton College.

T36. **Teaching, Learning, and Research in Geoscience Education.** Kyle Gray, University of Northern Iowa, kgray@uni.edu; Beth A. Johnson, University of Wisconsin–Oshkosh Fox Cities Campus.

T37. **Undergraduate Research Poster Session.** Cosponsored by Council on Undergraduate Research; GSA Geoscience Education Division. Robert D. Shuster, University of Nebraska–Omaha, rshuster@unomaha.edu.

**FIELD TRIPS**

Registration opens in February. For additional information, please contact the field trip chair: Carrie Jennings, cjennings@freshwater.org.

Pre-Meeting

St. Louis River Sediment Remediation, Aquatic Habitat Restoration, and Harbor Tour. Ben Sheets, BSheets@barr.com, Barr Engineering.

Northern Minnesota Peatland and Soil Research Tour. Ed Nater, nater001@umn.edu; Kyungsoo Yoo, University of Minnesota; Stephen Sebestyen, U.S. Northern Forest Research Station.

The Sandstone Karst of Pine County, Minnesota. Calvin Alexander, University of Minnesota, alexa001@umn.edu; Greg Brick.

During the Meeting

Geology under the Surface: Lake Superior and the Research Vessel Blue Heron. Doug Ricketts, University of Minnesota Duluth, ricketts@d.umn.edu; Nigel Wattrus, University of Minnesota Duluth.

Walking Tour of Minnesota Point. Harry Jol, jolhm@uwec.edu, University of Wisconsin–Eau Claire; Andy Breckenridge, University of Wisconsin–Superior.

Post-Meeting

Minnesota’s Minerals, Mining, and the Environment of the Mesabi Iron Range. Megan Kelly, megan.j.kelly@state.mn.us; Heather Arends, MnDNR Lands and Minerals; Alyse Freeman, Minnesota Discovery Center; John Westgaard, Science Museum of Minnesota.

Slope Stability, Extreme Floods, and Implications for Restoration in the Duluth Area. Emilie Richard, rich1726@d.umn.edu; Karen Gran, University of Minnesota Duluth; Faith Fitzpatrick, U.S. Geological Survey; Marty Melchoir, Inter-Fluve.


Duluth to Two Harbors—Transect through the Duluth Complex and Base of the North Shore Volcanic Group. Jim Miller, emeritus, University of Minnesota Duluth, mille066@d.umn.edu; Terry Boerboom, Minnesota Geological Survey.

Sediments, Landforms, and Proglacial Lake History in Western St. Louis County, Minnesota. Jennifer McDonald, University of Minnesota, jmhorton@umn.edu; Kaleb Wagner, Minnesota Geological Survey; Andy Breckenridge, University of Wisconsin–Superior.

**SHORT COURSES**

Registration opens in February. For additional information, please contact the short course chair: Josh Feinberg, feinberg@umn.edu.

Navigating the Path to Professional Licensure. Keith B. Rapp, AELSLAGID Geoscience Board Member, kbrapp@comcast.net.

3D Modeling Using Structure from Motion and Terrestrial Laser Scanning. Stephanie S. Day, North Dakota State University, stephanie.day@ndsu.edu; Zachary Phillips, North Dakota State University.

Programming IoT Monitoring Stations Built on the Arduino Framework with the EnviroDIY ModularSensor Library. Beth A. Fisher, Minnesota State University Mankato, beth.fisher@mnsu.edu; Anthony K. Aufdenkampe, LimnoTech.

Professional Ethics for Engineers and Geologists (2 PDH). Karl D. Everett, KEA Associates, karl-everett@q.com.

Ground-Penetrating Radar for the Geosciences. Harry Jol, University of Wisconsin–Eau Claire, jolhm@uwec.edu.

Workflow for Unmanned Aerial Systems. Scott M. Galetka, Bayfield County, sgalecka@bayfieldcounty.org; Martin Goettl, University of Wisconsin–Eau Claire.

**REGISTRATION**

Early registration deadline: 13 April
Cancellation deadline: 20 April

Registration opens in February. For further information or if you need special accommodations, please contact one of the general co-chairs: Karen Gran, kgran@d.umn.edu, or Harry Jol, jolhm@uwec.edu.
ACCOMMODATIONS
Hotel registration deadline: 27 April
A block of rooms has been reserved at the Canal Park Lodge (+1-218-279-6000), which is a few blocks from the Duluth Entertainment Convention Center (DECC), where the meeting will be held, for US$119/room, and at the Holiday Inn & Suites (+1-218-722-1202) in downtown Duluth for US$114/room. The Holiday Inn is connected to the DECC via the downtown skyway system. Please call hotels directly and reference the group code of NCGSA20 when reserving a room. Dormitory rooms are also available at the University of Minnesota Duluth and can be reserved online. Information and reservations are available at https://forms.gle/95vF2LSh3kEszLVz9. UMD is a 10-minute drive or 30-minute bus ride (DTA) from the DECC.

OCCUPY FOR STUDENTS AND EARLY CAREER PROFESSIONALS
Career Mentoring Luncheons
Ask your career-related questions and learn about non-academic pathways in the geosciences while networking with professionals at the Roy J. Shlemon and John Mann Mentor Luncheons. Students and early career professionals are welcome.

Career Workshop Series
This three-part series will feature career development planning, an exploration of geoscience job sectors, and information on best practices for crafting a résumé and cover letter. Non-technical skills and workforce statistics will be reviewed. The series will be led by workshop presenters and geoscientists. No registration is required, and everyone is welcome.

Learn more at www.geosociety.org/mentors. Questions? Contact Jennifer Nocerino at jnocerino@geosociety.org.

Presentation Awards
Awards for the best graduate and undergraduate student posters and papers are supported by the GSA North-Central Section and by the Great Lakes Section–SEPM (Society for Sedimentary Geology).

Lightning Talks
Students, please join us for an informal lightning-talk session during the Icebreaker Reception on Sunday night, 17 May. Lightning talks provide an opportunity to draw people to your poster or talk, or just to sharpen your presentation skills. Lightning talks must be three minutes (or less), and the three-minute limit will be enforced. Speakers may include up to two slides in their presentation, not including a title slide. The session is a great opportunity to meet other students and learn about their research. Anyone may attend, but speakers must be undergraduate or graduate students. Indicate your interest in giving a lightning talk when you register for the meeting. If you have questions, please contact Collin Roland at cjroland@wisc.edu.

PROFESSIONALS
Interested in sharing information about your applied geoscience or hydrology career with students? Being a mentor is a rewarding experience. To learn more about serving as a mentor at North-Central GSA, contact Jennifer Nocerino at jnocerino@geosociety.org.

The North-Central Section Meeting also offers an excellent opportunity to earn CEUs toward your continuing education requirements for your employer, K–12 school, or professional registration. Please check the meeting website after the meeting to download your CEU certificate.

LOCAL COMMITTEE
Chair: Karen Gran, kgran@d.umn.edu
Vice-Chair: Harry Jol, jolhm@uwec.edu
Technical Program Chair: Chad Wittkop, chad.wittkop@mnsu.edu
Field Trip Chair: Carrie Jennings, cjennings@freshwater.org
Sponsorship Chair: Howard Mooers, hmooers@d.umn.edu
Exhibits Chair: Erik Brown, etbrown@d.umn.edu
Student Programs/Student Volunteer Chair: Prajuki (Juk) Bhattacharyya, bhattacj@uw.edu
Treasurer: Doug Ricketts, ricketts@d.umn.edu
Short Course Chair: Josh Feinberg, feinberg@umn.edu
SECOND ANNOUNCEMENT

South-Central Section
54th Annual Meeting of the South-Central Section, GSA
Fort Worth, Texas, USA
9–10 March 2020
www.geosociety.org/sc-mtg

LOCATION
The meeting will be held at the Fort Worth Convention Center, 1201 Houston Street, Fort Worth, TX 76102, USA. Visitors can experience the city’s vibrant western heritage in the Stockyards National Historic District—complete with the world’s only year-round rodeo, authentic saloons, and the world’s largest honky-tonk. The renowned Cultural District, less than four miles away, is a haven for art enthusiasts and home to five internationally recognized museums plus the emerging art-filled Foundry District. Premier shopping, dining, and live entertainment continue in downtown Fort Worth, with more upscale finds at the new Shops at Clearfork. The Trinity River also provides outdoor activities like canoe and kayak tours, stand-up paddling, and 70+ miles of uninterrupted trails.

REGISTRATION
Early registration deadline: 3 Feb.
Cancellation deadline: 10 Feb.

REGISTRATION FEES (all fees are in U.S. dollars)

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CALL FOR PAPERS
Abstract deadline: 3 Dec.
For additional information, please contact the Technical Program Co-chairs, Xiangyang Xie, x.xie@tcu.edu, and Arne Winguth, awinguth@uta.edu.

TECHNICAL PROGRAM
Theme Sessions
T1. Open Versus Closed Systems in Diagenesis and Hydrothermal Alteration. R. Douglas Elmore, University of Oklahoma, delmore@ou.edu; Matt Hamilton, University of Oklahoma, Matt.Hamilton@ou.edu; Katie Garrett, University of Oklahoma, katie-garrett@ou.edu. Oral only.

T2. Recent Progress in the Southern Oklahoma Aulacogen. Matt Hamilton, University of Oklahoma, matt.hamilton@ou.edu; R. Douglas Elmore, University of Oklahoma, delmore@ou.edu; Jonathan D. Price, Midwestern State University, jonathan.price@msutexas.edu. Oral only.


T4. Geophysical Methods and Application. Jingyi Chen, The University of Tulsa, jingyi-chen@utulsa.edu; Priyank Jaiswal, Oklahoma State University, priyank.jaiswal@okstate.edu; Michael Behm, University of Oklahoma, michael.behm@ou.edu. Oral only.

T5. Recent Advances in Geoscience Research of Northeastern Mexico. Juan Alonso Ramirez-Fernandez, Universidad Autónoma de Nuevo Leon, alonso_fct@hotmail.com, juan.ramirezf@uanel.mx; Fernando Velasco-Tapia, Universidad Autónoma de Nuevo Leon, fernando.velascotapia@uanel.edu.mx; Uwe Jenchen, Universidad Autónoma de Nuevo Leon, uwe.jenchen@gmail.com. Oral and poster.

T6. Integrating Earth Observations and Geospatial Data for Monitoring and Assessing Natural and Anthropogenic Hazards in the South-Central United States (Posters). Esayas Gebremichael, Texas Christian University, e.gebremichael@tcu.edu. Posters only.

T8. **Permain of the South-Central U.S.: Land and Sea.** Lowell Waite, The University of Texas at Dallas, lowell.waite@utdallas.edu; Alicia Bonar, University of Oklahoma, alicia.bonar@ou.edu; Lily Pfeifer, University of Oklahoma, lspfeifer@ou.edu; Robert J. Stern, The University of Texas at Dallas, rjstern@utdallas.edu. Oral and poster.

T9. **Geophysics and Remote Sensing Applications in Tectonics and Geomorphology. Cosponsored by GSA Geophysics and Geodynamics Division.** Andrew Katumwehe, Midwestern State University, andrew.katumwehe@msutexas.edu; Luel Emishaw, Oklahoma State University, leulseg@ostateemail.okstate.edu; Kevin Mickus, Missouri State University, kevinmickus@missouristate.edu. Oral only.

T10. **Dynamics in Fluvial Process—Landform Relationships across Environmental Gradients.** Peyton E. Lisenby, Midwestern State University, peyton.lisenby@msutexas.edu; Michael C. Slattery, Texas Christian University, m.slattery@tcu.edu. Oral only.

T11. **Mass Extinction in Earth History: New Insights from Paleobiological, Geochemical, and Modeling Studies of Mass Extinction Events.** Arne Winguth, The University of Texas at Arlington, awinguth@uta.edu. Oral only.

T12. **Structural Evolution and Sedimentation along the Western Gulf of Mexico Margin.** Timothy Lawton, The University of Texas at Austin, tim.lawton@beg.utexas.edu; Elisa Fitz-Diaz, Universidad Nacional Autónoma de México, elisaf@geologia.unam.mx; Daniel F. Stockli, The University of Texas at Austin, stockli@jsg.utexas.edu. Oral and poster.

T13. **Sandstone Provenance Study and Its Implications.** Xiangyang Xie, Texas Christian University, x.xie@tcu.edu; Majie Fan, The University of Texas at Arlington, mfan@uta.edu. Oral and poster.

T14. **Topics in Ichnology: A Session on All Things Related to Trace Fossils.** Patrick Getty, Collin College, pgetty@collin.edu; Stephen Hasiosit, University of Kansas, hasiosit@ku.edu. Oral only.

T15. **Orogenesis and Global Change.** Guangsheng Zhuang, Louisiana State University, gzhuang@lsu.edu. Oral and poster.

T16. **The Role of Geochronology in Constraining the Development of Earth’s Lithosphere: Focus on the U.S. South-Central Region, Mexico, and Beyond.** Elizabeth Catlos, The University of Texas at Austin, ejcatlos@jsg.utexas.edu; Rita Economos, Southern Methodist University, reconomos@smu.edu; J. Douglas Walker, University of Kansas, jdwalker@ku.edu. Oral only.

T17. **Anthropogenic Seismicity in the Central U.S.** Heather DeShon, Southern Methodist University, hdeshon@smu.edu; Maria Beatrice Magnani, Southern Methodist University, mmagnani@smu.edu; Robert T. Gregory, Southern Methodist University, bgregory@smu.edu. Oral and poster.

T18. **Sedimentology, Geochemistry, Chemostratigraphy, and Geomechanics of Mudrock Systems.** Helge Alsløben, Texas Christian University, halsløben@tcu.edu. Oral and poster.

T19. **Little Minerals, Big Implications.** Nova Mahaffey, The University of Texas at Dallas, nxm154030@utdallas.edu; Leah N. Thompson, The University of Texas at Dallas, sip:int160230@utdallas.edu; Bob Finkelman, The University of Texas at Dallas, bobf@utdallas.edu. Oral only.

T20. **Low-Temperature Geochemistry and Biogeochemical Cycles (Posters).** Todd Longbottom, Texas Christian University, todd.longbottom@tcu.edu; Sharmila Giri, Case Western Reserve University, s.giri@csru.edu. Posters only.

T21. **Shelf-to-Basin Transition: Carboniferous Sedimentation in Southern Midcontinent.** Walter L. Manger, University of Arkansas at Fayetteville, wmanger@uar.edu; Xiangyang Xie, Texas Christian University, x.xie@tcu.edu; Shaun Prines, Texas Christian University, s.t.prines@tcu.edu. Oral and poster.

T22. **General Paleontology.** Arthur Busbey, Texas Christian University, a.busbey@tcu.edu. Oral and poster.

T23. **Hydrogeology and Water Resources.** Gehendra Kharel, Texas Christian University, g.kharel@tcu.edu. Oral and poster.

T24. **Graduate Student Research across the Geosciences.** Omar R. Harvey, Texas Christian University, omar.harvey@tcu.edu. Oral and poster.

T25. **Broadening Community Use of Available Data and Tools for Scientific Exploration and Education (Posters). Cosponsored by EarthCube: GSA Geoinformatics and Data Science Division.** Hongjie Xie, The University of Texas at San Antonio, hongjie.xie@utsa.edu; Alberto Mestas-Núñez, The University of Texas at San Antonio, alberto.mestas@utsa.edu. Posters only.

T26. **Strengthening Student Engagement, Inclusion, and Learning in the Geosciences, K—Higher Education. Cosponsored by National Association of Geoscience Teachers—Mid-Continent Section.** Brendan Hanger, Oklahoma State University, brennan.hanger@okstate.edu; Aida Farough, Kansas State University, afarough@ksu.edu; Liane Stevens, Stephen F. Austin State University, stevenslm@fsasu.edu; Wendi Williams, South Texas College, wwilliams@southtexascollege.edu. Oral and poster.

T27. **Hands-On Teaching Demonstrations in Geoscience Courses.** Michael T. DeAngelis, University of Arkansas at Little Rock, mtddeangelis@ualr.edu; René A. Shroot-Lewis, University of Arkansas at Little Rock, rashroatlew@ualr.edu. Oral only.
T28.  Enhancing Diversity in Geoscience Graduate Student Programs. Samuel L. Moore, The University of Texas at Austin, smlmoore@jsg.utexas.edu; Elizabeth J. Catlos, The University of Texas at Austin, ejcatlos@jsg.utexas.edu; Katherine K. Ellins, The University of Texas at Austin, kellins@jsg.utexas.edu; Dana L. Thomas, The University of Texas at Austin, dthomas@jsg.utexas.edu. Oral only.

T29. Undergraduate Student Research (Posters). Cosponsored by Council on Undergraduate Research. Omar R. Harvey, Texas Christian University, omar.harvey@tcu.edu.

FIELD TRIPS
For additional information, please contact the Field Trip co-chairs: Richard Hanson, r.hanson@tcu.edu, and Helge Alseleben, h.alseleben@tcu.edu.

F1. A View into the Igneous Rift Materials of the Wichita Mountains, Oklahoma: Origins, Emplacement, and Alteration. Sat.–Sun., 7–8 March. Max.: 20 participants. US$232. Principal Organizer: Jonathan D. Price, Midwestern State University, jonathan.price@mstateu.edu. Co-organizers: Erin Summerlin-Donofrio, Southern Methodist University, esummerlindonofrio@smu.edu; Matthew Hamilton, University of Oklahoma, matt.hamilton@ou.edu; Amber Quevy, Rigaku Americas Corporation, amberquevy@gmail.com; Alexandria Stevenson, Midwestern State University, alexandria.weiskircher@gmail.com.


F3. Wanderings in the Pangaean Wastelands of Permo-Triassic West Texas. Sat.–Sun., 7–8 March. Max.: 20 participants. US$390. Principal Organizer: John Holbrook, Texas Christian University, john.holbrook@tcu.edu. Co-organizers: Neil Tabor, Southern Methodist University, ntabor@mail.smu.edu; Anthony Skaleski, Texas Christian University, a.skaleski@tcu.edu.

F4. Building Stones of Downtown Fort Worth. Tues., 10 March. US$45. Principal Organizer: Tom Dill, GSA member, tdill@att.net.

F5. Middle and Upper Pennsylvanian Strata of the Fort Worth Basin. Wed., 11 March. Max.: 20 participants. US$75. Principal Organizer: Michael Read, The University of Texas at Arlington, michael.read@uta.edu. Co-organizer: Majie Fan, University of Texas at Arlington, mfan@uta.edu.


SHORT COURSES
SC1. An Overview of Earth-Science Applications in the Shimadzu Institute for Research Technologies at The University of Texas at Arlington. Sun., 8 March, 10 a.m.–3 p.m. Free. Principal Organizer: Matthew Loocke, The University of Texas at Arlington, matthew.loocke@uta.edu. Co-organizer: Jeff Campbell, The University of Texas at Arlington, jeff.campbell@uta.edu.

SC2. Making Geoscience Animations and Videos and Assessing Them in the Classroom. Sun., 8 March, 10 a.m.–4 p.m. Free. Instructors: Robert Stern, The University of Texas at Dallas, rjstern@utdallas.edu; Jeffrey Ryan, University of South Florida, ryan@usf.edu; Ning Wang, The University of Texas at Dallas, Ning.Wang@utdallas.edu; Siloa Willis, The University of Texas Dallas, Siloa.Willis@utdallas.edu.


SC4. Mudstones in Core and Thin-Section. Wed., 11 March, 9 a.m.–4 p.m. Max.: 20 participants. US$25. Principal Organizer: Richard Denne, Texas Christian University, r.denne@tcu.edu.

STUDENT OPPORTUNITIES
Career Mentoring Luncheons
Ask your career-related questions and learn about non-academic pathways in the geosciences while networking with professionals at the Roy J. Shlemon and John Mann Mentor Luncheons. Students and early career professionals are welcome.

Career Workshop Series
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To learn more about mentors and career workshops, go to www.geosociety.org/mentors/ or contact Jennifer Nocerino at jnocerino@geosociety.org.

ACCOMMODATIONS
Hotel registration deadline: 17 Feb.
A block of rooms has been reserved at the Omni Fort Worth Hotel at 1300 Houston Street, Fort Worth, Texas 76102, USA, at a special meeting rate of US$209 per night plus tax. Reservations should be made online (https://www.omnihotels.com/hotels/fort-worth/meetings/geological-society-of-america/) or by calling Omni Reservations at +1-800-THE-OMNI (toll free) and referencing the group name “Geological Society of America.”
Dinosaur tracks preserved in sandstone, knobs of granite rising from the plains, and springs cascading down limestone cliffs are just a few of the fascinating geologic features discussed in Roadside Geology of Oklahoma, a guide to more than 35 roads that crisscross the state. Geologist Neil Suneson tells you what to look for along the roads, points you to nearby parks with interesting rocks and crystals, and recounts the history of radium mineral baths, coal mines, fossil excavations, and petroleum drilling, not to mention the rush for nonexistent gold in the Wichita Mountains.

400 pages • 6 x 9 • full color • 220 color photographs
100 color maps and illustrations • glossary • references • index
paper $26.00 • Item 204 • ISBN 978-0-87842-697-3

NEW TO THE SERIES!
Southeastern and Northeastern Sections Joint Meeting
69th Annual Meeting of the Southeastern Section, GSA
55th Annual Meeting of the Northeastern Section, GSA
Reston, Virginia, USA
20–22 March 2020
www.geosociety.org/se-mtg

Sediments, Structures, Shores, and Storms: Keeping a Keen Eye on Eastern Geology

LOCATION
The joint meeting of GSA’s Southeastern and Northeastern Sections will be held in Reston, Virginia, USA. Reston is a modern, planned community located in northern Virginia. The numerous historic and cultural attractions of Washington, D.C., are just a short distance away and ready to be explored. A mix of bistros, restaurants, and shops on an extensive pedestrian mall are just out the door of the Hyatt Regency Reston, the conference venue. Situated at the Fall Zone and the transition from the southern to the central and northern Appalachians, Reston provides a unique vantage point to examine all aspects of eastern geology. We have developed a robust and diverse technical program that links the geology of the southeastern and northeastern U.S.—a program that ranges from the crust to mantle, data to policy, mountains to coastal processes, paleontology to energy. We invite you to join us at Reston 2020 for a field trip across D.C. or the Appalachian orogen, a short course on applied micropaleontology or storm-water management, and a broad scope of technical sessions and symposia that will help us keep a keen eye on eastern geology.

REGISTRATION
Early registration deadline: 18 Feb.
Cancellation deadline: 24 Feb.
Registration fees are in U.S. dollars. For further information or if you need special accommodations, please contact one of the general co-chairs: Arthur Merschat, amerschat@usgs.gov, or Patrick Burkhart, patrick.burkhart@sru.edu.

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<td>$65</td>
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<tr>
<td>Field Trip/Short Course Only</td>
<td>$75</td>
<td>n/a</td>
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ACCOMMODATIONS
Hotel registration deadline: 26 Feb., 5 p.m. Eastern Time
A block of rooms has been reserved at the Hyatt Regency Reston, 1800 Presidents Street, Reston, Virginia, 20190, USA, located in the vibrant Reston Town Square. The meeting rate is US$159 per night plus tax. The hotel offers many amenities (restaurants, bar, pool, Wi-Fi) and a complimentary shuttle to/from Dulles International Airport. Reservations can be made by calling +1-703-709-1234. Please be sure to identify yourself with the group code SEGSA20 and note that you are attending the GSA Southeastern and Northeastern Sections Joint Meeting. Parking is available at the hotel and at Reston Town Parking Garage next to the hotel.

TECHNICAL PROGRAM
Symposia
S2. The Appalachians, from North to South, from Crust to Mantle. Cosponsored by GSA Structural Geology and Tectonics Division; GSA Geophysics and Geodynamics Division. Allison Severson, Colorado School of Mines, aseverson@ymail.mines.edu; Yvette Kuiper, Colorado School of Mines, ykuiper@mines.edu; Maureen Long, Yale University, maureen.long@yale.edu; Lara Wagner, Carnegie Institution of Washington, lwagner@carnegiescience.edu; Chuck Bailey, College of William & Mary, cmbail@wm.edu.

S3. From the Margins to the Deep: A Tribute to the Science and Art of A. Conrad Neumann. Blair R. Torney, Western Carolina University, btorney@wcu.edu; Paul J. Hearty, The University of Texas at Austin, kaisdad04@gmail.com.

S4. New Developments in Diversity and Inclusion in the Geosciences. Alexander Gates, Rutgers University, agates@rutgers.edu; Marilyn Suiter, National Science Foundation, msuiter@nsf.gov.


S7. The Grenville Orogen in Eastern North America. Greg Walsh, U.S. Geological Survey, gwalsh@usgs.gov; John Aleinikoff, U.S. Geological Survey, jaleinikoff@usgs.gov; Paul Mueller, University of Florida, pamueller@ufl.edu; Richard Tollo, George Washington University, rollo@gwu.edu; Arthur Merschat, U.S. Geological Survey, amerschat@usgs.gov; Peter Valley, pvvalley@gmail.com; Mike Williams, University of Massachusetts Amherst, mlw@geo.umass.edu.

Theme Sessions
T1. Abiotic-Biotic Interactions in the Critical Zone. Justin Richardson, University of Massachusetts Amherst, jbrichardson@umass.edu.


T3. Paleolimnological Records of Climate and Environmental Change. Timothy L. Cook, University of Massachusetts Amherst, tcook@geo.umass.edu; Nicholas L. Balascio, College of William & Mary, nbalascio@wm.edu.

T4. Geoarchaeology of Dynamic Landscapes. Cosponsored by Eastern Section–SEPM (Society for Sedimentary Geology). Daria Nikitina, West Chester University of Pennsylvania, dnikitina@wcupa.edu; Ilya Buynevich, Temple University, coast@temple.edu; Heather Wholey, West Chester University of Pennsylvania, hwholey@wcupa.edu.


T8. Mega-Traces: Advances in Ichnology and Zoogeomorphology. Cosponsored by Eastern Section–SEPM (Society for Sedimentary Geology). Ilya V. Buynevich, Temple University, coast@temple.edu; Stephen T. Hasiotis, University of Kansas, hasiotis@ku.edu; Logan A. Wiest, Mansfield University, Logan._Wiest@baylor.edu.

T9. Neoproterozoic to Cambrian Transitions on the Appalachian, Laurentian Margin. Cosponsored by Paleontological Society. Steven J. Hageman, Appalachian State University, hagemansj@appstate.edu; Edward L. Simpson, University of Pennsylvania Kutztown, simpson@kutztown.edu.


T11. Integrating Field and Modeling Approaches to Understand Changing Coastal Systems. Justin Shawler, Virginia Institute of Marine Science, jsbould@vims.edu; Rose Palermo, Massachusetts Institute of Technology and Woods Hole Oceanographic Institution, rpalermo@mit.edu; Arie Janoff, Montclair State University, janoffa2@montclair.edu; Isamar Cortes, Montclair State University, cortes1@montclair.edu.

T12. Shale Production in the Eastern U.S.—E2: Environmental, Economic & Energy System Impacts. Timothy R. Carr, West Virginia University, tim.carr@mail.wvu.edu; Shikha Sharma, West Virginia University, shikha.sharma@mail.wvu.edu.

of Geoscience Teachers; Virtual Library of Virginia. Elizabeth Johnson, James Madison University, johns2ea@jmu.edu; Karen M. Layou, Reynolds Community College, klayou@reynolds.edu.

T14. Out of the Classroom, Out of the Box: Innovative Approaches to Geoscience Education. Cosponsored by National Association of Geoscience Teachers Southeastern Section. Patricia Kelley, University of North Carolina Wilmington, kelleyp@unw.edu; Michelle Casey, Towson University, mcasey@towson.edu.

T15. Active Learning and the Use of Technology in the Geoscience Classroom. Cosponsored by National Association of Geoscience Teachers. Tarin Weiss, Westfield State University, tweiss@westfield.ma.edu; Lori Weeden, University of Massachusetts–Lowell, Lori_Weeden@uml.edu.


T17. NAGT and NESTA Share-a-Thon: I’ve Got an Activity (Lab or Demo) for That! Cosponsored by National Association of Geoscience Teachers: National Earth Science Teachers Association. Christopher Roemmele, West Chester University, croemmele@wcupa.edu.

T18. Undergraduate Research (Posters). Cosponsored by Council on Undergraduate Research Geosciences Division. Lee Phillips, University of North Carolina at Greensboro, phillipl@uncg.edu; Jeff Ryan, University of South Florida, ryan@mail.usf.edu.


T21. Geologic Maps, Digital Geologic Maps, Geophysical Maps, and Derivatives from Geologic and Geophysical Maps (Posters). Randy L. Kath, University of West Georgia, rkath@westga.edu; Thomas J. Crawford, University of West Georgia, crawfordthomasj@gmail.com.

T22. What Are We Dating?: The Utility of Petrochronology in Linking Accessory Mineral Dates to Rock Forming Processes. Thomas “Alex” Johnson, University of California Santa Barbara, tajohnson@ucsb.edu; Ryan McAleer, U.S. Geological Survey, rmcaleer@usgs.gov.

T23. New Developments in the Understanding of Pre-Appalachian Rocks of Eastern North America. Brent Miller, Texas A&M University, bmiller@geo.tamu.edu; Brent Owens, College of William & Mary, beowen@wm.edu; Sandra Barr, Acadia University, sandra.barr@acadiau.ca.

T24. Timescales and Conditions of Appalachian Metamorphism. Cosponsored by GSA Geochronology Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Structural Geology and Tectonics Division. Calvin Mako, Bates College, cmako@bates.edu; Alexandra Nagurney, Virginia Tech, nagurney@vt.edu.

T25. Using Microstructural Analysis to Investigate Macroscale Structural Features. Cosponsored by GSA Structural Geology and Tectonics Division. Jamie Levine, Appalachian State University, levinej@appstate.edu; Jeffrey Rahl, Washington & Lee University, RahlJ@wlu.edu.

T26. Deciphering Active Tectonics and Seismic Hazard in Eastern North America. Lisa S. Schleicher, independent, lisasschleicher@gmail.com; J. Wright Horton, U.S. Geological Survey, whorton@usgs.gov; Chris Cramer, University of Memphis, ccramer@memphis.edu; Christine A. Powell, University of Memphis, capowell@memphis.edu.

T27. Appalachian Petrology: A Session to Honor the Career of Dr. Robert J. Tracy. Willis Hames, Auburn University, hameswe@auburn.edu; Nicholas M. Ratcliffe, U.S. Geological Survey, ratcliffe2@gmail.com; Craig Dietsch, University of Cincinnati, dietscc@ucmail.uc.edu; Mark Caddick, Virginia Tech University, caddick@vt.edu.

T28. Geoscience Careers for New Geoscience Graduates. Michael D. Lawless, Draper Aden Associates, Inc., mlawless@daa.com; and Ron Wallace, Georgia Department of Natural Resources (retired), rw30075@yahoo.com.

T29. Chem stratigraphic, Biotic, and Sedimentologic Changes through Earth History. Nevin P. Kozik, Florida State University, npk15@my.fsu.edu; Chelsie N. Bowman, Florida State University, cnb09@my.fsu.edu; Sean M. Newby, Florida State University, smn17b@my.fsu.edu; Selva M. Marroquin, Virginia Tech University, selva@vt.edu.

FIELD TRIPS
For additional information, please check the meeting website or contact the Field Trip co-chairs: Mark Carter, mcarter@usgs.gov, and Chris Swezey, cswezey@usgs.gov.

Pre-Meeting
1. The Central Appalachian Orogen: From Ancient Tectonics to Modern Seismicity. Mon.–Thurs., 16–19 March. US$300. Leaders: Christopher M. Bailey, College of William & Mary, cmbail@wm.edu; Callan Bentley, Northern Virginia Community College, cbentley@nvcc.edu; Frank J. Pazzaglia, Lehigh University, fpj3@lehigh.edu; Allan Pitts, University of Camerino, pitts.alan@gmail.com.


4. Age and Tectonic Significance of Diamictites at the Devonian–Mississippian Transition in the Central Appalachian Basin. Thurs., 19 March. US$160. Leaders: F.R. Ettensohn, University of Kentucky, fettens@uky.edu; Clay Seekinger, University of Kentucky, clayseekinger@iCloud.com.

Post-Meeting
5. The Geology of Washington, D.C. Sun., 22 March. US$70. Leaders: Callan Bentley, Northern Virginia Community College, cbentley@nvcc.edu; Christopher Roemmele, West Chester University, croemmele@wcupa.edu.


SPECIAL EVENT

SHORT COURSES
Clastic and Carbonate Petrology—From Hand Samples to Thin Sections. Thurs., 19 March. US$50 for professionals; US$25 for students. Leaders: John Haynes, James Madison University, haynesjx@jmu.edu; Mercer Parker, U.S. Geological Survey, mercerparker@usgs.gov.


GSA On To the Future (OTF) Professional Skills Workshop for Students. Thurs., 19 March. Free to OTF students (limit 20). Leaders: Stephen K. Boss, University of Arkansas, sboss@uark.edu; Tahlia Bear, Geological Society of America, tbear@geosociety.org; Katherine Ellins, The University of Texas at Austin, kellins@jsug.utexas.edu.

OPPORTUNITIES FOR STUDENTS AND EARLY CAREER PROFESSIONALS
Career Mentoring Luncheons
Ask your career-related questions and learn about non-academic pathways in the geosciences while networking with professionals at the Roy J. Shlemon and John Mann Mentor luncheons. Students and early career professionals are welcome.

Career Workshop Series
This three-part series will feature career development planning, an exploration of geoscience job sectors, and information on best practices for crafting a résumé and cover letter. Non-technical skills and workforce statistics will be reviewed. The series will be led by workshop presenters and geoscientists. No registration is required, and everyone is welcome.

To learn more about mentors and career workshops, go to www.geosociety.org/mentors/ or contact Jennifer Nocerino at jnocerino@geosociety.org.

Student Volunteers
Take advantage of work opportunities to earn free meeting registration. Students interested in helping with the various aspects of the meeting should contact Wilma B. Aleman Gonzalez, U.S. Geological Survey, waleman@usgs.gov.
Travel Grants
Application deadline: 18 February
Students who are GSA members and who register for the meeting are eligible to apply for student travel grants from their respective sections. For further information see https://www.geosociety.org/gsa/about/sections/GSA/Sections/se/students.aspx#travel for the Southeastern Section and https://www.geosociety.org/gsa/about/sections/gsa/Sections/ne/home.aspx for the Northeastern Section.

PROFESSIONALS
If you like to share your interest, enthusiasm, and experience in applied geology, consider being a GSA mentor at the joint meeting. Being a mentor is a rewarding experience. To learn more, contact Jennifer Nocerino at jnocerino@geosociety.org.

This meeting also offers an excellent opportunity to earn CEUs toward your continuing education requirements for your employer, K–12 school, or professional registration. The CEU certificate can be downloaded from the meeting website after the meeting.

LOCAL COMMITTEE
General Co-Chairs: Arthur Merschat, amerschat@usgs.gov; Patrick Burkhart, patrick.burkhart@sru.edu
Technical Program Co-Chairs: Chuck Bailey, cmbail@wm.edu; Wendell Barner, wendell.barner@gmail.com
Field Trip Co-Chairs: Mark Carter, mcarter@usgs.gov; Chris Swezey, cswezey@usgs.gov
Sponsorships Chair: Patrick Burkhart, patrick.burkhart@sru.edu
Short Course Co-Chairs: Daniel H. Doctor, dhdoctor@usgs.gov; Katie Tamulonis, ktamulonis@allegheny.edu
Exhibits Chair: Daniel Harris, harris_d@calu.edu
Treasurer: Patrick Burkhart, patrick.burkhart@sru.edu
Student Volunteer Chair: Wilma Aleman Gonzalez, waleman@usgs.gov

GSAvings

http://rock.geosociety.org/store
Expires 1 January 2020.
CALL FOR APPLICATIONS

2020–2021 GSA-USGS Congressional Science Fellowship

Application deadline: 15 Jan. 2020

Bring your science and technology expertise to Capitol Hill to work at the interface between geoscience and public policy. The GSA-USGS Congressional Science Fellowship provides a rare opportunity for a geoscientist to spend a year working for a member of Congress or congressional committee. If you are a geoscientist with a broad scientific background, experience applying scientific knowledge to societal challenges, and a passion for helping shape the future of the geoscience profession, GSA and the USGS invite your application. The fellowship is open to GSA members who are U.S. citizens or permanent residents. A Ph.D. at the time of appointment or a master’s degree in engineering plus five years of professional experience is required.

Learn more at www.geosociety.org/csf or by contacting Kasey White, +1-202-669-0466, kwhite@geosociety.org.

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Geologists may be some of the few who welcome a lump of coal in their stockings, but the GSA bookstore has what they really want this holiday season. Visit the online store to find all of GSA’s current books, selected books from other publishers, field tools, charts, maps, and the 2020 GSA 12-month calendar “Postcards from the Field.” Or surprise that lucky geologist with a journal subscription or GSA membership.

And if you have a stocking to fill, here are just some of the gifts you’ll find for under $10:

- Geologic Time Scale Poster v. 5.0
- The Geology of Plate Tectonics Chart
- Geology Terms in English and Spanish Pocket Guide
- GSA Note Cards Featuring Stunning Geologic Images (box of 10)
- DoohicKey 6x Key Tool from Nite Ize®
- Gear Tie Key Ring by Nite Ize® in Blue or Neon Yellow
- NEW! Rite in the Rain® Side Spiral Notebook in Blaze Orange

Orders are generally shipped within three business days. Allow appropriate time for shipping.

Start your holiday shopping at http://rock.geosociety.org/store
The University of Houston is an equal opportunity/affirmative action employer. Minorities, women, veterans, and persons with disabilities are encouraged to apply.

The University of Houston is the home of a distinguished School of Theology. It is an institution of the liberal arts tradition in education.

Expertise in climate change, sustainable land use, food production systems, watersheds, environmental health, energy or other areas that complement or expand the existing strengths of the faculty are desirable. Applicants must have their Ph.D. in hand by the time of appointment.

Review of applications will begin January 5, 2020. Send a letter of application, curriculum vitae, statements of teaching and research interests, transcripts (unofficial accepted), and three letters of reference through the online application portal at: https://jobs.sewanee.edu/postings/3893.

The University of Tennessee (UT) is a comprehensive, public institution with a reputation for excellence in research and teaching.

Candidates should submit: (1) a statement of teaching and research interests, (2) a curriculum vitae, (3) a list of at least three possible references and their contact information. Applications should be submitted online through https://jobs.utm.edu/. A background check is required prior to interviewing. Questions about these positions may be directed to search committee chair Julie Wellner (jwellner@uh.edu).

Notes to Applicant: Official transcripts are required for a faculty appointment and will be requested upon selection of the final candidate. All offices at the University of Houston are security sensitive and will require a criminal history check.

Tenure-Track, Assistant Professor of Geophysics, Northwestern University

Individuals are invited to submit applications to our open tenure-track faculty position at the rank of Assistant Professor in the field of geophysics, broadly considered. We seek a scholar whose expertise and creativity will complement and expand the Department’s strengths. Area(s) of specialization within solid-Earth, environmental or planetary geophysics are open and may include any aspect of geodesy, seismology, dynamic topography, geophysical fluid dynamics, hazards, climate, or planetary science across spatiotemporal scales. Applicants are likely to employ emerging technologies in remote sensing, machine learning, numerical methods, and/or field instrumentation. Applicants whose research reveals linkages between physical processes and societal impacts are particularly encouraged to apply. The deadline for applications is 12/16/19. Applicants should visit http://bit.ly/NUEARTH-faculty-position for submission instructions.

Northwestern University is an Affirmative Action Employer, and is committed to fostering a diverse faculty.

Faculty Positions at the Department of Geosciences, National Taiwan University

The Department of Geosciences at the National Taiwan University (NTU) is seeking active scientists to fill two to three faculty positions starting from August 1st, 2020. The positions are open to candidates from all fields in geosciences, but those who have strong background in the fields of (1) structural and field geology; (2) sedimentology and stratigraphy; (3) mineralogy and petrology; and (4) geological resources or hydro- and applied geology will receive more favorable consideration. Applicants are requested to send the following documents: CV, list of publications, statements of teaching and research interests, copies of diploma and transcript, names and contact information of three referees, and three to five articles published within the recent seven years (one of which needs to be designated as representative paper and must be published after August 1st, 2015). Application materials should be sent by email to Professor J. Bruce H. Shyu, the Chair of the Searching Committee, at jbs@ntu.edu.tw.

Deadline for application: January 5th, 2020. For more information, please refer to the website: http://web.gl.ntu.edu.tw/

NTU ranks in the top 100 universities worldwide (QS 2019), and Taipei was recently named the World's Friendliest and Safest City for Expats (InterNations 2018). Within Taipei there is easy access, through a world class transit system, to a vibrant city life and to numerous outdoor activities such as hiking, snorkeling, fishing, and mountain biking. The Department of Geosciences offers a dynamic and supportive working environment with a wide range of state-of-the-art research facilities. Generous start-up funding is available for new faculty members.

Associate Director, Environmental Division, Bureau of Economic Geology

The Bureau of Economic Geology (Bureau) in the Jackson School at The University of Texas at Austin seeks a highly talented individual to lead its Environmental Research Division.

Responsibilities
- Serve as part of a small, integrated administrative team of Directors
- Set vision for and manage and grow the Environmental Division staff of approximately 50 staff
- Create and pursue a vision for multidisciplinary environmental research
- Work with Principal Investigators (PI’s) to develop sources of funding for existing and new multidisciplinary programs in the areas of sustainable water resources, coastal geology, natural hazards, induced and naturally occurring earthquakes, car-
bon sequestration, and geologic mapping
• Build relationships with global federal and state agencies, industry, foundations, NGOs, and international groups that will ensure that new program opportunities are created and funded
• Manage staffing and scheduling; coordinate with administrators and project PI’s to ensure that projects are on schedule, on budget, and research groups are collaborating appropriately
• Represent the Bureau at conferences and UT meetings.

Required Qualifications. Advanced degree with major course work in the field of earth science. Ph.D. with minimum of 12 years work experience, or master’s degree with minimum 17 years experience, in a field related to the Bureau’s core areas of environmental research, as per responsibilities outlined above. Excellent management, administrative, leadership and organizational abilities. Previous experience as a successful leader of major research programs. Acknowledged contributions in one or more aspects of environmental research. Relevant education and experience may be substituted as appropriate.

Preferred Qualifications. Proven record of research and leadership, preferably related to the Bureau’s core areas of environmental research. Demonstrated ability to attract and administer external funds from a variety of sources, including federal agencies, state and local governments, and industry. A strong record of research publication and presentations. Evidence of innovation and ability to think creatively.

Salary Range. $180,000 + depending on qualifications.

About the Bureau of Economic Geology. Established in 1909, the Bureau of Economic Geology in the Jackson School of Geosciences is the oldest and second-largest organized research unit at The University of Texas at Austin. The Bureau is the State second-largest organized research unit at The University of Texas at Austin. The Bureau is the State

Assistant Professor of Instruction, Mineralogy/Petrology, University of Akron
The Department of Geosciences, University of Akron, Ohio, has an opening for a non-tenure track position in mineralogy/petrology (job# 11999). Candidates must possess a Ph.D. (or ABD with a previously earned master’s in geosciences) in the geosciences and have the ability to teach mineralogy, petrology, introductory-level earth science and summer Geology Field Camp courses. For complete required and preferred qualifications and to apply visit: http://www.uakron.edu/jobs. When completing the application attach: (1) a CV; (2) a brief statement of teaching philosophy that describes your pedagogical approaches and how your teaching and research experiences will contribute to the growth and success of the department; (3) unofficial transcripts; (4) contact information for at least 3 references. Review of applications will begin January 14, 2020. Questions can be directed to John Peck at jpeck@uakron.edu. The University of Akron is an equal education and employment institution committed to affirmative action. It is university policy that there shall be no unlawful discrimination.

Assistant Professor, Igneous Petrology or High-Temperature Geochemistry, University of Toronto
The Department of Earth Sciences [https://www.es.utoronto.ca/] in the Faculty of Arts and Science at the University of Toronto invites applications for a full-time tenure stream position in the area of igneous petrology or high-temperature geochemistry, particularly (but not exclusively) related to mineral deposits research. The appointment will be at the rank of Assistant Professor, and will commence on July 1, 2020, or shortly thereafter.

Applicants must have earned a Ph.D. degree in geology or a related area by the time of the appointment, or shortly thereafter, with a demonstrated record of excellence in research and teaching. The University of Toronto has an outstanding international reputation for research in the Earth Sciences. We seek candidates in any dynamic and evolving sub-discipline of igneous petrology or high-temperature geochemistry, and specifically application of the research to the study of economic geology or ore deposits research. The successful candidate will be expected to pursue innovative and independent research at the highest international level and to establish an outstanding, competitive and externally funded research program. The Department houses a collection [https://www.es.utoronto.ca/research/faculty-interests/] of modern experimental and analytical facilities which the successful candidate would have an opportunity to take advantage of and further develop.

Candidates must provide evidence of research excellence as demonstrated by a record of publications in top-ranked and field relevant journals or forthcoming publications meeting high international standards, the submitted research statement, presentations at significant conferences, awards and accolades and strong endorsements from referees of high standing.

The candidate must also show a strong commitment to excellence in undergraduate and graduate level teaching. Evidence of excellence in teaching will be demonstrated by teaching accomplishments, the teaching dossier, the teaching statement, sample course materials, and teaching evaluations, or other evidence of superior performance in teaching-related activities submitted as part of the application, as well as strong endorsements by referee. Other teaching-related activities include performance as a teaching assistant or course instructors, experience leading successful workshops or seminars, student mentorship, or excellent conference presentations or posters. Primary teaching responsibilities may include any sub-disciplines within petrology, mineralogy, and high-temperature-geochemistry as well as introductory-level courses within the broader field of Earth sciences. In addition, field-based courses will be integral parts of the teaching assignments.

Salary will be commensurate with qualifications and experience.

All qualified candidates are invited to apply online by clicking the link below. Applicants must submit a cover letter, a current curriculum vitae, a research statement outlining current and future research interests, up to three sample papers, and teaching dossier to include a statement of teaching philosophy and experience (3-5 pages for each statement), sample course materials, teaching evaluations, or evidence of superior performance in other teaching-related activities as listed above.

Applicants must also arrange to have three letters of reference sent directly by the referee by email (on letterhead and signed) to geol_sec@es.utoronto.ca. The application materials and letters of reference must be received by December 16, 2019.

Submission guidelines can be found at http://uoft.me/how-to-apply. We recommend combining attached documents into one or two files in PDF/ MS word format. If you have any questions about this position, please contact Ampy Tolentino at geol_sec@es.utoronto.ca.

The University of Toronto is strongly committed to diversity within its community and especially welcomes applications from racialized persons/persons of colour, women, Indigenous/American People of North America, persons with disabilities, LGBTQ persons, and others who may contribute to the further diversification of ideas.

As part of your application, you will be asked to complete a brief Diversity Survey. This survey is voluntary. Any information directed related to you is confidential and cannot be accessed by search committees or human resources staff. Results will be aggregated for institutional planning purposes. For more information, please see http://uoft.me/UP.

All qualified candidates are encouraged to apply, however, Canadians and permanent residents will be given priority.
President, Incorporated Research Institutions for Seismology (IRIS)
The Incorporated Research Institutions for Seismology (IRIS) invites applications and nominations for the next President of the Consortium. The President is the public face of IRIS and represents the Consortium through leadership and management activities with the geosciences community, federal agencies, partners, and member institutions.

Founded in 1984 with support from the National Science Foundation (NSF), IRIS is a consortium of 125 U.S. universities dedicated to advancing research and education in seismology to understand our dynamic planet and to benefit society. IRIS programs contribute to new discoveries within our planet, natural hazard mitigation, national security, environmental monitoring, advances in geo-computation, networking and communications, and in building a scientifically and technologically proficient workforce. The IRIS membership comprises virtually all U.S. universities with research programs in seismology and includes a growing number of Educational Affiliates, U.S. Affiliates, and Foreign Affiliates. IRIS management is currently headquartered in Washington, D.C., but IRIS facilities are distributed internationally and operated in cooperation with the U.S. Geological Survey and other partner organizations and institutions. IRIS has annual revenues of approximately $30 million, and the Consortium employs roughly 53 full-time professional staff.

Candiates for the President position will have significant management experience as well as a background in leading complex research or facilities programs in academia, related government agencies, or industry. Candidates should be able to collaborate and negotiate strategically with other scientific and educational facilities and organizations. This is particularly critical at this time given NSF’s 2019 decision to support a single seismic and geodetic facility starting in 2023. The ideal candidate will have a Ph.D. in Earth Science, or equivalent professional expertise, along with experience in the administration of federal awards, a comprehensive understanding of federal funding structures and requirements, and an ability to identify and pursue new and diverse funding sources.

The President should be a dynamic leader who is able to communicate effectively with the IRIS community, federal agency leadership, and other sponsors and scientists. The ideal candidate will have a demonstrated record of successful scientific and administrative leadership and be able to proficiently engage with and build consensus across the geophysical community. The President will be capable of vision, planning, and executive management in partnership with the governing IRIS Board of Directors. Candidates must promote and embrace diversity and inclusion, global awareness, and ethical values.

A more in-depth position description may be found at [www.iris.edu/hq/employment/job/president](http://www.iris.edu/hq/employment/job/president).

Requests for additional information should be directed to Professor Charles J. Ammon, Chair, IRIS President Search Committee, hr@iris.edu.

Applications should include a full vita; a statement describing the applicant’s vision for IRIS for the immediate term and for the period beyond the 2023 expiration of the current SAGE2 cooperative agreement; a statement addressing past and/or potential contributions to diversity, equity, and inclusion; and the names and contact information of three references. Applications and nominations will be accepted until a new President is selected. For optimal consideration, interested parties are encouraged to apply by 15 December 2019 at the address below.

Presidential Search Committee c/o IRIS, 1200 New York Avenue, NW, Suite 400, Washington, DC 20005.

The IRIS Consortium believes a diverse staff makes us a stronger organization. We are committed to hiring people of all ages, races, ethnicities, genders, sexual orientation or gender identities, marital status, veteran status, religions, and disabilities. All qualified candidates are encouraged to apply.

Tenure Track, Remote Sensing, Montana State University
The Department of Land Resources and Environmental Sciences at Montana State University, Bozeman (http://landresources.montana.edu/), is seeking applicants for a tenure track faculty position in remote sensing (45% research, 45% teaching, 10% service). We intend to hire a talented and enthusiastic individual who will: (1) provide leadership in the acquisition, analysis, characterization and application of remotely sensed imagery at multiple scales; (2) actively contribute to sustaining and enhancing the department’s research, teaching, and outreach programs related to remote sensing as applied to land resources and environmental sciences; and (3) contribute to the MSU Spatial Sciences Center and its mission to advance academic research and instructional programs and to participate in campus-wide synergistic collaboration.

Candidates should have outstanding research and teaching experience (or potential) and fundamental training in remote sensing and quantitative analysis as applied to a relevant agricultural/natural resources/ environmental sciences field. Examples of potential research foci include ecosystem and landscape processes, environmental restoration, climate change, environmental biology, pest ecology and management, and sustainable and precision agricultural systems. The successful candidate will complement existing departmental strengths, and will be expected to develop a nationally competitive research program supported by extramural grant funds. The successful candidate will teach undergraduate and graduate courses in remote sensing, and mentor undergraduate and graduate students.

Applications can be submitted at [https://jobs.montana.edu/postings/18304 where more details about the position are also available. Screening will begin 15 December 2019, and applications will be accepted until an adequate applicant pool has been established. Montana State University values diverse perspectives and is committed to continually supporting, promoting, and building an inclusive and culturally diverse campus environment.

Salary. Salary commensurate with experience, education, and qualifications.

Location—Bozeman, Montana.

Geohydrology, Binghamton University
Binghamton University invites applications for a tenure-track appointment in the area of Geohydrology at the assistant professor level to begin in Fall 2020. We are seeking an earth scientist who studies physical, chemical or biological processes involving surface water or groundwater by using a combination of field measurements, observations, and modeling. We are particularly interested in candidates whose research area includes investigation of water-related near-surface geophysical processes, though individuals with other research areas in the broad field of geohydrology are also encouraged to apply. Priority will be given to candidates who demonstrate a commitment to interdisciplinary and transdisciplinary teaching and scholarship.

In particular, we seek candidates who will strengthen our existing research and teaching programs in Geological Sciences ([https://www.binghamton.edu/geology/](https://www.binghamton.edu/geology/)), Environmental Studies ([https://www.binghamton.edu/environmental-studies/](https://www.binghamton.edu/environmental-studies/)), Sustainable Communities ([https://www.binghamton.edu/Sustainable-Communities/](https://www.binghamton.edu/Sustainable-Communities/)) and the Center for Integrated Watershed Studies ([https://www.binghamton.edu/centers/ciws/](https://www.binghamton.edu/centers/ciws/)). The position will be part of a new interdisciplinary initiative that brings together faculty from geology, environmental science, ecology, and sustainability sciences to study the earth and the challenges facing the planet. This position is also affiliated with the Sustainable Communities Transdisciplinary Area of Excellence (TAE), one of six TAEs that Binghamton University has developed as areas of focused interdisciplinary research across the university ([https://www.binghamton.edu/transdisciplinary-areas-of-excellence/sustainable-communities/](https://www.binghamton.edu/transdisciplinary-areas-of-excellence/sustainable-communities/)).

Candidates must have a Ph.D. in geology, environmental science, or a related field at the time of appointment. The successful candidate must develop and sustain a nationally-recognized, externally-funded research program in their area. We also expect the candidate to develop a strong record of teaching, thesis advising, and mentoring of students and to offer undergraduate/graduate level courses in their area of expertise. Our preferred candidate will also be able to translate their research to broader audiences in water resources and water resources policy courses.

To apply, please submit a curriculum vita; a cover letter describing experience and interest in the position; statements of research and teaching interests, and names and contact information of at least three references. All documents should be submitted to: [https://binghamton.interviewexchange.com.](https://binghamton.interviewexchange.com).

Completed applications received by December 15, 2019 will receive full consideration. Applications arriving after this date will be reviewed as needed until the position is filled.

Binghamton University is an Equal Opportunity/ Affirmative Action Employer. It is the policy of Binghamton University to provide for and promote
equal opportunity employment, compensation, and other terms and conditions of employment without discrimination on the basis of sex, age, race, color, religion, disability, national origin, gender identity or expression, sexual orientation, veteran or military service member status, marital status, domestic violence victim status, genetic predisposition or carrier status, or arrest and/or criminal conviction record unless based upon a bona fide occupational qualification or other exception.

One-Year Visiting Assistant Professor, Paleoclimate/Global Change, Colby College, Waterville, Maine

The Colby College Department of Geology invites applications for a one-year Visiting Assistant Professor specializing in paleoclimate, paleoceanography, global environmental change, or a related field to begin September 1, 2020. The successful candidate will teach a sophomore-level undergraduate course on Earth’s climate and paleoclimate history with a lab, as well as an introductory geology course and an upper-level elective in their area of specialty (a total of four course equivalents). Our ideal candidate will be able to offer both field- and lab-based study of past environmental change in Maine to give students hands-on experience with paleoclimate research. The successful candidate will have access to instrumentation and facilities in the Departments of Geology and Chemistry for research and teaching. These include a powder-XRD, micro-XRF, SEM-EDS, CHNSO Elemental Analyzer, ICP-OES, petrographic and binocular microscopes, and sediment-sieving equipment. The search committee is especially interested in candidates with a demonstrated ability to teach and mentor a diverse student population. A Ph.D. at the time of appointment is preferred, but ABD candidates will be considered.

Complete applications will include: (1) a brief cover letter, (2) a curriculum vitae, (3) a statement of teaching philosophy illustrating commitment to diversity and inclusive teaching, and (4) three confidential letters of recommendation. Please submit all materials via Interfolio at: apply.interfolio.com/69710. Applications received by January 6, 2020 will receive full consideration, but applications will be reviewed until the position is filled. Inquiries may also be directed to paleoclimate@colby.edu.

Colby is a private, coeducational liberal arts college that admits students and makes employment decisions on the basis of the individual’s qualifications to contribute to Colby’s educational objectives and institutional needs. Colby College does not discriminate on the basis of race, color, gender, sexual orientation, gender identity or expression, disability, religion, ancestry or national origin, age, marital status, genetic information, or veteran’s status in employment or in our educational programs. Colby is an Equal Opportunity employer, committed to excellence through diversity, and encourages applications from qualified persons of color, women, persons with disabilities, military veterans and members of other under-represented groups. Colby complies with Title IX, which prohibits discrimination on the basis of sex in an institution’s education programs and activities. Questions regarding Title IX may be referred to Colby’s Title IX coordinator or to the federal Office of Civil Rights. For more information about the College, please visit our website: www.colby.edu.

Assistant Professor, Earth Materials, School of the Environment, Washington State University

The School of the Environment at Washington State University invites applications for an Assistant Professor in Earth Materials, to begin August 2020, with an emphasis in petrology, mineralogy, volcanology, magmatic processes, or tectonic processes. The candidate will take a leadership role in developing and funding research initiatives that take advantage of WSU’s Peter Hooper Geo-Analytical Laboratory and the Radiogenic Isotope and Geochronology Laboratory, which maintain state-of-the-art capabilities in whole rock and micro-scale major and trace element analysis, geochronology, and radiogenic and stable isotope geochemistry. Lab facilities include current generation electron microprobe, X-ray fluorescence, inductively-coupled plasma mass spectrometer, and laser ablation facilities (https://environment.wsu.edu/facilities/geoanalytical-lab/).

The successful candidate will: (i) develop an externally funded research program; (ii) publish research in top quality journals; (iii) teach undergraduate and graduate courses in Earth Materials; (iv) mentor graduate students; (v) take a leadership role in the Geo-Analytical Laboratory; (vi) work with faculty and mentor students from a wide range of backgrounds; and (vii) serve university and professional organizations. To learn more and apply, visit: https://www.wsujobs.com/postings/48041.

WSU is an EO/AA Educator and Employer.

Tenture Track Assistant Professor, Remote Sensing/Geospatial Technology, California State Polytechnic University, Pomona

The Geological Sciences Department at California State Polytechnic University, Pomona (Cal Poly Pomona), invites applications for a tenure-track, ASSISTANT PROFESSOR position, beginning in the 2020–2021 academic year. We invite applications from geoscientists whose research incorporates data from ground-based remote sensing or observations from unmanned aerial vehicles or satellites, and the position is open to a broad range of research specializations, such as natural hazards, active tectonics, environmental geoscience, and/or climate change. A Ph.D. in geology, geophysics, environmental geoscience or a directly related science or engineering discipline is required. The successful candidate will have the potential for excellence in undergraduate and graduate teaching, and for developing an externally-funded research program that will involve undergraduate and master’s students. Teaching responsibilities will typically include a mix of geoscience courses at the lower division, upper division, and graduate levels, and will incorporate classes in Geographic Information Systems, Remote Sensing or other specialty courses in the candidate’s area of expertise. Demonstrated experience with data collection and analysis using modern instrumentation is expected. Preferred qualifications include demonstrated success with external funding, established ties to research institutions, industry or government agencies and interest in developing intradepartmental and cross-campus collaborations. At Cal Poly Pomona we cultivate student and faculty success through a diverse culture of experiential learning, discovery, and innovation. Cal Poly Pomona is committed to being the model for an inclusive polytechnic university that inspires creativity and innovation, embraces local and global challenges, and transforms lives.

The position is open until filled. First consideration will be given to completed applications received no later than December 30, 2019. Full position description and application procedure: http://www.cpp.edu/~faculty-affairs/open-positions/.

Igneous Petrology, Western Washington University

The Geology Department at Western Washington University (WWU) invites applications for a tenure-track, assistant professor position with specialty in Igneous Petrology to begin Sept 16, 2020. We seek individuals who are enthusiastic about teaching and who will establish a vigorous research program, and are particularly interested in those who will combine field and analytical, experimental or modeling approaches in their research, and who will involve undergraduate and Masters-level students in their research.

The ideal candidate will enhance our existing strengths in geoscience teaching and research by developing new courses and research avenues in igneous petrology. Broad areas of interest include, but are not limited to, the timescales of magmatic processes, the evolution of the continental crust, mantle, oceanic lithosphere/ocean island/mid-ocean ridge processes, the recycling of elements and volatiles within are magmas and subduction systems, and links between tectonic and magmatic processes.


Review of applications begins December 15, 2019 and continues until position is filled. Please contact the search committee chair, Susan DeBari (debari@wwu.edu) for questions about this position.

Assistant Professor, Geology—Marine and Coastal Science, Western Washington University

The Geology Department and the Marine and Coastal Science (MACS) program at Western Washington University (WWU) invite applications for two tenure-track, assistant professor positions with specialties in one of three fields:

Coastal Geomorphology/Coastal Geohazards. The ideal candidate will enhance our existing strengths in geoscience teaching and research by developing new courses and research avenues in coastal geomorphology, coastal tectonics and geohazards. Broad areas of interest include, but are not limited to, coastal erosion and sediment trans-
port, delta evolution, beach/tidal morphodynamics, marine geohazards, and tectonic processes that impact coastal zones, including uplift, subsidence, and tsunami generation and impacts.

Paleoceanography/Paleoclimate. The ideal candidate will enhance our existing strengths in geoscience teaching and research by developing new courses and research avenues in paleoceanography/paleoclimatology. Broad areas of interest include, but are not limited to, oceanic circulation and heat transport, micropaleontology/paleoecology, the carbon cycle, and geochemical processes that are related to climate variations on geological timescales. Tools and techniques used to address these problems can include geochemical or sedimentological proxies of climate variations, palaeoecological proxies/indicators of climate variations, physical oceanographic data, or other appropriate techniques.

Marine Geologist. The ideal candidate will enhance our existing strengths in geoscience teaching and research by developing new courses and research avenues in marine geology with a focus on crustal/lithospheric evolution and/or tectonic processes. Broad areas of interest include, but are not limited to, formation of the oceanic lithosphere and crustal evolution, geodynamics of the ocean basins, hydrothermal circulation at mid-ocean ridges, geochemistry of rock-water interactions, submarine volcanic systems, or tectonic processes associated with oceanic plate boundaries. Tools and techniques used to address these problems can include geochemical analyses, geophysical methods, spatial analysis, textural rock analysis, numerical models, or other appropriate techniques.

These positions will begin Sept 16, 2020. As members of the group of initial faculty hired into the MACS program, the successful applicant will foster an interdisciplinary approach to teaching and research in geology and marine science. We seek individuals who are enthusiastic about teaching and who will establish a vigorous research program, and are particularly interested in those who will combine field, experimental, and/or modeling approaches in their research program, and who will involve undergraduate and Masters-level students in their research.

To apply, and for further details regarding qualifications and position responsibilities, please see http://employment.wvu.edu/cw/en-us/job/497185/assistant-professor-geology-marine-and-coastal-science.

Please contact the search committee chair, Bernd Housen (bernh@wvu.edu) for questions about these positions. Review of applications begins October 14, 2019 and continues until the positions are filled.

Geology Faculty, Hope College

The Department of Geological & Environmental Sciences seeks applicants for a full-time non-tenure track position for up to three years, beginning in the Fall of 2020. The applicant must be able to teach courses in either structural geology or geomorphology as well as introductory level courses in geology and environmental science. The applicant will also be expected to collaborate with undergraduate students on research projects.

Qualifications: The candidate must either have a Ph.D. in geology or a reasonable prospect of having a Ph.D. by the Fall of 2020.

Application Instructions: Applications are accepted online at www.hope.edu/employment/faculty. As part of the online application candidates will upload a cover letter, curriculum vitae, transcripts (unofficial transcripts accepted for the initial application), and a statement of teaching philosophy and competencies. Applicants will also submit a statement describing their fit to the mission of Hope College (https://hope.edu/about/mission.html). As it may not be addressed elsewhere in the application, applicants should devote particular attention to the Christian aspect of the mission statement and their personal engagement with faith and/or a faith community.

In addition, names and contact information for three references will be entered into the application. Those references will be contacted upon application to submit letters of reference.

Application deadline is January 15, 2020. For a full job description and to read about Hope College please visit our website at www.hope.edu/employment/faculty.

Hope College seeks to be a community that affirms the dignity of all persons as bearers of God’s image. It is Hope College policy not to discriminate on the basis of age, color, disability, family status, genetic information, height, national origin, pregnancy, race, religion, sex, or weight, except in the event of a bona fide occupational qualification. Hope College is an equal opportunity employer.

OPPORTUNITIES FOR STUDENTS

Multiple Ph.D. student positions in Geomechanics at The University of Texas at Austin. We are currently seeking Ph.D. students to join the Geomechanics and GeoFluids research program in the Department of Geological Sciences, Jackson School of Geosciences, The University of Texas at Austin. Our group works on a wide range of problems related to stress, fault and rock strength, coupled deformation and fluid flow, and rock and sediment physical properties in the Earth’s crust, through integration of experimental, theoretical modeling, and field-based approaches. Active research projects provide an opportunity to engage and are strongly allied with Scientific Ocean Drilling efforts offshore New Zealand, Japan, Costa Rica, the Gulf of Mexico, and several other continental margins; these projects also offer outstanding opportunities to engage with research in the energy industry. Current areas of focus include mechanical and hydrological processes in active tectonic environments, such as subduction zones and transform systems; deformation, material properties, and pore pressure in regions with complex stress histories; flow and mechanical properties of mudrocks, and gas hydrate systems. Tuition, stipend, and other fees will be fully funded for these research positions. For information please contact Demian Saffer (demian.saffer@utexas.edu) or Peter Flemings (pflemings@jsg.utexas.edu).

All applications must be completed in the Graduate and International Admissions Center (GIAC) by the appropriate deadline (December 1st 2019 for fellowship consideration and January 1st for all applications). See https://gradschool.utexas.edu/admissions/how-to-apply.

More information about the application process can be found at The University of Texas at Austin, Jackson School of Geosciences admissions portal: http://www.jsg.utexas.edu/education/graduate/admissions/.

For additional information concerning the application process, contact the Jackson School of Geosciences graduate Program Coordinator, Philip Guerrero: philipg@jsg.utexas.edu.

Graduate Student Opportunities (MS), Ohio University. The Department of Geological Sciences at Ohio University invites applications to its research thesis-based MS degree in Geology for the Fall of 2020. The Geological Sciences faculty at Ohio University collaborate in three research clusters: paleobiology and sedimentary geology, solid earth and planetary dynamics, and environmental and surficial processes. Prospective students are encouraged to contact faculty directly to discuss potential research topics. Qualified students are eligible to receive teaching assistantships that carry a full tuition scholarship and a competitive stipend. For program and application information, visit the department website at http://www.ohio.edu/cas/geology/graduate or contact the graduate chair, Dr. Daniel Hembree (hembree@ohio.edu). Review of applications begins February 1, 2020.

Graduate Student Opportunities (Online MS), Ohio University. The Department of Geological Sciences at Ohio University invites applications to its online, non-thesis MS degree in Geology for the Fall of 2020. The program includes courses on research methods, paleobiology and sedimentary geology, Earth materials and planetary geology, and environmental and surface processes. The program is designed for students planning to enter or already in the geoscience workforce (industry, government, non-profit) that do not require research experience as well as K–12 educators seeking additional training in the geosciences. For program and application information, visit the department website at http://www.ohio.edu/cas/geology/graduate or contact the graduate chair, Dr. Daniel Hembree (hembree@ohio.edu). Review of applications begins February 1, 2020.

Graduate Student Opportunities, Baylor University. The Department of Geosciences at Baylor University invites applications for full-time Ph.D. and MS students starting in August 2020. Admission to the program includes 5 years of financial support for Ph.D. students and 2 years of financial support for MS students through research and teaching assistantships and fellowships. Admitted students also receive a full tuition waiver, 80% health insurance subsidy, annual travel funding from department and university for conference attendance, and research funding for graduate stu-
GEOSCIENCE JOBS & OPPORTUNITIES

Duke University invites intellectually engaged and motivated students to apply to our doctoral program. We particularly seek applicants in the fields of biogeochemical oceanography, geochemical hydrology, coastal processes and geomorphology, atmospheric dynamics, climate change, and energy and resources. As part of Duke’s Nicholas School of the Environment, our graduate students interact with faculty and students in diverse fields related to the earth, oceans, atmosphere, biosphere and environment. We offer 5 years of financial support through research and teaching assistantships and fellowships. For more information, please visit https://nicholas.duke.edu/academics/doctoral-programs/earth-ocean-sciences-eos or email our Director of Graduate Studies at: abmurray@duke.edu.

Graduate Assistantship, New Mexico Highlands University. Graduate assistantships are available for students wishing to pursue an MS in Geology–Environmental Science beginning Spring or Fall 2020 term. The NMHU Environmental Geology Program strengths are in Petrology, Environmental geochemistry, Water Resources & Water Quality, Paleomagnetism, Volcanology, and collaborative endeavors with the New Mexico Forest Service and the New Mexico Forest and Watershed Restoration Institute. The Paleomagnetism–Rock Magnetism, Powder X-Ray Diffraction, and Water Chemistry laboratories support wide-ranging analytical and field research. The NMHU campus is situated at the boundary of the Great Plains and the Sangre de Cristo Mountains. Campus is located within one to two hours from Cenozoic volcanic fields, Precambrian rock exposures, glaciated valleys, desert terrains, and several world-renowned geologic features - the Valles Caldera and the Rio Grande Rift. A low student:faculty ratio, state-of-the art laboratory facilities, and committed faculty provide students with a superior learning experience. The graduate assistantship includes a nine-month stipend and tuition waiver per academic year. Application review begins 01/10/19 Spring and 01/02/20 Fall. For more information, contact Dr. Petronis, Environmental Geology, NRM Department, New Mexico Highlands University, Box 9000, Las Vegas, New Mexico 87701, mspetro@nmhu.edu. For disabled access or services call 505-454-3513 or TDD# 505-454-3003. AA/EOE Employer.

Graduate Student Opportunities at Case Western Reserve University. Students with backgrounds in geology, physics, chemistry, biology, engineering, and related fields are encouraged to apply for our Ph.D. and MS programs in Earth, Environmental, and Planetary Sciences. Areas of active research in the Department include planetary geology and geodynamics, planetary materials, high-pressure mineral physics and geochemistry, and mantle processes, environmental science, sedimentary geology, and sediment transport. For more information, please visit http://eeps.case.edu or write to eeps-gradinfo@case.edu. Financial assistance is available. Application deadline: 1/15/2020.

Hiring?


That unique candidate is waiting to be found.
Support the GSA Programs You Are Passionate About with These Tax-Wise Tools

If you are like me, the end of the year presents a difficult choice—whom should I support philanthropically, and how can I do so in the most tax-effective manner? One method several GSAF donors have chosen is charitable rollovers from traditional individual retirement accounts. Through IRA rollovers, you can make a generous gift during your lifetime from assets that could otherwise be subject to multiple levels of taxation.

The requirements and benefits to an IRA rollover contribution are simple. If you are at least 70½ years of age, you can direct a transfer from your traditional IRA to the Geological Society of America Foundation. This transfer will count toward your required minimum distribution for the calendar year. Because your funds are going from your IRA directly to GSAF, your gift amount can be excluded from your income for federal tax purposes. An additional benefit is the immediate and dramatic impact you will make in the lives of students and GSA members through supporting the GSA programs that matter to you.

Of course, before pursuing this avenue of giving, you should consult your own professional advisors to discuss your specific situation, as IRS limitations may apply.

For long-time Foundation supporter Charles Ross, IRA rollover contributions have become his preferred way to support GSA—a desire he shared with his wife, June, who passed away in 2012. As Charles recounts, GSA had been a continual, supportive funding source for his and June’s work throughout their careers. In recognition of this, they started the Charles A. and June R.P. Ross Award, which supports research grants in paleontology, paleogeography, and paleobiogeography. When June passed, Charles decided to strengthen his commitment to GSA. He consulted his tax professional, and after determining that it was the best giving option for him, committed to supporting his fund by giving through IRA rollover contributions. Charles believes in GSA and its mission, so he gives happily, saying, “I feel good about the way the money is being used and the work it is supporting.”

For those who have yet to reach 70½ there are still plenty of ways to support GSA this year end! You can visit [https://gsa-foundation.org/donate/](https://gsa-foundation.org/donate/) to make an immediate online gift. If you are shopping for the holidays, please consider using AmazonSmile and designating GSAF as the recipient—Amazon will donate 0.5% of the price of your purchases to GSAF. Finally, you may work for one of the thousands of companies who will match employees’ gifts to non-profit organizations like GSAF—contact your HR department for details about their program and double your impact!

These are just some of the ways you can support the projects you are passionate about this December. For more details on traditional IRA rollover contributions and related material, or to discover more ways that you can give, visit [https://gsa-foundation.org/ways-to-give/](https://gsa-foundation.org/ways-to-give/) or contact Clifton Cullen at +1-303-357-1007 or ccullen@geosociety.org.

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**Basics of IRA Charitable Rollover**

- **Be 70½ years of age or older.**
- **Direct a transfer of up to US$100,000 from your IRA account to GSAF.**
- **Exclude the gift amount from your income for federal tax purposes.**
- **Count the gift toward your required minimum distribution for that year.**
- **YOU MAKE AN IMMEDIATE IMPACT ON OUR WORK.**
Call for Short Course and Technical Session Proposals

It's time to plan for our 2020 Annual Meeting in Montréal, Québec, Canada. We look forward to highlighting the geology in the area. We challenge you to propose a short course and/or a technical session that will teach your colleagues and promote discussion about the incredible regional geology.

Exchange the geology by organizing and chairing a Technical Session.
Technical Session deadline: 1 Feb. 2020
Proposals are being taken for both Pardee Symposia and Topical Sessions.
https://gsa.confex.com/gsa/2020AM/cfs.cgi

Share the geology as an instructor through a Short Course.
Short Course proposal deadline: 1 Feb. 2020
Courses run the Friday and Saturday before the Annual Meeting and are typically a half day to two full days.
https://gsa.confex.com/gsa/2020AM/shortcourse/cfs.cgi

A MESSAGE FROM THE GSA EXECUTIVE DIRECTOR

Dear Colleagues,

GSA is committed to the ideal of scientific discovery, rigor, diversity, and integrity. I invite you to prepare a proposal for a technical session for the 2020 Annual Meeting that reflects your expertise and research but also pushes the boundaries of the discipline. Without expanding our horizon, we will not move the geosciences forward and keep our relevance. I also challenge you to broaden your reach with whom you collaborate by including diversity in all ways—discipline, career progression, and individuals.

Thank you for considering sharing your science and work at the GSA Annual Meeting.

Vicki S. McConnell

www.geosociety.org/annualmeeting
Postcards from the Field

CAL2020 | $9.95

This 12-month, 9.5” × 12.5” calendar showcases compelling submissions to the GSA calendar photo search. Featuring images of coral at Moor Reef, Westmoreland (Jamaica), Peyto Lake and the Mistaya River Valley, Banff National Park, Alberta (Canada), White Pocket, Vermilion Cliffs National Monument (Arizona), and Rub’ Al-Khali desert (Saudi Arabia), this serene calendar will spruce up your home or office.

- Dates of many noteworthy eruptions & earthquakes
- Birthdates of famous geoscientists
- Calendar of GSA events, meetings, & deadlines