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**Nickel-Bearing Laterite  
Deposits in Accretionary  
Context and the Case of New  
Caledonia: From the Large-  
Scale Structure of Earth to  
Our Everyday Appliances**





Special Paper 541



# Circum-Arctic Structural Events

Tectonic Evolution of the Arctic Margins and Trans-Arctic Links  
with Adjacent Orogens

Edited by Karsten Piepjohn, Justin V. Strauss, Lutz Reinhardt, and William C. McClelland

**IN  
PRESS**

## Circum-Arctic Structural Events: Tectonic Evolution of the Arctic Margins and Trans-Arctic Links with Adjacent Orogens

*Edited by Karsten Piepjohn, Justin V. Strauss, Lutz Reinhardt, and William C. McClelland*

The circum-Arctic region has received considerable attention over the past several decades with vigorous debate focused on topics such as mechanisms for opening the Eurasian and Amerasian basins, the importance of plume-related magmatism in the development of the Arctic Ocean, and mechanisms for ancient terrane translation along the Arctic margins. In recognition of the 25th anniversary of the Circum-Arctic Structural Events (CASE) program, an international polar research effort organized and led by the Bundesanstalt für Geowissenschaften und Rohstoffe (BGR) of Germany, this volume presents results from 18 major field expeditions involving over 100 international geoscientists from a broad spectrum of disciplines. The resulting publication focuses on the Proterozoic to Cenozoic tectonic evolution of the circum-Arctic region with correlations to adjacent orogens.

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## SCIENCE

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Pierre Maurizot et al.

**Cover:** A typical hydrous Mg-Ni silicate ore with green garnierite veins (>2 wt% Ni) (Poro mine, New Caledonia). See related article, p. 4–10.



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# Nickel-Bearing Laterite Deposits in Accretionary Context and the Case of New Caledonia: From the Large-Scale Structure of Earth to Our Everyday Appliances

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## ABSTRACT

Nickel production is vital to modern economic development. Of the different ore types, supergene Ni-laterite production, as open-cast mining exploitation, is on the rise and surpassing the more conventional hypogene sulfide type. This trend will likely continue. Assessing the global resource of Ni laterite is therefore of crucial importance. Compilation of scientific publications shows that the main producers and occurrences are concentrated in a few countries in South-east Asia (New Caledonia, Indonesia, the Philippines) and the Caribbean region (Cuba and the Dominican Republic). In these regions a common geological background appears, characterized by large obducted ophiolites in tectonically active settings, subject to weathering during the Neogene. The neofomed mineralogy of such surficial deposits is well documented. A model is proposed, based on the knowledge gained on Ni-laterite deposits in New Caledonia, that could be applied to similar geological settings worldwide. This model states that in accretionary terranes, vertical motions during weathering control both ore type and location.

## INTRODUCTION

Nickel-based alloys are used in many applications, from modern information and communication technologies to large-scale industrial infrastructures, including stainless-steel products used in our everyday life, such as coins, beer kegs, coffee spoons, and much more. Improving knowledge about geological factors that

control nickel deposits is therefore crucial to industrial development.

If one excludes polymetallic nodules of the ocean floor, for which mining technology and jurisdictional issues are still not solved (Volkman and Lehnen, 2017), two main types of nickel deposits are known on land worldwide (Mudd and Jowitt, 2014): (i) hypogene magmatic nickel-sulfide deposits are found as lodes or layered complexes in ancient cratons and are mostly mined underground; and (ii) supergene Ni-laterite deposits, which are formed by weathering of exposed ultramafic units, and as such are exploited in open pits.

Supergene mineral deposits are low-grade, large-tonnage resources, exploited in easy surface conditions (ICMM, 2012). In the last decade, global production of Ni laterite has overtaken Ni sulfide (60% vs. 40% according to Mudd and Jowitt, 2014), and the laterite proportion is still growing.

Nickel-laterite deposits require ultramafic protoliths, such as Precambrian komatiites and layered complexes or Phanerozoic ophiolites. Ophiolites correspond to remnants of oceanic mantle and crust emplaced on land in collision zones involving oceanic plates (Coleman, 1977). Mantle rocks are not commonly exposed at Earth's surface and hence are restricted to a few countries (Fig. 1).

Typical mantle rocks have been enriched, through repeated partial melting and extraction episodes, in nickel up to 0.18 wt%; i.e., 20 times the average Earth crust concentration (Palme and O'Neill, 2014). However, economically, this is not significant, and a secondary enrichment process has to take place.

Ultramafic rocks are composed of silicate minerals, notably olivine, which are, under wet and warm intertropical climates, unstable and rapidly weathered (Thorne et al., 2012; Wilson, 2004). Mg and Si are released, whereas Fe, Al, Ni, and Co stay in situ. Consequently, a thick, soft, residual cover of typical red- to yellow-colored Fe oxy-hydroxides accumulates, at times capped with ferricrete (Fig. 2). Nickel is then concentrated up to a grade of 1%–2% or even more (Butt, 2007; Freyssinet et al., 2005; Gleeson et al., 2003). This natural supergene process of enrichment is very efficient with a second-enrichment factor of 10 times compared to the initial ultramafic protolith and 200 times the average Earth crust composition. Grades of Ni-laterite deposits (0.8–15 wt% Ni) exceed that of magmatic Ni-sulfide deposits (0.5–5 wt% Ni; Arndt and Ganino, 2012). Cobalt is, in some deposits, enriched in the same proportion, but its initial and final concentrations are roughly 10 times lower. In addition, recent studies about scandium enrichment within Ni-Co laterites of New Caledonia show that Sc-bearing goethites contain about 10 times the Sc content of the parent rock (up to 100 ppm; Teitler et al., 2018).

Scientific research on Ni-Co laterites, which present in essence a strong heterogeneity, is still low globally. New Caledonia, a small French overseas territory in the southwest Pacific, holds ~25% of the global Ni-laterite resource (Berger et al., 2011; Mudd and Jowitt, 2014). In terms of surface (18,500 km<sup>2</sup>) and population (~300,000), the archipelago is certainly the smallest among the



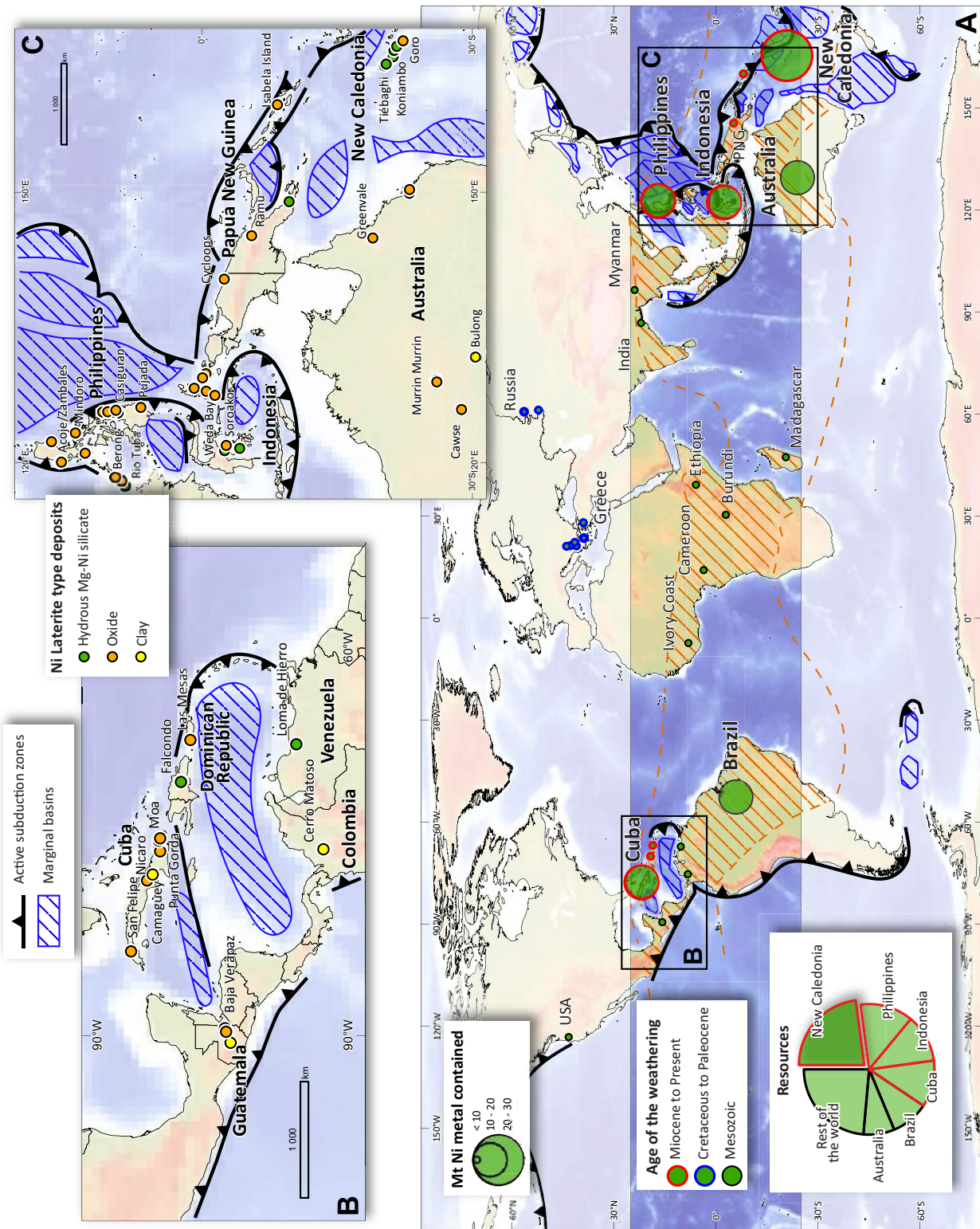


Figure 1. (A) Global resource of Ni metal contained in laterite type deposits by country (after Berger et al., 2011). The intertropical zone, where most of the deposits are located, is highlighted. Orange dashed areas represent the envelope of the world's main lateritic zones (after Tardy, 1993). Weathering profiles being highly sensitive to erosion, most of the preserved nickel laterite deposits are (geologically) young and are found in the intertropical belt. Higher-latitude occurrences correspond to minor and older deposits formed during past warm climate periods. Insets: (B) the Caribbean and (C) SW Asia-Oceania regions, showing individual and mostly known deposits and deposit types. PNG — Papua New Guinea.



major Ni-producing countries, but it is recognized by metallogenists (Laznicka, 2006) as one of the largest and richest Ni-providing areas in the world. Many scientific aspects are addressed by Ni-laterite deposits, including resources, processes, environment, and societal impact (CNRT, 2017). In this paper, we present some recent advances in knowledge of geological controls and Ni speciation of these deposits in some emblematic regions of the world and the contribution of New Caledonia in this respect.

### ORE TYPOLOGY

Three types of Ni-laterite ore types, and hence deposits, are known worldwide (Brand et al., 1998; Freyssinet et al., 2005; Golightly, 2010; Butt and Cluzel, 2013), although mixed-type deposits are frequent: (i) hydrous Mg-Ni silicate (garnieritic) ore has the highest Ni grade, commonly  $\geq 2$  wt% Ni with very low Co; (ii) oxide ore is dominated by iron oxy-hydroxides, with 1.5 wt% Ni on average and generally recoverable Co up to 0.3 wt%; (iii) clay deposits are dominated by Ni-bearing swelling clays (nontronite), containing Ni in the same range as oxide deposits.

Garnierite was first discovered by Jules Garnier in New Caledonia (Garnier, 1867). Garnierite is actually a field term not recognized by the International Mineral Association (IMA), referring to a rather complex mixture of poorly crystallized phyllosilicate phases composed mainly of serpentinite-like, talc-like, chlorite-like, and clay-like phases (Fritsch et al., 2016). The appended “-like” refers to a certain weakness in the crystallinity of these phases and stacking disorder. Most of the types individualized so far belong to a continuous solid-solution from Mg to Ni end-members. These highly variable, poorly crystallized minerals can have up to 27% Ni (Freyssinet et al., 2005).

Clay deposits are typical of large, stable continental, or cratonic, areas, formed on Archean to Proterozoic ultramafic layered intrusions or komatiite, further weathered in the Mesozoic, continuing to the present (e.g., in Australia, Brazil, and Africa), whereas hydrous Mg-Ni silicate formed mostly on ophiolites, eventually weathered in the Late Mesozoic to Cenozoic. Oxide deposits are present in both contexts. For many authors (Elias, 2002; Freyssinet et al., 2005; Golightly, 1981; Trescases, 1975), oxide-dominant ore deposits are formed

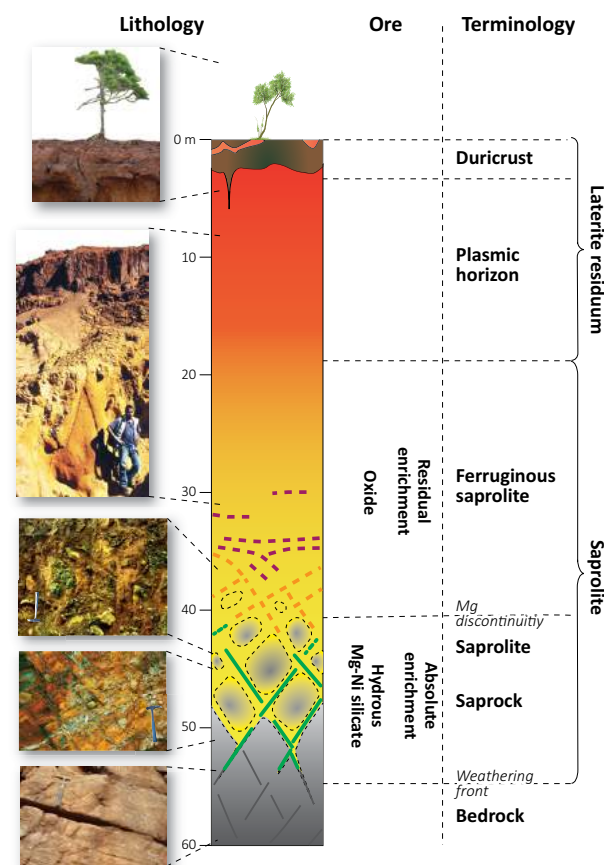


Figure 2. Weathering profiles on ultramafic protolith. Lithology: common terminology of the different horizons of the weathering profile and reaction fronts (after Eggleton, 2001; Freyssinet et al., 2005; Butt and Cluzel, 2013). Ore: enrichment and ore types.

where the topographic gradient is low, internal drainage is weak, the water table is high, leaching and precipitation are limited, and Ni enrichment is mainly residual, located in the saprolite horizon; conversely, hydrous Mg-Ni silicate dominant ore deposits are formed where the topographic gradient is important, internal drainage is free, the water table is low, leaching and precipitation are optimal, and Ni enrichment is mainly absolute and located deeper in the saprock.

Theoretically, calculated as purely “residual enrichment,” a simple removal of mobile elements would result in 0.6–1 wt% Ni (Brand and Butt, 2001). Therefore, higher grades recorded in saprock of hydrous Mg-Ni deposits must be explained by other factors and are referred to as “absolute enrichment.” The total mass loss and dissolved phase may reach 80% of the fresh rock (Trescases, 1975; Brand and Butt, 2001; Freyssinet et al., 2005).

### GEOLOGY AND METALLOGENY

The four highest-ranked countries by Ni-laterite resource (New Caledonia, Philippines, Indonesia, and Cuba) are located in the Southwest Pacific,

Southeast Asia, and the Caribbean region, all within  $\sim 25^\circ$  of the equator (Fig. 1). These countries hold more than 50% of the global Ni laterite and were in the top five Ni producers for the past decade. They present a similar geological setting, as islands emerging from a series of sinuous eastern-facing belts, corresponding to complex ocean-ocean or continent-ocean convergence zones, distributed along the western parts of the Pacific and Atlantic Oceans. They are separated from the continent to the west by marginal basins and from the ocean to the east by island arcs and active subduction or transcurrent fault zones. On land, most of these belts include one or several ultramafic terranes, remnants of short-lived ( $\sim 50$  m.y.) marginal basins opened above successive subduction planes and then accreted during repeated convergence periods. Most of these ophiolites were emplaced during the (Late) Cretaceous to Paleogene periods. In this accretionary context, lying in the intertropical zone, weathering started as soon as the Oligocene. Hydrous Mg-Ni silicate deposits are dominant, and oxide or clay deposits are subordinate. A majority of these countries are tectonically still



active, in the sense that they are under the influence of an active plate boundary.

The striking asymmetrical distribution of the marginal basins-arc-trench system at Earth's surface, which was remarked upon by some authors in the early stages of global tectonic theory (e.g., Uyeda and Kanamori, 1979), is out of the scope of this paper, but the coincidence of (i) the large-scale structure of the Earth, where important portions of oceanic crust and mantle have been thrust on land, and of (ii) a warm and wet intertropical climate belt, illustrates perfectly how the overlapping of two independent factors may be determinant in the formation and location of a mineral resource.

In a comparable accretionary context, New Caledonia is the emerged part of the Norfolk Ridge in the northern part of what has been recently referred to as Zealandia, a mostly submerged continent (Mortimer et al., 2017). In this area of interaction between the Australian and Pacific plates, the Eastern Gondwana margin has been fragmented into several thinned continental ribbons and extensional basins, some of which are oceanic (e.g., the Tasman Sea and Loyalty basins). The most emblematic and prominent geological unit of Grande Terre, the "main island" of New Caledonia, is the Peridotite Nappe (Avias, 1967; Fig. 3), which covers about a third of the surface area of the country. The ultramafic terrane is interpreted as the lithospheric mantle of the Late Cretaceous to Paleogene South Loyalty Marginal Basin

(Collot et al., 1987), which was emplaced onto the continental Norfolk Ridge at the end of the Eocene (Cluzel et al., 2012) and was mentioned as a typical example of the obduction concept defined by Coleman (1971).

The terrane was exposed to emergence, dismantling, weathering, and erosion during the Neogene post-obduction period. Early Miocene conglomerate of the Népoui area reworks abundant weathered products of the peridotite, including supergene nickel ore (Coudray, 1971; Maurizot et al., 2016). The oldest weathering profiles have been dated indirectly by paleomagnetism methods at 25 Ma (Sevin et al., 2012). The nickel ore-forming process was therefore already active at the end of Oligocene, ~10 my. after obduction, and is likely ongoing, as attested to by dissolution activity and youngest paleomagnetic ages.

### THE NICKEL FACTORY

Worldwide, Ni-Co-laterite deposits are controlled by a wide range of interacting factors (Freyssinet et al., 2005; Butt and Cluzel, 2013): lithology (including serpentinization) of the ultramafic rock, fracturing, permeability, climate change, tectonic activity, and morphologic evolution. Weathering tends to accumulate laterite and thus nickel; tectonic activity or eustatic variations tend to erode and destroy, or cover up and conceal, these accumulations. If the rate of chemical weathering of a peridotite is greater than the rate of physical

erosion, a deep weathering profile may be preserved. Conversely, it is destroyed.

Mantle rocks (dunite, harzburgite, lherzolite), which have a very low hydraulic conductivity, are, however, densely fractured as a result of their long evolution in oceanic domains and their eventual obduction. Serpentinization of the protolith, diffuse or closely associated with fracturing, is a common alteration, which, on the whole, corresponds to hydration and cooling of the lithospheric mantle rocks. Once exposed on land, above sea level, the fracture network allows pervasive underground water circulation and setting up of a water table. Through internal water fluctuations and circulation, fluids in the ultramafic protolith propagate weathering, leading to a general saprolitization, karstification with sinkholes, underground conduits, and lapies. A complete and differentiated weathering profile may reach 50 m in thickness. The youngest and active front is at the base, the oldest at the top. It comprises, from top to base (Eggleton, 2001; Fig. 2):

- Lateritic residuum divided into:
  - The topmost duricrust (or ferricrete or iron cap), which corresponds to the zone of oscillation of the sub-surface water table, where alternating saturated and unsaturated conditions allow precipitating of massive iron oxy-hydroxides;
  - A plasmic zone (or red limonite), in which all primary structures are erased;

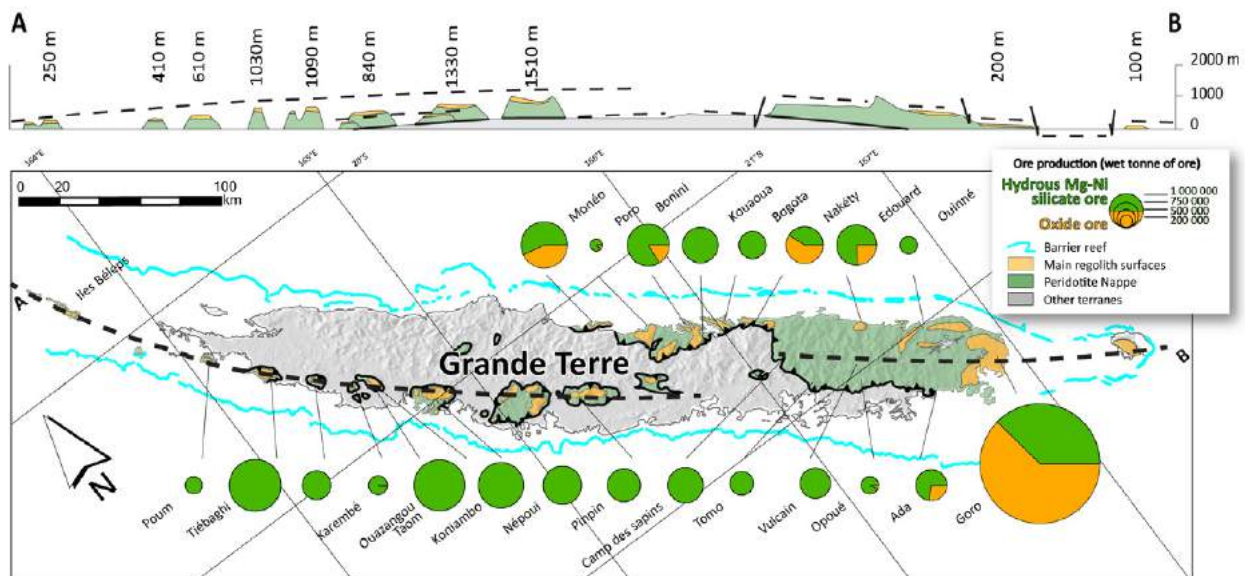


Figure 3. Simplified geological map of Grande Terre and section along Grande Terre showing the general shape of the ultramafic terrane.



- Ferruginous saprolite (or yellow limonite), where the inherited bed-rock structure is retained but transformation to a soft material is almost complete, correlative of an important mass loss.
- Saprolite divided into:
  - Saprolite (more than 20% of weathered rock), in which concentric spheroidal weathering preserves blocks or boulders of fresh rocks (corestones);
  - Saprock (less than 20% of weathered rock). Saprock may be the Ni-richest horizon.
- Protolith fresh peridotite.

The highest concentration of nickel is at the base of the weathering profile, in the typical high-grade hydrous Mg-Ni silicate ore type, where its concentration may reach several tenths of a percent of Ni. In the saprock and above, early-formed serpentinite can be secondarily enriched up to 3–6 wt% by Ni-Mg substitution. The degree of serpentinization of the protolith is therefore an important factor of mineralization, which greatly contributes to Ni grade, more than the degree of weathering (Orloff, 1968; Pelletier, 1996; Trotet et al., 2015). When early serpentinite is saturated in Ni, the typical green-colored garnierite precipitates commonly as a stockwork of veins. Garnierite occurrences are generally associated with other supergene precipitates, including variously crystallized silica (chalcedony, quartz), as brecciated veins, sigmoidal fillings, and slickenside coating on serpentinite fault planes, indicating a complex supergene syn-tectonic evolution (Cluzel and Vigier, 2008; Genna et al., 2005; Iseppi et al., 2018).

Higher in the profile, the Mg discontinuity is characterized by a drastic change in the Mg, Si, and Fe proportion. A number of dark Mn- and Co-rich concretions appear that include phyllo-manganate family minerals, which are the main Co (and Ni) carriers (Llorca, 1993; Freyssinet et al., 2005; Roqué-Rosell et al., 2010; Fritsch et al., 2014). In the rest of the profile, Ni is mainly hosted by iron oxyhydroxides (dominant goethite, subordinate hematite) in the typical low-grade oxide ore type. Nickel content is correlated with goethite crystallinity and anticorrelated with hematite proportion. Nickel content thus decreases, while hematite increases upward (Dublet et al., 2015, 2012).

## A MODEL FOR Ni-LATERITE DEPOSITS IN ACCRETIONARY TERRANES

Owing to its importance regarding ore processing, detailed publications on the mineralogy and geochemistry of deposits worldwide are generally available. However, the shape of deposits and distribution of ore grades are rarely documented. The strategy of exploration for many mining companies is commonly very basic, consisting of expensive and environmentally harmful systematic grid drillings with a mesh adapted to the high variability of the Ni content (Ni semi-variogram ranges are commonly <20 m). The experience and knowledge gained from research on deposits in New Caledonia can be applied to exploration in accretionary terranes elsewhere.

At a large scale, the regolith surfaces topping the Peridotite Nappe are enclosed in a broad, shallow-dipping envelope, delineating a conspicuous longitudinal upwarp (Fig. 3; Sevin et al., 2012). At both ends of Grande Terre (Iles Béleps to the north and Ile des Pins to the south), the major duricrust surfaces plunge under sea level, whereas in the middle of the island, dismantled regolith surfaces culminate at more than 1000 m. Although disrupted at smaller scale by many discontinuities and associated with complex sets of stepped benches, this bulge shape is interpreted as the result of the long-term post-obduction isostatic re-equilibrium. It is worth noting

that this uplift, which started as soon as 25 Ma (Sevin et al., 2014), is still active as recorded in the construction of the Pleistocene and Holocene reef barrier that rims Grande Terre (Cabiocch, 2003).

In New Caledonia, mining geologists commonly distinguish deposit types according to their geomorphological context (Fig. 4); namely, basin, plateau, and mountain (crest or slope) deposits (Trotet et al., 2015). Basin deposits host large areas of dominant oxide ore (e.g., Goro, Prony). Mountain deposits typically host smaller-sized deposits, with typical high-grade hydrous Mg-Ni silicate ore. Plateau deposits are intermediate with both types of ore, including even clay mineralogy (e.g., Tiébaghi). This typology of deposit and geomorphological features can be associated in a consistent model (Maurizot et al., 2019). Basins, plateaus (which are inverted basins), and mountainous areas (which are dissected plateaus) may be considered as different steps of a continuum of geomorphological evolution on which the nickel factory has evolved through time (Fig. 4).

The rate of chemical weathering versus the rate of physical erosion (driven by post-obduction deformation) is therefore crucial in the constitution of Ni resources. Where subsidence prevails and internal drainage is impeded, Ni concentrations will cease to increase and will be buried under sediments (e.g., Fluvio-lacustrine Formation, near the Goro deposit; Folcher

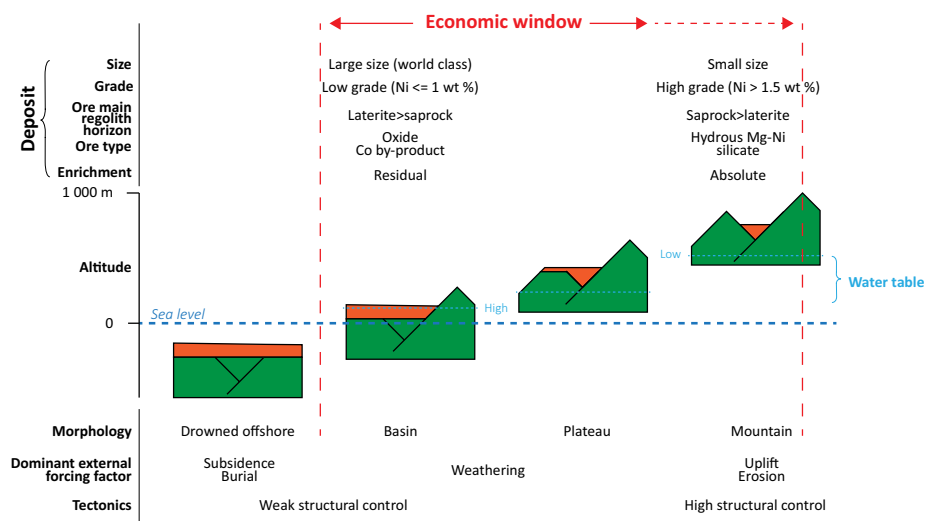


Figure 4. A model for Ni-laterite deposits in New Caledonia. Typology, based upon geomorphology, geology, and economic factors of Ni deposits, is a function of altitude, which in turn is a function of time.

et al., 2015) or drowned below sea level (e.g., at both ends of Grande Terre). When the rate of uplift compensates for the rate of weathering, large contiguous basin deposits can form, with dominant residual enrichment and oxide type ore (e.g., Goro). Where the rate of uplift is higher than the rate of weathering, basins are inverted to plateaus, and absolute enrichment prevails, forming the typical high-grade hydrous Mg-Ni ore deeper in the profile (e.g., Tiébaghi, Koniambo). Beyond that, in mountainous areas, the trend of enrichment is enforced by more uplift, to the expense, however, of a partial destruction and fragmentation of the deposits, which are dissected by erosion. This last stage before complete destruction of deposits is exemplified by many small high-grade deposits disseminated in New Caledonia, which were mined in the early time of Ni exploitation.

## CONCLUSIONS

World Ni consumption is growing, and exploration and exploitation of Ni laterite will increase significantly in the future. Globally, the largest resources of this ore type are hosted in accretionary settings, where important ophiolites have been entrapped through repeated obduction processes, which are still under the twofold influences of convergent plate tectonic activity and the intertropical belt climate since Neogene time. Our model shows that such deposits are restricted to specific areas, resulting from a specific geodynamical history. Detailed analysis at mineral and borehole scales is essential; however, in order to have a better assessment of the Ni potential of a region at larger scale, a geomorphological appraisal, including space and time parameters, may be useful and contribute to improved global Ni resource management.

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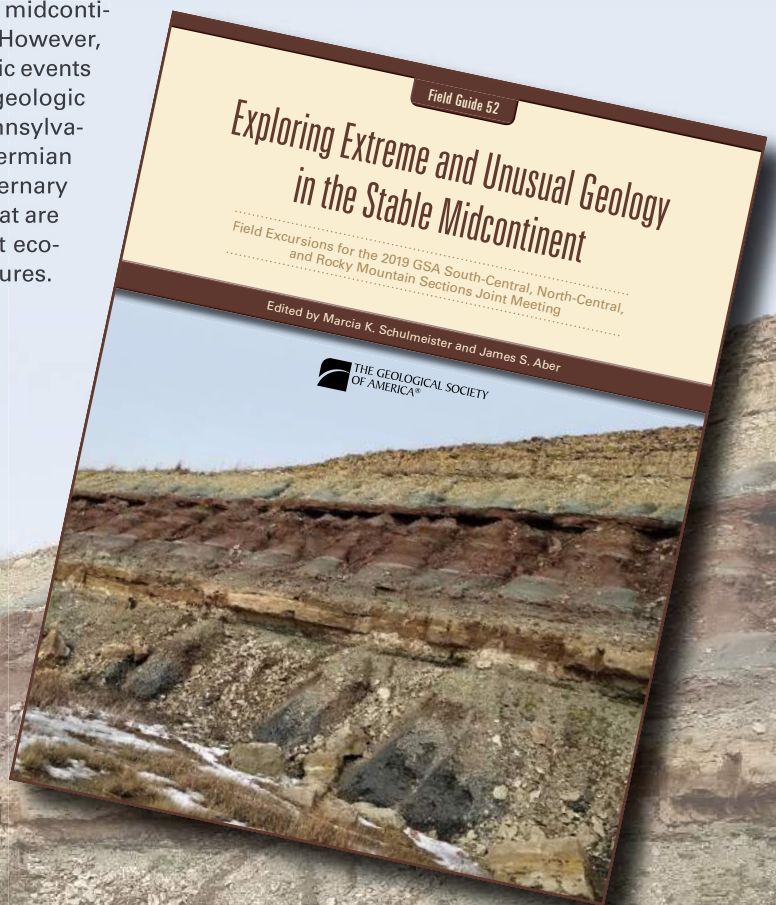
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Now open	Meeting room request system (non-technical, social, and business meeting room requests)
Early May	Housing open (Orchid.Events is the official housing bureau)
Early May	Registration and Travel Grant applications open
6 May	Meeting room request deadline—fees increase after this date
25 June	Abstracts deadline
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# The Grand Canyon State Welcomes You!

The Grand Canyon State welcomes the Geological Society of America Annual Meeting & Exposition to our capital city of Phoenix for the first time in more than three decades. It's an especially auspicious year for GSA to come here, as 2019 marks both the 150th anniversary of John Wesley Powell's first expedition through Grand Canyon and the 100th anniversary of Grand Canyon National Park! Arizona is indeed a land of textbook geology, where you can set your feet, hands, senses, and camera on the exposed rock record of nearly two billion years of deep time.

As symbolized in the logo for the 2019 Annual Meeting, Arizona has tremendous geologic, topographic, climatic, and ecological diversity: from the Sonoran Desert landscapes of the rugged and arid Basin and Range in the south where Phoenix is located, through the mountainous Transition Zone, north to the high-elevation Colorado Plateau with its colorful, fossil-rich layer-cake strata incised a mile deep in the mighty Grand Canyon. Owing to this great natural diversity, Arizona is often referred to as "many states in one." We produce more copper than all but a few nations, let alone any other U.S. state. We are home to 22 national parks, monuments, and historic sites, and wonderful state and local parks as well. The record of human history and culture in Arizona dates back many millennia, and 21 contemporary Native American nations know it as their homeland. Arizona's history and culture have also long benefited from our proximity to and friendly relations with México. Twenty-nine different pre-meeting and post-meeting field trips are scheduled, offering you many opportunities to explore and enjoy the geology, geography, and scenery of Arizona and adjoining areas of the Southwest.

Today's Phoenix is decidedly different from the town that hosted the GSA Annual Meeting in 1987. We are now the fifth

largest city in the United States: a sunny, friendly, exciting, culturally rich, proudly Southwestern place. Amenities range from the lovely landscapes of the Desert Botanical Garden to the world's largest collection of Native American art at the Heard Museum, to famed architect Frank Lloyd Wright's fascinating western home base at Taliesin West, to the climate-controlled Chase Field just blocks from the Convention Center, where you can come watch the Arizona Diamondbacks play during a home series that coincides with our meeting. And Phoenix is a gastronomic paradise, renowned for its multi-regional Mexican, Latin American, and indigenous cuisines, to be sure, but also home to scores of other diverse and delightful restaurants and pubs—including a pizzeria that many national food critics consider to be among the very best in the USA. Our light-rail and bus systems make it easy to get around, and Sky Harbor Airport, served by all major carriers, is a very short hop from downtown.

The Annual Meeting technical program features 34 short courses and workshops, six Pardee Symposia, and 202 topical sessions and symposia. We're also planning plenty of activities and informal gatherings, and as always, a dynamic Exhibit Hall. Students and early career geoscientists will find much here to engage and interest them. Come join your colleagues in Phoenix this September: We look forward to welcoming one and all to the Valley of the Sun!



**Steve Semken**

GSA 2019 General Chair  
Professor of Geology and Education,  
School of Earth and Space Exploration,  
Arizona State University



# Call for Papers

## ABSTRACTS DEADLINE: 25 June

### SUBMITTING AN ABSTRACT

- **Submission deadline:** Tuesday, 25 June.
- To begin your submission, go to [community.geosociety.org/gsa2019/learn/technical/presenter](https://community.geosociety.org/gsa2019/learn/technical/presenter).
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### ABSTRACTS SUBMISSION CODE OF ETHICS

Working together as a community of geoscientists, we will continue to advance the finest science in a respectable, professional manner. Authors will display integrity in disseminating their research. Presentations will adhere to the content and conclusions of abstracts, as submitted and reviewed. Listed co-authors will have made a bona fide contribution to the project. Conversely, the presenter should remain gracious by offering collaborators the opportunity for recognition as a co-author. All co-authors must be aware of their inclusion and have accepted that recognition. Presenters must be diligent in preparing a polished product that conveys high quality scholarship. Submission of an abstract implies a sincere intent to attend the meeting.



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# Pardee Keynote Symposia



Joseph Thomas Pardee  
(1871–1960)

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

## P1. Digital Learning Innovation in the Geosciences

**Cosponsors:** *GSA Geoscience Education Division; American Geophysical Union; National Association of Geoscience Teachers; National Earth Science Teachers Association*

**Disciplines:** Geoscience Education

**Advocate:** Ariel D. Anbar

New technologies for data visualization and discovery, and new education technologies, are transforming geoscience education, enabling active modes of discovery-based learning at scale. Interactive simulations, immersive and extended-reality environments, adaptive and personalized learning platforms, and digital tutoring are examples of technologies that enable rich, active learning experiences in and out of traditional classrooms. This symposium includes presentations, panel discussion, and a hands-on showcase to explore the state of the art and future frontiers.

## P2. Grand Ideas, Grand Events: Geoscience Research, Geoscience Education, and Human Connections to Grand Canyon at its Six Millionth, 150th, and 100th Anniversaries

**Cosponsors:** *GSA History and Philosophy of Geology Division; National Association of Geoscience Teachers; GSA Geoscience Education Division*

**Disciplines:** History and Philosophy of Geology, Geoscience Education, Geoscience Information/Communication

**Advocates:** Steven Semken; Eleanor Snow; Karl E. Karlstrom; Laura J. Crossey

In commemoration of the concurrent 150th anniversary of John Wesley Powell's first expedition and the 100th anniversary of Grand Canyon National Park this year, this symposium presents historical and modern perspectives on understanding and sustaining the iconic geological landscapes of Grand Canyon that encode nearly two billion years of earth history. Presenters will highlight the importance of Grand Canyon to the indigenous people who have long inhabited it, the generations of geoscientists who explore and study it, the expert interpreters and educators who teach from it, and the millions who visit to experience and learn from this singular place.

## P3. Geoscience Communication in the Modern Age

**Cosponsors:** *GSA Geology and Society Division; GSA History and Philosophy of Geology Division; National Association of Geoscience Teachers; GSA Geoscience Education Division*

**Disciplines:** Geoscience Information/Communication, Geoscience Education, Geoscience and Public Policy

**Advocates:** Iain Stewart; Callan Bentley; Mika McKinnon

Geoscience communication takes many forms, sharing information critical to society from scientist practitioners to decision makers and the public, as well as more creative interpretations by communicators seeking connection. This symposium celebrates excellence in several important domains of modern geoscience communication: popular writing (both fiction and non-fiction), visual art, photography, music, film, mainstream media, and social media, as well as research into effective science communication. We examine inspiring examples from accomplished communicators and gain insight into how best to help society enjoy a sustainable future on planet Earth (and beyond!).

## P4. Fostering an Inclusive Academic Culture for the Twenty-First Century: Advancing Policies, Departments, and Supporting Faculty to Address the Needs and Challenges for Building a Healthy Geoscience Enterprise

**Cosponsors:** *GSA Geology and Society Division; American Geophysical Union; American Geosciences Institute*

**Disciplines:** Geoscience and Public Policy, Geoscience Education

**Advocates:** Pranoti M. Asher; Christopher Keane; Heather R. Houlton; Lexi Shultz

As society increasingly relies on geoscientists for resources and hazards mitigation, the profession must remain on the leading edge of innovation to solve complex challenges. Geoscience departments and academic leaders play a critical role in recruiting and training these future innovative geoscientists, as well as promoting an inclusive culture to support the academic enterprise that extends beyond our departments. Panelists who have championed non-traditional policies for faculty advancement, bolstered inclusive departmental cultures, and initiated practices that highlight the successes of their departments will discuss their strategies and how to overcome common challenges.

## P5. Extreme Impacts of Global Climate Change: Effective Communication for Geoscientists, Educators, Policy Makers, and the Press

**Cosponsors:** *GSA Quaternary Geology and Geomorphology Division; GSA Energy Geology Division; GSA Environmental Geology and Engineering Division; GSA Geology and Health Division; GSA Geology and Society Division; GSA History and Philosophy of Geology Division; GSA Hydrogeology Division; International Union for Quaternary Research (INQUA)*

**Disciplines:** Geoscience Education, Geoscience Information/Communication, Geoscience and Public Policy

**Advocates:** Jennifer L. Pierce; George T. Stone

Fires, floods, and melting ice—can't we talk about something nice? Scientific data overwhelmingly demonstrate recent global temperature increases—due largely to combustion of fossil fuels—disrupt Earth's hydrologic, biologic, atmospheric, and geologic systems, thereby driving extreme impact events resulting in destruction of life and property. Despite this, effectively communicating the causes and risks of climate change and changing how people think about climate change remains a challenge. Why? In this interactive session, we combine up-to-date science on extreme events such as wildfires, hurricanes, sea-level rise, and arctic warming with compelling presentations on climate communication and education.

## P6. Understanding the Neoproterozoic Earth-Life System

**Disciplines:** Paleontology, Paleoecology/Taphonomy, Geochemistry, Precambrian Geology

**Advocates:** Qing Tang; Huan Cui; Feifei Zhang

This session aims to boost discussion and interdisciplinary collaboration by bringing together a trans-disciplinary group of innovative thinkers to present advances on biological, geochemical, sedimentologic, and climatic evolution in the Neoproterozoic in order to better understand the Neoproterozoic earth-life system.

## Discipline Sessions

In addition to topical sessions, GSA offers vibrant discipline sessions, which are an essential addition to the fulfillment of the overall meeting. We will have technical sessions that relate to recent advances in:

Archaeological Geology  
Economic Geology  
Energy Geology  
Engineering Geology  
Environmental Geoscience  
Geochemistry  
Geochronology  
Geoinformatics  
Geology and Health  
Geomicrobiology  
Geomorphology  
Geophysics/Geodynamics  
Geoscience and Public Policy  
Geoscience Education

Geoscience Information/Communication  
History and Philosophy of Geology  
Hydrogeology  
Karst  
Limnogeology  
Marine/Coastal Science  
Mineralogy/Crystallography  
Paleoclimatology/Paleoceanography  
Paleontology, Biogeography/Biostratigraphy  
Paleontology, Diversity, Extinction, Origination  
Paleontology, Paleoecology/Taphonomy  
Paleontology, Phylogenetic/Morphological Patterns

Petrology, Igneous  
Petrology, Metamorphic  
Planetary Geology  
Precambrian Geology  
Quaternary Geology  
Sediments, Carbonates  
Soils  
Stratigraphy  
Structural Geology  
Tectonics/Tectonophysics  
Volcanology





# Topical Sessions

## GEOMORPHOLOGY

### T1. Grand Canyon, Colorado Plateau, and Rocky Mountain Debates and Their Global Reverberations, 150 Years after Powell

**Cosponsors:** GSA Hydrogeology Division; GSA Structural Geology and Tectonics Division; GSA Quaternary Geology and Geomorphology Division; GSA Sedimentary Geology Division; GSA Geophysics and Geodynamics Division; GSA Geochronology Division

**Disciplines:** Geomorphology, Tectonics/Tectonophysics, Geophysics/Geodynamics

**Advocates:** Karl E. Karlstrom; Andres Aslan; Laura J. Crossey; Ryan Crow; Carol M. Dehler; Rebecca Dorsey; P. Kyle House; Eugene Humphreys; G. Randy Keller; Shari Kelley

Several sub-sessions on the Colorado Plateau–Rocky Mountain region will look back over the past century of geoscience progress, pose and evaluate debated “hot topics,” and look forward toward resolution of debates and their global reverberations.

### T2. Geomorphology and Climate Change in Hot Deserts

**Cosponsors:** GSA Quaternary Geology and Geomorphology Division; GSA Soils and Soil Processes Division

**Disciplines:** Geomorphology, Quaternary Geology, Paleoclimatology/Paleoceanography

**Advocates:** Mark R. Sweeney; Nick Lancaster; Eric V. McDonald

Geomorphic processes in hot deserts are dominated by extreme events. This session seeks presentations on any aspect of hot deserts, including fluvial-eolian interactions and processes, hillslope processes, geochronology, soil development, climate change, and vegetation dynamics.

### T3. Fluvial Responses to Perturbations at Varying Spatial and Temporal Scales

**Cosponsor:** GSA Quaternary Geology and Geomorphology Division

**Disciplines:** Geomorphology, Quaternary Geology, Environmental Geoscience

**Advocates:** Karen B. Gran; Stephanie S. Day

This session explores fluvial response to perturbations over different temporal and spatial scales. We welcome field, laboratory, and modeling studies, and encourage research that integrates how river responses to perturbations at different scales interact.

### T4. Eolian Processes and Landscape Evolution

**Cosponsors:** GSA Quaternary Geology and Geomorphology Division; GSA Sedimentary Geology Division; International Society for Aeolian Research; GSA Soils and Soil Processes Division

**Disciplines:** Geomorphology, Environmental Geoscience, Quaternary Geology

**Advocates:** Stephen A. Wolfe; Ian J. Walker

This session examines contemporary and past eolian processes within coastal, alpine, fluvial, tropical, arid, semi-arid, and cold-climate settings. Student presentations, and presentations on landscape evolution, ecosystem form and function, and environmental stressors, are encouraged.

### T5. Geomorphic and Hydrologic Processes in Post-Wildfire Environments: Drivers, Impacts, and Hazards

**Cosponsors:** GSA Quaternary Geology and Geomorphology Division; GSA Soils and Soil Processes Division

**Disciplines:** Geomorphology, Quaternary Geology, Soils

**Advocates:** Luke McGuire; Ann M. Youberg; Jason Williams; Joel B. Sankey

This session highlights how wildfire impacts fluxes of water, sediment, and pyrogenic debris across spatial and temporal scales. We encourage submissions addressing geomorphology, soil, hydrology, ecohydrology, and hazards in past, present, and future post-wildfire environments.

### T6. Ecologic, Hydrologic, and Geomorphic Connections in Alluvial River Systems

**Cosponsors:** GSA Quaternary Geology and Geomorphology Division; GSA Soils and Soil Processes Division

**Disciplines:** Geomorphology, Hydrogeology, Quaternary Geology

**Advocates:** Lyman P. Persico; Rebekah Levine

We seek to integrate current knowledge of how the dynamics between water, sediment, and organisms control alluvial river processes and shape river channel dynamics on both short- and long-term time scales.

## INDUSTRY TRACKS

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



Economic Geology



Energy



Engineering



Hydrogeology and Environmental Geology

### T7. Potential for Geopark Development in Saudi Arabia

**Disciplines:** Geomorphology, Archaeological Geology, Geoscience Education

**Advocates:** Ting Chen; Hussam Turki

Geoparks are single, unified geographical areas where sites and landscapes of international geological significance are managed with a holistic concept of protection, education, and sustainable development.

### T8. Statistical and Mathematical Approaches to Understanding Surface Processes and Stratigraphy

**Cosponsors:** *GSA Geoinformatics and Data Science Division*

**Disciplines:** Geomorphology, Stratigraphy, Sediments, Clastic

**Advocates:** Andrew J. Moodie; Tian Y. Dong

This session highlights research utilizing novel statistical, mathematical, and machine-learning approaches to address questions and challenges in the fields of surface processes and stratigraphy.

## QUATERNARY GEOLOGY

### T9. Tectonic and Climatic Disruption of Hydrological Systems as a Driver for Evolution of Biota and Ecosystems

**Cosponsor:** *GSA Hydrogeology Division*

**Disciplines:** Quaternary Geology, Paleontology, Diversity, Extinction, Origination, Tectonics/Tectonophysics

**Advocates:** Fred M. Phillips; Jeffrey R. Knott; Jeffrey S. Pigati; Kathleen B. Springer

We seek contributions documenting how tectonic and climatic changes have disrupted hydrological systems and how biota and ecosystems have evolved in response to this forcing. Comparison of organismal molecular clocks with geochronological data is of particular interest.

### T10. Novel Approaches to Sedimentology in the Anthropocene

**Disciplines:** Quaternary Geology, Sediments, Clastic, Marine/Coastal Science

**Advocates:** Zachary T. Sickmann; Cody C. Mason; Kelly Thomson

Recent sedimentary deposits record a diverse array of anthropogenic perturbations to natural systems. We encourage abstracts focused on new techniques or novel applications of sedimentological methods to understand such perturbations and predict their future implications.

### T11. Microbial and Organic Matter Signatures: Biophysical Feedbacks between Water, Sediment, and Biota

**Cosponsor:** *GSA Quaternary Geology and Geomorphology Division*

**Disciplines:** Quaternary Geology, Stratigraphy, Geomicrobiology

**Advocates:** Nicholas A. Sutfin; Ashley R. Manning-Berg

Interdisciplinary biophysical approaches have enhanced research in contemporary environments that serve as analogs for paleoenvironmental conditions. We seek abstracts investigating feedbacks between water, sediment, and biota occurring across all time scales (seconds to millennia).

### T12. Cordilleran Ice Sheet through the Quaternary: Chronology, Paleoenvironments, and Implications

**Cosponsor:** *GSA Quaternary Geology and Geomorphology Division*

**Disciplines:** Quaternary Geology, Archaeological Geology, Geochronology

**Advocates:** Brent C. Ward; Alia J. Lesnek

This session brings together observational and modeling studies on any aspect of the Cordilleran Ice Sheet and its associated paleoenvironments. Topics may include, but are not limited to, glacial geomorphology/stratigraphy, archaeology, paleoecology, and paleoglaciology.

### T13. Applications of High-Resolution Topographic Data to Geologic Hazards

**Cosponsor:** *GSA Quaternary Geology and Geomorphology Division*

**Disciplines:** Quaternary Geology, Geoinformatics, Geomorphology

**Advocates:** Emily Kleber; Christopher J. Crosby; J Ramón Arrowsmith; Samuel Johnstone

This session will highlight high-resolution topographic (HRT) analysis to investigate, monitor, and mitigate the effects of geologic hazards. Abstracts presenting mapping, landscape reconstruction, change detection, and other uses of HRT data are welcome.

### T14. Advances in Alpine Glacier Studies through Process and Chronology: In Honor of Gerald Osborn for His Career and Contributions to the Field

**Cosponsor:** *GSA Quaternary Geology and Geomorphology Division*

**Disciplines:** Quaternary Geology, Geomorphology, Paleoclimatology/Paleoceanography

**Advocates:** P. Thompson Davis; Eric Leonard; Brian Menounos; Douglas H. Clark

This session, in recognition of the long, distinguished career and contributions of Gerald Osborn, University of Calgary, focuses on the understanding of Earth's alpine glaciers, especially those in the western hemisphere, through multiple lenses, including process, chronology, and climate change.

## SOILS

### T15. Soil Forming Processes and Quaternary Landscape History

**Cosponsor:** *GSA Soils and Soil Processes Division*

**Disciplines:** Soils, Quaternary Geology, Geomorphology

**Advocates:** J.B.J. Harrison; Eric V. McDonald; Brad D. Sion

This session seeks studies using soil and geomorphic data to constrain the nature or timing of surficial process, including tectonic activity, climatic histories, records of sediment aggradation, rates and processes of erosion, and periglacial processes.



**T16. Building Bridges between Modern and Deep-Time Critical Zones**

**Cosponsors:** *GSA Soils and Soil Processes Division; GSA Hydrogeology Division; GSA Quaternary Geology and Geomorphology Division; GSA Karst Division*

**Disciplines:** Soils, Sediments, Clastic, Quaternary Geology  
**Advocates:** Ashlee Laura Denton Dere; Gary E. Stinchcomb; Zsuzsanna Balogh-Brunstad; Steven G. Driese; Lee C. Nordt; Bryan G. Moravec

This session seeks to build bridges in communication among researchers working in either modern or deep-time Critical Zones.

**PETROLOGY, IGNEOUS**

**T17. Small-Volume Cenozoic Volcanism of the Interior West of the United States**

**Cosponsor:** *GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division*

**Disciplines:** Petrology, Igneous, Volcanology, Geochronology  
**Advocates:** Tiffany A. Rivera; Brian R. Jicha

This session will highlight research focused on understanding the origin, evolution, eruption, and deposition of geologically recent small-volume volcanic products found in western North America.

**T18. The Solidification Path of Magma—Information from Igneous Rocks, Eruptions, and Experimental Petrology: In Honor of the Mineralogical Society of America Awardee for 2019, Olivier Namur**

**Cosponsor:** *Mineralogical Society of America*

**Disciplines:** Petrology, Igneous, Volcanology, Economic Geology  
**Advocates:** Michael D. Higgins; Bernard Charlier

Placing constraints on the solidification path of magma, or its liquid line of descent, is a key problem in igneous petrology: Information must be integrated from experimental reconstructions, together with decoding of the plutonic volcanic record.

**T19. Subduction Zone Systems: Geochemical, Petrochronological, and Geophysical Constraints on Lithospheric Structure, Composition, and Geodynamics**

**Cosponsors:** *GSA Structural Geology and Tectonics Division; GSA Geophysics and Geodynamics Division*

**Disciplines:** Petrology, Igneous, Geophysics/Geodynamics, Tectonics/Tectonophysics

**Advocates:** Antoine Triantafyllou; Mihai N. Ducea; Jonathan R. Delph; Mark K. Reagan

This session aims to provide new insights into the evolution of the lithosphere during subduction and collisional tectonics, through multidisciplinary contributions: petrochronology, geochemistry, experimental petrology, geophysical studies, and geodynamic modelling.

**T20. Rift-Grabens, Volcano-Sedimentary Strata, Plutons, and Transtensional Shear Zones: A Multi-Disciplinary Approach to Reconstructing the Jurassic Cordilleran Margin of the**

**Southwest U.S. (Southern California, Nevada, Arizona, and Northern Mexico)**

**Cosponsor:** *GSA Structural Geology and Tectonics Division*

**Disciplines:** Petrology, Igneous, Tectonics/Tectonophysics, Stratigraphy

**Advocates:** Michelle Gevedon; Diane Clemens-Knott

Contributions should elucidate the magmatic, tectonic, hydrothermal, or sedimentological histories of regions surrounding the Jurassic Cordilleran arc to better understand the timing, extent, and character of this extensional regime and its implications for margin evolution.

**T21. Reading Igneous Textures**

**Cosponsor:** *Mineralogical Society of America*

**Disciplines:** Petrology, Igneous, Mineralogy/Crystallography, Volcanology

**Advocates:** David London; Mona-Liza C. Sirbescu

This session is an open call to anyone working on aspects of igneous texture, from nanometer to macroscopic scales, on the basis of field, laboratory, or numerical studies. All igneous rocks are included.

**VOLCANOLOGY**

**T22. Basaltic Volcanism on Earth and Beyond: Exploring the Physical Controls on Eruptive Styles and Associated Deposits**

**Disciplines:** Volcanology, Planetary Geology, Petrology, Igneous

**Advocates:** Jean-Francois Smekens; Erika Rader; Amanda B. Clarke; Kurt Roggensack; Brett B. Carr

We welcome abstracts that investigate the causes and consequences of basaltic volcanism of all scales and styles, using two or more approaches, such as field, laboratory, and numerical techniques.

**PETROLOGY, METAMORPHIC**

**T23. Metamorphism and Orogenesis at Convergent Plate Margins**

**Cosponsor:** *GSA Structural Geology and Tectonics Division*

**Disciplines:** Petrology, Metamorphic, Tectonics/Tectonophysics

**Advocates:** Richard M. Palin; Kyle T. Ashley

Metamorphism at convergent plate margins imparts a fundamental control on the spatio-temporal evolution of collisional and accretionary orogens. We seek studies investigating drivers and/or petrological and tectonic implications of metamorphism of the continental crust.

**T24. Metamorphic Petrology Past, Present, and Future: Preparing for the Next 100 Years with the Mineralogical Society of America**

**Cosponsors:** *Mineralogical Society of America; GSA History and Philosophy of Geology Division*

**Disciplines:** Petrology, Metamorphic, Mineralogy/Crystallography, Geochronology

**Advocates:** Robert M. Holder; Mark J. Caddick; Sarah C. Penniston-Dorland

The metamorphic record is a crucial but complex archive of evolving geodynamic processes throughout earth history. In celebration of the Mineralogical Society of America centenary, this session will highlight past, recent, and future developments in metamorphic petrology.

### T25. A Life in Mineralogy and Petrology: A Session in Honor of Robert J. Tracy

**Cosponsors:** *GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; Mineralogical Society of America*

**Disciplines:** Petrology, Metamorphic, Mineralogy/Crystallography, Geochronology

**Advocates:** Kristin M. Dorfler; Michael Brown; Victor Guevara; Nancy L. Ross

In memory of Robert “Bob” Tracy, this session focuses on topics to which Bob dedicated his career, including the tectonics and petrology of New England, monazite geochronology, phase petrology, ultrahigh-temperature metamorphism, and cross-institutional leading-edge petrology research.

## MINERALOGY/CRYSTALLOGRAPHY

### T26. Visions of Minerals at the Nanoscale: In Honor of Mineralogical Society of America Roebling Medalist Peter R. Buseck

**Cosponsor:** *Mineralogical Society of America*

**Disciplines:** Mineralogy/Crystallography, Geochemistry, Environmental Geoscience

**Advocates:** Mihály Pósfai; Jill F. Banfield; Lindsay P. Keller

This session aims to present research using advanced imaging and spectroscopic techniques of nanoscale phenomena.

### T27. The Carbon Mineral Challenge: Assessing Four Years of the First Targeted, Worldwide Search for New Mineral Species

**Disciplines:** Mineralogy/Crystallography, Geoscience Information/Communication, Geochemistry

**Advocate:** Daniel R. Hummer

This session will highlight the results of the Carbon Mineral Challenge, a four-year collaboration between professional and amateur mineralogists to predict and discover new carbon-bearing mineral species.

### T28. Mineralogical Society of America at 100: The Many Faces of Tourmaline—From Crystallographic Complexity to Recorder of Crustal Evolution

**Cosponsor:** *Mineralogical Society of America*

**Disciplines:** Mineralogy/Crystallography, Petrology, Metamorphic, Geochemistry

**Advocates:** Darrell J. Henry; Barbara L. Dutrow

This session highlights advances in the understanding and utility of tourmaline, a quintessential crustal mineral, as a petrogenetic indicator. Topics encouraged span the spectrum of crystallography, mineralogy, petrology, geochemistry, geochronology, and others.

### 🇺🇸 T29. Mineralogical Society of America (MSA) at 100: Reflections, Refractions, Diffractions, Intrusions, Subductions, Reactions, etc., from MSA Past Presidents

**Cosponsor:** *Mineralogical Society of America*

**Disciplines:** Mineralogy/Crystallography, Petrology, Igneous, Petrology, Metamorphic

**Advocates:** Mickey E. Gunter; Carol D. Frost

The Mineralogical Society of America (MSA) celebrates its 100th anniversary in 2019. This session features presentations from those who successfully led MSA through these 100, and what can be done to assure another successful 100!

### T30. Gemological Research in the 21st Century—Gem Minerals and Localities

**Cosponsor:** *Gemological Institute of America*

**Disciplines:** Mineralogy/Crystallography, Economic Geology, Geoscience Information/Communication

**Advocates:** Caroline Nelms; James E. Shigley; Wuyi Wang; Barbara L. Dutrow; John W. Valley

Gemstones are among the most recognized of all minerals. This session focuses on diverse aspects of gems including exploration, formation conditions, properties, compositions, treatment, identification, diamond and its mineral inclusions, and their geological implications.

### T31. Deformation at Multiple Scales: From Atoms to Minerals to Rocks to Planets

**Cosponsor:** *Mineralogical Society of America*

**Disciplines:** Mineralogy/Crystallography, Tectonics/Tectonophysics, Planetary Geology

**Advocates:** Roberta L. Flemming; Phil J.A. McCausland

We welcome all investigations of deformation, using multiple techniques, at multiple scales, from any stress regime and geodynamic setting—tectonism to impacts. Only by integrating observations from all scales can we understand our planet.

### T32. Data-Driven Discovery of Carbon-Bearing and Other Earth Materials

**Cosponsor:** *GSA Geoinformatics and Data Science Division*

**Disciplines:** Mineralogy/Crystallography, Geochemistry, Planetary Geology

**Advocates:** Daniel R. Hummer; Grethe Hystad; Shaunna M. Morrison

This session will explore the diversity and relationships of solid earth materials found on Earth or other planetary bodies using large data resources and techniques.

### 🇺🇸 T33. Advances in Characterization of Uranium Minerals and Fuel Cycle Materials for Forensics, Safeguards, and Secure Disposal of Nuclear Waste

**Cosponsor:** *Mineralogical Society of America*

**Disciplines:** Mineralogy/Crystallography, Geochemistry, Energy Geology

**Advocates:** Tyler Spano; Travis Olds

Development of novel analytical methodologies is essential to understanding uranium minerals and materials relevant to the



## GSA 2019 ANNUAL MEETING & EXPOSITION

nuclear fuel cycle. This session explores recent advances and novel approaches to mineralogical challenges associated with the use of uranium as nuclear fuel.

### GEOCHEMISTRY

#### T34. Understanding Water Resources Related to Mineralized Uranium and Other Metal Deposits

**Cosponsor:** *GSA Hydrogeology Division*

**Disciplines:** Geochemistry, Environmental Geoscience, Hydrogeology

**Advocates:** Johanna M. Blake; Kimberly R. Beisner; Jose Cerrato

This session aims to share information about reactivity, mobility, and transport with water from mineralized sites. Presentations may include field, lab, and geochemical characterizations of mineralized deposits.

#### T35. Subduction Zone Magmatism from Source to Eruption, in the Lab and in the Field: In Honor of Christy Till, GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division Early Career Awardee

**Cosponsor:** *GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division*

**Disciplines:** Geochemistry, Petrology, Igneous

**Advocates:** Adam J.R. Kent; Michael J. Krawczynski

This session explores subduction zone magmatism via field and laboratory measurements, together with experimental studies at high pressure and temperature. The session honors GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division early career award winner Christy Till, who exemplifies this approach.

#### T36. Iron Formations, Ferruginous Sediments, and Redox through Time and Space

**Disciplines:** Geochemistry, Paleoclimatology/Paleoceanography, Economic Geology

**Advocates:** Athena Eyster; Latisha Ashley Brengman; Geoffrey J. Gilleaudeau

The temporal and spatial distribution of iron-rich sedimentary rocks records a complex interplay between the solid earth, atmosphere, and biosphere. We seek experimental, theoretical, and field-based contributions on Archean–Phanerozoic iron formations and ferruginous sediments.

#### T37. Investigating the Origin of Arc Magmatism and the Evolution of Continental Crust from the Aleutians to the Southern Andes: In Honor of Suzanne Mahlburg Kay, Recipient

#### of the Mineralogy, Geochemistry, Petrology, and Volcanology Division Distinguished Geological Career Award

**Cosponsor:** *GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division*

**Disciplines:** Geochemistry, Petrology, Igneous, Tectonics/Tectonophysics

**Advocates:** C. Brenhin Keller; Brian R. Jicha; Matthew Gorrington

Suzanne Kay has used petrology, geochemistry, and mineralogy to investigate arc magmatism and its relation to regional tectonics, crustal formation, and ore deposits. Contributions in these topics are welcome to celebrate her career and legacy.

#### T38. Effects of Mineral-Water Interface Complexity on Geochemical Processes: A Session in Honor of Mineralogical Society of America Awardee for 2018, Laura Nielsen Lammers

**Cosponsor:** *Mineralogical Society of America*

**Discipline:** Geochemistry

**Advocates:** Benjamin Gilbert; Donald J. DePaolo; Garrison Sposito; Rick Ryerson

Mineral surfaces in natural aqueous fluids contain or host defect sites, impurities, adsorbates, particles, or coatings that alter stability and reactivity. This session explores the influence of natural interfacial complexity on geochemical processes.

### GEOLOGY AND HEALTH

#### T39. Role of Microbes and Organic Matter in Trace and Redox Sensitive Elements and Their Mobilizations in Surface and Groundwater Systems

**Cosponsors:** *GSA Geology and Health Division; GSA Geobiology & Geomicrobiology Division; GSA Hydrogeology Division*

**Disciplines:** Geology and Health, Geomicrobiology, Hydrogeology

**Advocates:** Harshad Kulkarni; Saugata Datta; Karen Johannesson

This session will enhance our understanding of the roles of microbes and organic matter in biogeochemical cycling of trace and redox sensitive elements of health concerns in various environments.

### GEOMICROBIOLOGY

#### T40. Microbial Interactions with Sulfide Minerals

**Cosponsors:** *GSA Geobiology & Geomicrobiology Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Environmental and Engineering Geology Division*

**Disciplines:** Geomicrobiology, Environmental Geoscience, Mineralogy/Crystallography

**INDUSTRY TRACKS** Look for these icons, which identify sessions in the following areas:



Economic Geology



Energy



Engineering



Hydrogeology and  
Environmental Geology

**Advocates:** Daniel S. Jones; Joshua Feinberg

This session seeks to bring together field and laboratory studies using geochemical, genetic, and mineralogical approaches to understand the interactions between microorganisms and sulfide minerals within any geologic or anthropogenic environment and time scale.

### 🔥 T41. New Voices in Geobiology

**Cosponsor:** *GSA Geobiology & Geomicrobiology Division*

**Disciplines:** Geomicrobiology, Paleontology, Biogeography/Biostratigraphy, Environmental Geoscience

**Advocates:** Trinity L. Hamilton; Rowan C. Martindale; Victoria Petryshyn; Simon A.F. Darroch; Lydia S. Tackett; David Gold; Andrew D. Putt; Amanda Lynn Godbold

This session will bring together new research focusing on the interplay between geologic and biologic processes with a special emphasis on new field sites, novel materials/methods, and the development/refinement of proxies.

## GEOCHRONOLOGY

### 🕒 T42. Zircon and Beyond: Quantitative Methods for Characterizing Provenance in Modern and Ancient Sediment Routing Systems

**Cosponsors:** *GSA Geochronology Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division*

**Disciplines:** Geochronology, Sediments, Clastic, Mineralogy/Crystallography

**Advocates:** Paul J. Sylvester; A. Kate Souders; Zane Jobe; Glenn R. Sharman

Sedimentary “source-to-sink” models depend on quantitative methods for characterizing detrital provenance. We seek contributions that improve provenance interpretations, particularly using complementary, multi-mineral chronometers, isotope/chemical tracers, field-based datasets, and novel statistical or quantitative techniques.

### T43. Diversifying Geochronology: Innovations in Techniques, Applications, and Perspectives

**Cosponsors:** *GSA Geochronology Division; On To the Future; Association for Women Geoscientists; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Quaternary Geology and Geomorphology Division*

**Discipline:** Geochronology

**Advocates:** Julie C. Fosdick; Leah Morgan; George Gehrels; Alan D. Rooney

This session calls for abstracts themed around the broad array of innovations in techniques, applications, emerging instrumentation, building diversity in geochronology, and improving access to training and outreach opportunities. Contributions from students, early career scientists, and underrepresented groups are encouraged.

## ECONOMIC GEOLOGY

### 💰 T44. Sustainable Mineral Resource Management: Role of Geoscientists

**Cosponsor:** *Society of Economic Geologists*

**Discipline:** Economic Geology

**Advocate:** Abani Ranjan Samal

This session will address the role of geologists in mineral exploration and mining of a deposit, ensuring sustainable mineral resource management and enabling the mineral industry to deliver value and quality of life to society.

### 💰 T45. Porphyry Copper and Related Mineral Deposits of Arizona, the Basin and Range Province, and Beyond

**Cosponsors:** *GSA Environmental & Engineering Geology Division; Arizona Geological Society*

**Disciplines:** Economic Geology, Structural Geology, Geochemistry

**Advocates:** Sarah Elizabeth Baxter; Michael Conway

This session focuses on the geology of porphyry copper deposits, their related (and much larger) magmatic-hydrothermal systems, and their temporal evolution within and without the Basin and Range Province.

### 💰 T46. Investigations of Hydrothermal Systems: Advances and Challenges

**Cosponsor:** *GSA Hydrogeology Division*

**Disciplines:** Economic Geology, Geochemistry, Hydrogeology

**Advocates:** Martin S. Appold; Hector Lamadrid; Marek Locmelis

This session aims to highlight recent progress in the study of hydrothermal systems, including advances in methodologies, case studies of individual active and fossil hydrothermal systems, and the identification of future research needs.

### 💰 T47. A Metal Rhythm: Understanding Cyclical Processes in Mineralization

**Disciplines:** Economic Geology, Geochronology, Geochemistry

**Advocates:** Sean Gaynor; Josh Rosera; Celestine N. Mercer

Research increasingly shows that many economic ore deposits form via cyclical processes that commonly obscure their petrogenetic interpretation. This session seeks research illuminating cyclical relationships or petrologic evidence resistant to alteration to better delineate the pulsed histories of ore deposits.

## TECTONICS/TECTONOPHYSICS

### T48. Unconventional Ideas and Outrageous Hypotheses: In Honor of Warren B. Hamilton

**Cosponsor:** *GSA Structural Geology and Tectonics Division*

**Disciplines:** Tectonics/Tectonophysics, Structural Geology, Planetary Geology

**Advocates:** Gillian Foulger; K. Howard; Donna M. Jurdy

This is an interdisciplinary session to present and discuss new, innovative ideas from any branch of earth or planetary science, including field geology, geophysics, petrology, early evolution of Earth, and the geology of the terrestrial planets.

### 💰 🕒 T49. The Paradox Basin Revealed

**Cosponsors:** *GSA Structural Geology and Tectonics Division; GSA Sedimentary Geology Division; GSA Geochronology Division; GSA Quaternary Geology and Geomorphology Division*

**Disciplines:** Tectonics/Tectonophysics, Sediments, Clastic, Sediments, Carbonates

**Advocates:** Jessica A. Thompson Jobe; Katherine A. Giles

This session seeks multidisciplinary studies addressing Paleozoic–Quaternary evolution of the Paradox Basin and Four Corners Region, Southwestern U.S. We seek a range of outcrop, subsurface, and modeling studies that focus on lithospheric to surface processes.

### **T50. Structure and Tectonic Studies, from Outcrop to Supercontinent: In Honor of Ian Dalziel**

**Cosponsor:** *GSA Structural Geology and Tectonics Division*

**Disciplines:** Tectonics/Tectonophysics, Geophysics/Geodynamics, Stratigraphy

**Advocates:** B.M. Eglinton; Terry J. Wilson; Lawrence Lawver

Ian Dalziel has stimulated research by students and international collaborators over many years. He continues to motivate researchers in fields related to supercontinent cyclicity and the development of Antarctica, South America, and Africa. This session is to honor him.

### **T51. Shaping the Landscape: The Interaction between Fractures, Erosion, and Plate Tectonics**

**Cosponsors:** *GSA Structural Geology and Tectonics Division; GSA Quaternary Geology and Geomorphology Division*

**Disciplines:** Tectonics/Tectonophysics, Geomorphology, Quaternary Geology

**Advocates:** Cassandra A.P. Brigham; Chelsea Phipps Scott

Fractures in bedrock and sediment are often key to deciphering landscape history, geomorphic processes, and tectonics. This session will highlight the cross-disciplinary linkages between fracturing, erosion, and tectonics at different spatial and temporal scales.

### **T52. Quaternary Tectonics of the Eastern California Shear Zone**

**Cosponsors:** *GSA Structural Geology and Tectonics Division; GSA Quaternary Geology and Geomorphology Division; GSA Geophysics and Geodynamics Division*

**Disciplines:** Tectonics/Tectonophysics, Quaternary Geology, Geophysics/Geodynamics

**Advocates:** Andrew J. Cyr; Victoria E. Langenheim; Michael E. Oskin

This session will focus on the bedrock, surficial geologic, and geophysical evidence for the distribution of Quaternary slip and related deformation across the Mojave Desert portion of the Eastern California Shear Zone.

### **T53. Present-Day and Ancient Flat-Slab Subduction in Rock Records, Geophysical Images, and Geodynamic Models**

**Cosponsor:** *GSA Structural Geology and Tectonics Division*

**Disciplines:** Tectonics/Tectonophysics, Geophysics/Geodynamics, Geochronology

**Advocates:** Yiduo Liu; Tyson Michael Smith

Flat-slab subduction is observed in the present day and proposed for past, subduction zones all over the world. A global appraisal of flat-slabs helps us better evaluate the observations versus model predictions, and commonalities versus differences.

### **§ T54. Origin and Evolution of Proterozoic Lithosphere in the Western United States**

**Cosponsor:** *GSA Structural Geology and Tectonics Division*

**Disciplines:** Tectonics/Tectonophysics, Structural Geology, Petrology, Metamorphic

**Advocates:** Graham B. Baird; Kevin H. Mahan; Yvette D. Kuiper; Richard M. Palin

The Proterozoic rocks of the Western U.S. record a long history of magmatic, metamorphic, and deformation processes. This session welcomes any presentation that offers insight into the tectonic origin and history of these rocks.

### **T55. New Perspectives on Integrating Fault Zone Behavior through the Full Thickness of the Continental Lithosphere**

**Cosponsors:** *GSA Structural Geology and Tectonics Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Geophysics and Geodynamics Division*

**Disciplines:** Tectonics/Tectonophysics, Structural Geology, Geophysics/Geodynamics

**Advocates:** Keith A. Klepeis; Elena A. Miranda; Joshua J. Schwartz; Laura E. Webb; Harold Stowell

This session focuses on research aimed at determining how deformation in faults and shear zones connects vertically through continental lithosphere from Earth's surface to the upper mantle. We seek contributions from any observational, analytical, or modeling perspective.

### **§ T56. New Developments in the Appalachian-Caledonian-Variscan Orogen**

**Cosponsor:** *GSA Structural Geology and Tectonics Division*

**Disciplines:** Tectonics/Tectonophysics, Structural Geology, Geochronology

**Advocates:** Yvette Kuiper; R. Damian Nance; J. Brendan Murphy; Rob Strachan

We welcome any contributions including new data and/or interpretations based on work in the Appalachian-Caledonian-Variscan orogen along the eastern and northern margins of North America and in Europe and Africa.

### **§ T57. Low-Angle Subduction beneath the Cordillera**

**Cosponsors:** *GSA Structural Geology and Tectonics Division; GSA Geochronology Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division*

**Disciplines:** Tectonics/Tectonophysics, Geochronology, Volcanology

**Advocates:** Nikki M. Seymour; Carl E. Jacobson; Alan D. Chapman; Marty J. Grove

Low-angle subduction has been tied to a range of features, including subduction complexes, basement-cored uplifts, and extensive volcanism. We encourage contributions that integrate results from mapping, petrology, geochronology, geochemistry, and geophysics to produce a holistic view of low-angle subduction processes.



🇺🇸 🕒 **T58. Late Cretaceous to Early Paleogene Tectonic Development of the North American Cordillera**

**Cosponsors:** *GSA Structural Geology and Tectonics Division; GSA Sedimentary Geology Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Geochronology Division; GSA Geophysics and Geodynamics Division*

**Disciplines:** Tectonics/Tectonophysics, Structural Geology, Stratigraphy

**Advocates:** John S. Singleton; Scott M. Johnston; Emily S. Finzel; David M. Pearson

Subduction-related magmatism, underplating, orogenesis, and margin-parallel translation characterized the North American Cordillera in the Late Cretaceous–early Paleogene. This tectonics-focused session will highlight new insights from Alaska to Mexico, including plate motion/geometry, deformation, magmatism, and sedimentation.

🇺🇸 🕒 🌊 **T59. Integrated Tectono-Sedimentary Records in the Tibetan Plateau and Adjacent Areas**

**Cosponsors:** *GSA Sedimentary Geology Division; GSA International*

**Disciplines:** Tectonics/Tectonophysics, Sediments, Clastic, Stratigraphy

**Advocates:** Feng Cheng; Andrew V. Zuza; Ryan J. Leary

This session provides an opportunity to present new results and integrate them into a comprehensive understanding of the dynamics of tectono-sedimentary systems in the Tibetan Plateau and adjacent areas.

🇺🇸 **T60. Initiation of Plate Boundaries: Insights from Geologic, Geophysical, and Numerical Modeling Studies**

**Cosponsors:** *GSA Structural Geology and Tectonics Division; GSA Quaternary Geology and Geomorphology Division*

**Disciplines:** Tectonics/Tectonophysics, Structural Geology, Petrology, Igneous

**Advocates:** Timothy M. Kusky; Zhong-Hai Li; Erdin Bozkurt; Osman Parlak; John F. Dewey

A major unsolved problem in geodynamics is how plate boundaries initiate. We will bring together geologists, geophysicists, and numerical modelers to document examples of plate boundary initiation and test their viability using numerical models.

🇺🇸 **T61. Fossil Magnetism and Paleopoles; Tectonics, Stratigraphy, Geochronology, and Geomorphology; Geoscience Challenges and Education: A Celebration of John Geissman's Career**

**Cosponsors:** *GSA Structural Geology and Tectonics Division; GSA Geophysics and Geodynamics Division; GSA Sedimentary Geology Division; GSA Quaternary Geology and Geomorphology Division; GSA Geochronology Division*

**Disciplines:** Tectonics/Tectonophysics, Geophysics/Geodynamics, Stratigraphy

**Advocates:** Alexis K. Ault; Stephen S. Harlan

This session celebrates the science and service legacy of John Geissman's multifaceted career. Contributions combining

structural geology, paleomagnetism, geochronology, and geomorphology to address grand challenges and celebrate his commitment to the scientific community are encouraged.

🇺🇸 **T62. Exploring Connections between Extension, Sedimentation, and Volcanism in the Rio Grande Rift**

**Cosponsors:** *GSA Structural Geology and Tectonics Division; GSA Sedimentary Geology Division; GSA Geophysics and Geodynamics Division; New Mexico Geological Society; Southern Rift Institute–New Mexico State University*

**Disciplines:** Tectonics/Tectonophysics, Stratigraphy, Volcanology

**Advocates:** Brian A. Hampton; Jeffrey M. Amato; Reed J. Burgette; Emily R. Johnson

This cross-disciplinary session explores emerging ideas about tectonic processes that shaped the Eocene–present evolution of the Rio Grande rift in southwestern North America. Studies utilizing structural geology, volcanology, sedimentology, geochronology, and geophysics are encouraged.

**T63. Subduction Top to Bottom 2 (ST2B-2), Modern and Ancient**

**Cosponsor:** *GSA Structural Geology and Tectonics Division*

**Discipline:** Tectonics/Tectonophysics

**Advocates:** David W. Scholl; Gray E. Bebout; Robert J. Stern; Laura Wallace

This session presents geological, geophysical, geochemical, and theoretical advancements and promising directions for subduction zone research, emphasizing the study of both modern (active) subduction zones and rock bodies thought to be ancient (fossil) ones.

**T64. Celebrating the Legacy of Professor Eldridge Moores in Global Tectonics and Societal Relevance of Geosciences**

**Cosponsors:** *GSA History and Philosophy of Geology Division; GSA Structural Geology and Tectonics Division; GSA Geology and Society Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA International; Geological Society of London; Geological Society of China*

**Disciplines:** Tectonics/Tectonophysics, History and Philosophy of Geology, Geoscience and Public Policy

**Advocates:** Yildirim Dilek; John Wakabayashi

We welcome contributions on all aspects of global tectonics, ophiolites, orogenic belts, Precambrian geology, and science for society to reflect on the scientific impact of Eldridge Moores on our research and to celebrate his distinguished career.

**PRECAMBRIAN GEOLOGY**

🇺🇸 **T65. Precambrian Linkages across Laurentia: Looking for Geological, Geophysical, and Paleogeographic Connections and Controversies Associated with the Growth and Tectonic Evolution of Laurentia from the Neoproterozoic to the Neoproterozoic**

**Cosponsors:** *GSA Structural Geology and Tectonics Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology*

## GSA 2019 ANNUAL MEETING & EXPOSITION

*Division; GSA Geochronology Division; GSA Geophysics and Geodynamics Division*

**Disciplines:** Precambrian Geology, Tectonics/Tectonophysics, Geochronology

**Advocates:** Ruth F. Aronoff; Christopher G. Daniel; Michael F. Doe; Alexander Iriondo; Jeff D. Vervoort; Michael L. Williams

We welcome contributions that examine and discuss geological, geophysical, and paleogeographic connections and controversies concerning the Precambrian tectonic evolution of the Laurentian margin.

### T66. Life and Death of a Craton: Implications of Archean Crust-Keel Systems for Crustal Growth, Crustal Preservation, and Mantle Evolution

**Cosponsors:** *GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Structural Geology and Tectonics Division; GSA Geochronology Division; GSA Planetary Geology Division; GSA Geobiology & Geomicrobiology Division; GSA Sedimentary Geology Division; GSA Geophysics and Geodynamics Division*

**Disciplines:** Precambrian Geology, Geochemistry, Tectonics/Tectonophysics

**Advocates:** Paul A. Mueller; Carol D. Frost; Jennifer N. Gifford; David W. Mogk

Archean crust-keel systems record the earliest stages of evolution of modern earth systems, including: earliest geodynamics, compositional and structural evolution of continental crust, chemical and isotopic evolution of the silicate earth, and early surficial systems.

## GEOPHYSICS/GEODYNAMICS

### T67. Volcanic Stratigraphy at Extensional Zones

**Cosponsors:** *GSA Geophysics and Geodynamics Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division*

**Disciplines:** Geophysics/Geodynamics, Volcanology, Tectonics/Tectonophysics

**Advocates:** Anahita Tikku; Christian Heine

This session will focus on observational data and models that relate to understanding the stratigraphy of volcanic flows in extensional zones and the relationship to the dynamics of flow emplacement.

### T68. Recent Advances in Applied Geophysics for Mineral and Resource Exploration and Assessment

**Cosponsors:** *GSA Geophysics and Geodynamics Division; Society of Economic Geologists; GSA Energy Geology Division; GSA Hydrogeology Division*

**Disciplines:** Geophysics/Geodynamics, Economic Geology, Energy Geology

**Advocate:** Kevin L. Mickus

Presentations are encouraged that highlight the latest geophysical methods for the exploration and assessment of mineral, energy, and groundwater resources.

### T69. New Geological Insights Revealed by Dense Geophysical Data

**Cosponsors:** *GSA Geophysics and Geodynamics Division; GSA Structural Geology and Tectonics Division; GSA Geoinformatics and Data Science Division*

**Disciplines:** Geophysics/Geodynamics, Structural Geology, Tectonics/Tectonophysics

**Advocates:** Ting Chen; Catherine M. Snelson; Robert Mellors

Geophysical data collected at high spatial resolution provide new insights into the understanding of geological processes. We welcome contributions that focus on the method and applications of dense geophysical data to various geological problems.

### T70. New Advances in Using Near-Surface Geophysics to Solve Geological Problems

**Cosponsors:** *GSA Geophysics and Geodynamics Division; GSA Hydrogeology Division; GSA Geoarchaeology Division; GSA Soils and Soil Processes Division; GSA Environmental & Engineering Geology Division; GSA Karst Division; GSA Quaternary Geology and Geomorphology Division*

**Disciplines:** Geophysics/Geodynamics, Environmental Geoscience, Engineering Geology

**Advocate:** Kevin L. Mickus

This session encourages presentations using all types of near-surface geophysical methods to study near-surface environmental, engineering, hydrological, karst, geological, and geoarchaeological problems.

## STRUCTURAL GEOLOGY

### T71. The New Appalachians: Cenozoic Deformation, Drainage Reorganization, and Landscape Disequilibrium in a Paleozoic Orogen

**Cosponsor:** *GSA Structural Geology and Tectonics Division*

**Disciplines:** Structural Geology, Geomorphology, Tectonics/Tectonophysics

**Advocates:** Kevin G. Stewart; Mervin J. Bartholomew

This session will include presentations from a wide variety of disciplines, including geomorphology, structural geology, geophysics, and geochronology, all aimed at understanding the Cenozoic history of the central and southern Appalachians.

**INDUSTRY TRACKS** Look for these icons, which identify sessions in the following areas:



Economic Geology



Energy



Engineering



Hydrogeology and  
Environmental Geology

## T72. Subduction-Related Deformation

**Cosponsor:** *GSA Structural Geology and Tectonics Division*

**Disciplines:** Structural Geology, Tectonics/Tectonophysics, Geophysics/Geodynamics

**Advocates:** Juliet G. Crider; John Wakabayashi

Subduction deforms the lithosphere in the subducting slab, accretionary wedge, forearc, arc, and backarc. We encourage contributions regarding structural, geomorphic, and geophysical observations of lithospheric deformation in subduction settings, on- or off-shore, ancient or active.

## T73. Structural Geology in the 21st Century: Rheology of Naturally Deformed Rocks

**Cosponsor:** *GSA Structural Geology and Tectonics Division*

**Disciplines:** Structural Geology, Tectonics/Tectonophysics, Geophysics/Geodynamics

**Advocates:** Basil Tikoff; Whitney M. Behr

The rheology of naturally deformed rocks exhibits wide temporal and spatial variations. We seek contributions that address any aspect of rock rheology from any tectonic setting, or studies that combine experimental and natural samples.

## T74. Structural Geology and Geomechanics in Applied Geosciences

**Cosponsors:** *GSA Structural Geology and Tectonics Division; GSA Energy Geology Division; GSA Environmental & Engineering Geology Division; American Association of Petroleum Geologists Structural Geology and Geomechanics Division*

**Disciplines:** Structural Geology, Energy Geology, Engineering Geology

**Advocates:** J. Steve Davis; Kellen Gunderson; Andreas Eckert; Amanda Hughes

This session highlights structural geology and geomechanics research and applications in energy, mining, geological engineering, and environmental geology. Applications of structural analysis, computational kinematic and dynamic deformation modeling, geomechanics, and fracture and fault characterization are encouraged.

## T75. Large-Volume Pluton Emplacement Processes within Fold-and-Thrust Belts: Testing Models with New Perspectives

**Disciplines:** Structural Geology, Tectonics/Tectonophysics, Petrology, Igneous

**Advocates:** David Lageson; Andrew Laskowski

How are plutons emplaced into continental crust that is undergoing tectonic shortening? Do they result in crustal growth or material transfer? This session highlights research on these broad topics from broad perspectives.

## T76. How Old, How Long, and How Fast: Establishing the Timing, Duration, and Rates of Mid- to Lower-Crustal Deformation

**Cosponsors:** *GSA Structural Geology and Tectonics Division; GSA Geochronology Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division*

**Disciplines:** Structural Geology, Geochronology, Petrology, Metamorphic

**Advocates:** Amy C. Moser; Tarryn Cawood; Calvin A. Mako

We encourage contributions that develop or apply novel techniques to directly date or bracket the timing of mid- to lower-crustal deformation and abstracts that constrain the duration, rates, and evolution of high-temperature deformation.

## T77. From Oceanic Subduction to Inter-Continental Collision: Examples of Convergent Margin Processes in Non-Collisional and Collisional Settings

**Cosponsor:** *GSA Structural Geology and Tectonics Division*

**Disciplines:** Structural Geology, Tectonics/Tectonophysics, Petrology, Metamorphic

**Advocates:** Michael H. Taylor; Paul A. Kapp; Michael Murphy

Convergent margins encompass many of Earth's plate boundaries. We suggest that collisional margins such as the Himalayan-Tibetan orogen can shed light on processes acting during the transition from Andean-style subduction to inter-continental collision.

## T78. Folding: Processes, Observations, and Consequences

**Cosponsor:** *GSA Structural Geology and Tectonics Division*

**Disciplines:** Structural Geology, Tectonics/Tectonophysics

**Advocates:** Caroline M. Burberry; Amanda Hughes; Andreas Eckert

We encourage contributions investigating the processes of folding on multiple scales. We seek contributions from field, analytical, and modeling studies investigating causes and consequences of folding in the contexts of tectonic history, crustal deformation, rheology, landscape evolution, or fluid migration.

## T79. Combining Analog and Numerical Modeling Approaches to Understand the World around Us (Posters)

**Disciplines:** Structural Geology, Tectonics/Tectonophysics

**Advocates:** Caroline M. Burberry; Eunseo Choi

This session will showcase analog and numerical modeling experiments that seek to leverage knowledge gained by working in tandem to model earth processes on a variety of scales.

## T80. Best Student Geologic Mapping Competition (Posters)

**Cosponsors:** *Association of American State Geologists; U.S. Geological Survey–National Cooperative Geologic Mapping Program; Geological Society of America; GSA Foundation; American Geosciences Institute; American Institute of Professional Geologists; Journal of Maps*

**Disciplines:** Structural Geology, Stratigraphy, Geomorphology

**Advocates:** Darcy K. McPhee; Michael Marketti

Students will present their research through geologic mapping projects that have a significant field component that addresses scientific or societal issues. The top three geologic maps will be awarded.



## STRATIGRAPHY

### T81. Hello (Ancient) World!: Exploring the Neoproterozoic to Cambrian Interval by Quantitatively Probing the Rock Record

**Disciplines:** Stratigraphy, Precambrian Geology, Sediments, Carbonates

**Advocates:** Akshay Mehra; Bolton Howes; Ryan Manzuk

Neoproterozoic to Cambrian strata contain ambiguous and enigmatic signals of a tumultuous time in earth history. How can novel quantitative data collection and analysis techniques help decode the events of this interval?

### 🕒 T82. Chemostratigraphy: Physical and Temporal Applications

**Cosponsors:** North American Commission on Stratigraphic Nomenclature; SEPM (Society for Sedimentary Geology)

**Disciplines:** Stratigraphy, Geochemistry, Paleontology, Biogeography/Biostratigraphy

**Advocates:** Richard H. Fluegeman; Robert W. Scott; Carlton E. Brett; Brian R. Pratt

This session will focus on the use of chemical records preserved in sedimentary deposits for correlation, but will also showcase other applications of chemostratigraphy in the solution of diverse geologic problems.

### 🕒 T83. Advances in Using Sedimentary Data to Constrain the Timing and Rates of Geologic Events and Processes

**Cosponsors:** GSA Sedimentary Geology Division; GSA Geochronology Division; GSA Structural Geology and Tectonics Division

**Disciplines:** Stratigraphy, Geochronology, Tectonics/Tectonophysics

**Advocates:** Theresa M. Schwartz; Matthew A. Malkowski; Glenn R. Sharman

We encourage abstracts that highlight innovative uses of sedimentary data (e.g., isotopic, geochronologic) to constrain the timing and rates of geologic events and processes. Studies focused on a broad range of geologic time scales, settings, and methods are welcome.

## SEDIMENTS, CLASTIC

### 🔥 T84. Scientific Ocean Drilling's Impact on Geoscience: Past, Present, and Future

**Cosponsors:** GSA Continental Scientific Drilling Division; GSA Geobiology & Geomicrobiology Division; GSA Geochronology Division; GSA Geology and Society Division; GSA Geoscience Education Division; GSA Geophysics and Geodynamics Division; GSA History and Philosophy of Geology Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA International; Cushman Foundation; GSA Sedimentary Geology Division; GSA Hydrogeology Division; GSA Structural Geology and Tectonics Division; SEPM (Society for Sedimentary Geology)

**Disciplines:** Sediments, Clastic, Paleoclimatology/Paleoceanography, Tectonics/Tectonophysics

**Advocates:** Suzanne OConnell; Ken Miller; David Mallinson; James D. Wright

Scientific Ocean Drilling, an international ocean discovery program, has been seminal in developing our understanding of earth systems. This session will provide an overview of past and current accomplishments and highlight future opportunities.

### 💰🕒 T85. Laurentian Evolution during the Late Mississippian to Early Permian: Interactions and Feedbacks between Tectonism, Climate, and Sedimentary Systems

**Cosponsors:** SEPM (Society for Sedimentary Geology); GSA Structural Geology and Tectonics Division

**Disciplines:** Sediments, Clastic, Structural Geology, Tectonics/Tectonophysics

**Advocates:** Daniel M. Sturmer; Tandis S. Bidgoli; Mike Blum; Gerilyn S. Soreghan; Ryan J. Leary; Paul J. Umhoefer; M. Elliot Smith

In this session, we seek to explore the interplay of tectonism, climate, and sedimentation during the Late Mississippian to early Permian in Laurentia. We encourage contributions from the depositional system scale to the plate scale.

### 🕒🔥 T86. Inverting Source from Sink: Decoding Sedimentary Records of Climate, Erosion, and Vegetation

**Cosponsors:** GSA Quaternary Geology and Geomorphology Division; GSA Sedimentary Geology Division; GSA Soils and Soil Processes Division; GSA Karst Division

**Disciplines:** Sediments, Clastic, Geomorphology, Paleoclimatology/Paleoceanography

**Advocates:** Joanmarie Del Vecchio; Troy Ferland; Sarah A. Schanz; Matthew Cross Jungers

Climate, vegetation, and erosion stories of the past are told through sedimentary records that comprise the interactions between these very forces. How can we disentangle the causal relationships between these factors?

## SEDIMENTS, CARBONATES

### 🕒🔥 T87. GSA Sedimentary Geology Division/SEPM (Society for Sedimentary Geology) Student Research Poster Competition: Dynamics of Stratigraphy and Sedimentation (Posters)

**Cosponsors:** GSA Sedimentary Geology Division; SEPM (Society for Sedimentary Geology)

**Disciplines:** Sediments, Carbonates, Sediments, Clastic, Stratigraphy

**Advocate:** Amy L. Weislogel

Students (at any level) may present posters of original research on any topics within sedimentary geology: carbonates, clastics, chemical sediments, and ancient and/or modern systems. Posters are judged for monetary awards distributed at the "Seds and Suds" reception.

## PLANETARY GEOLOGY

### T88. The InSight Mission to Mars: Geology of the Landing Site

**Cosponsor:** *GSA Planetary Geology Division*

**Disciplines:** Planetary Geology, Geomorphology

**Advocates:** John A. Grant; Matthew P. Golombek; Sharon A. Wilson; Nicholas H. Warner

This session will use lander and/or orbital data to explore the range of geomorphic processes, including impact, eolian, and mass wasting, that modified the surface of the InSight landing site on Mars.

### T89. The G.K. Gilbert Award Session

**Cosponsor:** *GSA Planetary Geology Division*

**Discipline:** Planetary Geology

**Advocates:** Bradley J. Thomson; Sharon A. Wilson; Emily S. Martin

This session will honor the 2019 winner of GSA's Planetary Geology Division's G.K. Gilbert Award, highlighting recent contributions in the awardee's field of research.

### T90. The Big Picture from Small Bodies: Dwarf Planets, Asteroids, and Comets

**Cosponsor:** *GSA Planetary Geology Division*

**Disciplines:** Planetary Geology, Geomorphology, Structural Geology

**Advocates:** Jennifer E.C. Scully; Debra L. Buczkowski; David A. Williams; Kynan H.G. Hughson

We welcome presentations about Vesta, Ceres, Pluto, Ultima Thule, Bennu, Ryugu, 67P, and more, using data from spacecraft, telescopes, models, and laboratories to learn about the objects themselves and the evolution of the solar system.

### T91. Shake 'n Break: Volcanism and Tectonism through the Solar System

**Cosponsor:** *GSA Planetary Geology Division*

**Disciplines:** Planetary Geology, Volcanology, Tectonics/Tectonophysics

**Advocates:** Debra L. Buczkowski; Paul K. Byrne; Christian Klimczak; Danielle Y. Wyrick

This session solicits abstracts on volcanic, tectonic, or volcano-tectonic landforms and processes on solar system bodies, and encompasses surface geology, interior and thermal evolution, and comparative planetary studies with observational, experimental, or theoretical approaches.

### T92. Remote Sensing of Mineralogy on the Earth and Planets

**Cosponsor:** *GSA Planetary Geology Division*

**Disciplines:** Planetary Geology, Mineralogy/Crystallography, Economic Geology

**Advocates:** John C. Mars; William H. Farrand

Remote mapping and characterization of surface mineralogy has been enabled through hyperspectral remote sensing. Applications and examples of detailed mineralogical information derivable through these technologies will be presented.

### T93. Lunar Reconnaissance Orbiter: Ten Years Exploring the Moon

**Cosponsor:** *GSA Planetary Geology Division*

**Disciplines:** Planetary Geology, Tectonics/Tectonophysics, Volcanology

**Advocates:** Jeffrey B. Plescia; Mark S. Robinson; Jaclyn D. Clark

Recent observations have fundamentally changed our view of the Moon; it is an even more complex body than previously recognized. The session focuses on the recent discoveries, arising new questions, and future measurements.

### T94. Impact Cratering: A Most Penetrating Geologic Process

**Cosponsors:** *GSA Planetary Geology Division; GSA Continental Scientific Drilling Division; GSA Geophysics and Geodynamics Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Structural Geology and Tectonics Division*

**Disciplines:** Planetary Geology, Structural Geology, Petrology, Metamorphic

**Advocates:** Jeffrey B. Plescia; Christian Koeberl

Impact cratering is a key geologic process across the solar system. This session focuses on the geologic, geochemical, and geophysics signatures of impacts, impact flux, and implications for geologic evolution.

### T95. Geomorphology and Landscape Evolution of Mars: Insight into the Climate History of the Red Planet

**Cosponsors:** *GSA Planetary Geology Division; GSA Soils and Soil Processes Division; GSA Quaternary Geology and Geomorphology Division*

**Disciplines:** Planetary Geology, Geomorphology, Stratigraphy

**Advocates:** Sharon A. Wilson; Marisa Palucis; Nicholas P. Lang; Elena Favaro

This session welcomes abstracts on fluvial, alluvial, and lacustrine landforms that use orbital and/or rover data to investigate the geomorphology, geology, and climate history of Mars, as well as related Earth analogue studies.

### T96. Friends of Hoth: Episode IV—Bodies of the Outer Solar System

**Cosponsor:** *GSA Planetary Geology Division*

**Discipline:** Planetary Geology

**Advocates:** Emily S. Martin; D. Alex Patthoff

We welcome abstracts relating to surface, impact, structural, and tectonic processes; interior and thermal evolution; and planetary analogs as they pertain to solid bodies in the outer solar system. This includes experimental, observational, and theoretical approaches.

### T97. Dynamic Moon: Redefining Surface Evolution with a Decade of Lunar Reconnaissance Orbiter Observations

**Cosponsor:** *GSA Planetary Geology Division*

**Disciplines:** Planetary Geology, Geochemistry, Geophysics/Geodynamics

**Advocates:** Jaelyn D. Clark; Emerson Speyerer

The first 10 years of the Lunar Reconnaissance Orbiter mission have changed our perspective with the discovery of young tectonism, new impact craters, and ephemeral alterations to the lunar surface that can now be measured.

**T98. Best Practices and Exciting Discoveries in Identifying, Mapping, and Analyzing Planetary Landforms and Terrestrial Analogues**

**Cosponsors:** *GSA Planetary Geology Division; U.S. Geological Survey Astrogeology Center; GSA Quaternary Geology and Geomorphology Division*

**Disciplines:** Planetary Geology, Tectonics/Tectonophysics, Volcanology

**Advocates:** Kelsey T. Crane; Jeannette M. Wolak; Nicholas P. Lang

We welcome abstracts that investigate the methodology of planetary and terrestrial landform analysis or that explore and utilize these methodologies as a means of achieving insight into the evolution of those landforms.

**T99. Aeolian Activity across Our Solar System**

**Cosponsor:** *GSA Planetary Geology Division*

**Disciplines:** Planetary Geology, Sediments, Clastic, Geomorphology

**Advocates:** Mackenzie D. Day; Matthew Chojnacki; Serina Diniega; Sharon A. Wilson

Aeolian activity has been identified or suggested on seven different bodies in our solar system. We explore the forefront of aeolian research by bringing together topics related to Earth, planetary, modern, and ancient aeolian geoscience.

**PALEONTOLOGY**

**T100. Phylogenetic Paleobiology: Good Things Come in Trees**

**Cosponsors:** *Paleontological Society; Paleontological Research Institution*

**Disciplines:** Paleontology, Phylogenetic/Morphological Patterns, Paleontology, Diversity, Extinction, Origination

**Advocates:** Erik A. Sperling; Sandra J. Carlson; David W. Bapst; Selina R. Cole; Jeffrey R. Thompson; William Gearty; April Wright; Peter Wagner; David F. Wright; Curtis R. Congreve

Applying phylogenetic techniques to paleontological questions has revolutionized our understanding of evolutionary and ecological trends. This session welcomes talks on any aspect of phylogenetic paleobiology (including but not limited to morphological, ecological, molecular, biogeographical, etc.).





**T101. Ediacaran Body Builders: Form and Function within the Earliest Complex Communities**

**Cosponsor:** *Paleontological Society*

**Disciplines:** Paleontology, Phylogenetic/Morphological Patterns, Paleontology, Paleoecology/Taphonomy, Paleontology, Diversity, Extinction, Origination

**Advocates:** Scott D. Evans; Christine M.S. Hall

This session will explore the morphology, growth, and development of fossil organisms from the Ediacara biota. We also welcome submissions investigating the ecology of these early complex forms or how they were preserved.

    **T102. X-ray Computed Tomography in the Earth Sciences**

**Disciplines:** Paleontology, Paleoecology/Taphonomy, Sediments, Clastic

**Advocate:** Ria L. Mitchell

X-ray computed tomography (X-ray CT) has emerged as a leading technique within the earth sciences, with applications ranging from paleontology, soil science, and beyond. This session will cover the broad and varied range of applications.

**T103. Refining Terrestrial Ecosystem Evolution through Scientific Drilling**

**Cosponsors:** *GSA Continental Scientific Drilling Division; GSA Sedimentary Geology Division; GSA Geochronology Division; SEPM (Society for Sedimentary Geology)*

**Disciplines:** Paleontology, Paleoecology/Taphonomy, Paleoclimatology/Paleoceanography, Sediments, Clastic

**Advocates:** Christopher J. Campisano; Christopher J. Lepre; Cynthia M. Liutkus-Pierce

This session will explore the evidence for ecosystem evolution collected via continental scientific drilling. Records from any epoch and location are welcome, and we seek presentations from diverse fields related to geochronology, paleoclimatology, and paleoecology.

**T104. Paleobiogeographic and Paleocological Trends in the Fossil Record**

**Cosponsor:** *Paleontological Society*

**Disciplines:** Paleontology, Paleoecology/Taphonomy, Paleontology, Biogeography/Biostratigraphy, Paleontology, Phylogenetic/Morphological Patterns

**Advocates:** Sarah L. Sheffield; Jennifer E. Bauer

This session highlights recent work in macroevolutionary paleobiogeographic and paleoecologic trends in the fossil record. We encourage submissions from all time periods and taxonomic groups.

**INDUSTRY TRACKS** Look for these icons, which identify sessions in the following areas:



Economic Geology



Energy



Engineering



Hydrogeology and Environmental Geology



### T105. Cephalopods through Time: Paleobiology, Paleoecology, and Links to Paleoenvironmental Change

**Cosponsors:** *Paleontological Society; Paleontological Research Institution; SEPM (Society for Sedimentary Geology)*

**Disciplines:** Paleontology, Paleoecology/Taphonomy, Paleontology, Diversity, Extinction, Origination, Paleontology, Biogeography/Biostratigraphy

**Advocates:** James D. Witts; Corinne Myers

This session will highlight research on fossil and modern cephalopod mollusks, with a focus on understanding their paleobiology and the effects of Phanerozoic environmental changes on the fossil record of this diverse clade.

### T106. Biogeochemical Signatures of Fossils: From Paleoclimate to Diagenesis

**Cosponsors:** *GSA Geobiology & Geomicrobiology Division; GSA Soils and Soil Processes Division*

**Disciplines:** Paleontology, Paleoecology/Taphonomy, Paleoclimatology/Paleoceanography, Soils

**Advocate:** John David Fortner

This session brings together research focused on the chemistry of fossil soils and organisms, spanning marine to terrestrial environments, as well as their depositional and subsequent burial environments.

### T107. Volcanism, Impacts, and Phanerozoic Mass Extinctions: Discovering a Common Cause and Planning for the Sixth Mass Extinction

**Cosponsors:** *SEPM (Society for Sedimentary Geology); GSA Geochronology Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; Cushman Foundation; Paleontological Society*

**Disciplines:** Paleontology, Diversity, Extinction, Origination, Volcanology, Paleoclimatology/Paleoceanography

**Advocates:** Paula Mateo; Gerta Keller; Stephen E. Grasby; Thierry Adatte

This topical session explores evidence that reveals the common cause of major mass extinctions in Earth's history and furthers our understanding of the environmental catastrophe looming in our future—the sixth mass extinction.

### T108. Understanding the Neoproterozoic Earth-Life System

**Cosponsor:** *Paleontological Research Institution*

**Disciplines:** Paleontology, Diversity, Extinction, Origination, Geochemistry, Precambrian Geology

**Advocates:** Qing Tang; Huan Cui; Feifei Zhang

Paleontologists, geochemists, sedimentologists, stratigraphers, earth-system modelers, and more will be assembled to foster a better understanding of the Neoproterozoic earth-life system.

### T109. LIP Marks: The Search for Definitive Signatures of Large Igneous Province Eruptions in the Sedimentary Record

**Cosponsors:** *GSA Geobiology & Geomicrobiology Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division*

**Disciplines:** Paleontology, Diversity, Extinction, Origination, Geochemistry, Volcanology

**Advocates:** Stephen E. Grasby; David P.G. Bond

Geochemical proxies (e.g., Hg, Ni) and other signatures of Large Igneous Province eruptions (LIP marks) in the sedimentary record across extinction boundaries will be examined to better refine the temporal relationship between the two phenomena.

### T110. Extinction Selectivity and Climate Change: How Are Patterns across Time, Space, Taxa, and Habitat Similar, and How Are They Different?

**Cosponsor:** *Paleontological Society*

**Disciplines:** Paleontology, Diversity, Extinction, Origination, Paleontology, Biogeography/Biostratigraphy, Paleontology, Paleoecology/Taphonomy

**Advocates:** Andrew G. Simpson; Seth Finnegan; Scott L. Wing; Felisa Smith

This will be a cross-disciplinary session on relationships between selectivity of extinction and climate change across a range of taxa, including vertebrates, invertebrates, and plants, comparing similarities and differences between groups.

### T111. Broadening Participation in Paleontology: Approaches for Enhancing Diversity, Equity, and Inclusion

**Cosponsors:** *Paleontological Society; National Association for Geoscience Teachers; GSA Geoscience Education Division; GSA Geobiology & Geomicrobiology Division*

**Disciplines:** Paleontology, Diversity, Extinction, Origination, Geoscience Education, Geomicrobiology

**Advocates:** Christy C. Visaggi; Robyn Mieke Dahl

This session addresses approaches to broadening participation of underrepresented groups in paleontology, including demonstrations and discussion of inclusive teaching practices and student-centered pedagogy as well as innovative outreach projects, mentoring models, and other approaches.

### T112. Quantitative Paleobiology of Marine Ecosystems

**Cosponsors:** *GSA Geobiology & Geomicrobiology Division; Paleontological Research Institution*

**Disciplines:** Paleontology, Biogeography/Biostratigraphy, Paleoclimatology/Paleoceanography, Paleontology, Paleoecology/Taphonomy

**Advocates:** William J. Foster; Amanda Lynn Godbold; Erin Saupe

This session will discuss scientific data resulting from quantitative methods such as multivariate statistics, machine learning, niche modelling, or community analysis methods to test leading hypotheses in paleobiology.

### T113. Future Leaders in Paleontology

**Cosponsor:** *Paleontological Society*

**Disciplines:** Paleontology, Biogeography/Biostratigraphy, Paleontology, Diversity, Extinction, Origination, Paleontology, Paleoecology/Taphonomy

**Advocate:** Matthew E. Clapham

This session will showcase outstanding student research in all aspects of paleontology.

📄 🕒 **T114. Integrated Biostratigraphy and Chemostratigraphy Using Conodonts—North American Pander Society Annual Meeting**

**Cosponsors:** *Paleontological Society; Pander Society*

**Disciplines:** Paleontology, Biogeography/Biostratigraphy, Geochemistry, Stratigraphy

**Advocates:** D. Jeffrey Over; Martyn L. Golding; Pilar Navas-Parejo; Neo E.B. McAdams

Conodonts are a key element in Paleozoic and Triassic investigations of biostratigraphy, depositional settings, isotope stratigraphy, ocean chemistry, and evolution. Studies utilizing conodonts in all aspects are welcome.

**PALEOCLIMATOLOGY/  
PALEOCEANOGRAPHY**

**T115. The Paleocene–Eocene Thermal Maximum Recorded in Continental Margin Sections: Constraining Timing and Cause of Carbon Injection**

**Cosponsors:** *Cushman Foundation; GSA Continental Scientific Drilling Division; International Nannoplankton Association; Paleontological Research Institution; GSA Sedimentary Geology Division; GSA Planetary Geology Division*

**Disciplines:** Paleoclimatology/Paleoceanography, Stratigraphy, Marine/Coastal Science

**Advocates:** Kenneth G. Miller; Marci Robinson; Megan K. Fung

This session will highlight expanded Paleocene–Eocene Thermal Maximum records cored from the mid-Atlantic U.S. Coastal Plain and elsewhere that place constraints on initiation and timing of global carbon, global temperature, and regional environmental changes.

**T116. The Ordovician Earth: Integrated Perspectives on the Fossil and Rock Records**

**Cosponsors:** *Paleontological Society; Paleontological Research Institution; IGCP 653: The Onset of the Great Ordovician Biodiversification Event; IGCP652: Reading Time in Paleozoic Sedimentary Rocks*

**Disciplines:** Paleoclimatology/Paleoceanography, Paleontology, Biogeography/Biostratigraphy, Stratigraphy

**Advocates:** Matthias Sinnesael; Julie De Weirtdt; Christopher T. Conwell; Joshua B. Zimmt; Y. Datu Adiatma; Teresa D. Avila

This session will highlight recent advancements in our knowledge of the Ordovician earth system as well as cross-discipline methods that provide new insight into the regional to global fossil and rock records.

📄 🕒 **T117. Testing the Fidelity of C-Isotope Records as Proxies for Global Carbon Cycle History—Across Time, Space, and Composition**

**Cosponsors:** *SEPM (Society for Sedimentary Geology); North American Commission on Stratigraphic Nomenclature*

**Disciplines:** Paleoclimatology/Paleoceanography, Geochemistry, Stratigraphy

**Advocates:** Patrick I. McLaughlin; Poul Emsbo; Andrew H. Caruthers

We encourage contributions exploring the fidelity of organic or carbonate carbon isotopes as proxy records with emphasis placed on integrated studies combining analytical techniques, spectrum of materials, diverse depositional settings, or varied diagenetic histories.

**T118. Stratigraphic Rhythms, Paleoclimate, and Ocean Evolution: Honoring the Scientific Contributions of Alfred G. Fischer**

**Disciplines:** Paleoclimatology/Paleoceanography, Sediments, Carbonates, Stratigraphy

**Advocates:** Michael A. Arthur; Robert E. Garrison; Linda A. Hinnov; Steven M. Stanley

Research arising from the scientific contributions of Alfred G. Fischer (1920–2017) will be honored with talks in sedimentology, stratigraphy, paleoclimatology, paleoceanography, and paleontology by colleagues and geoscientists who have been directly influenced by Fischer’s work.

🌊 **T119. Paleotempestology**

**Disciplines:** Paleoclimatology/Paleoceanography, Marine/Coastal Science

**Advocate:** Joanne Muller

This session will focus on the latest research in the field of paleotempestology and climate models that relate to past and future hurricane dynamics.

**T120. Oceans and Climates throughout Earth’s History: From Proxy Reconstructions to Model Assessments (Posters)**

**Cosponsors:** *Cushman Foundation; Paleontological Research Institution*

**Disciplines:** Paleoclimatology/Paleoceanography, Geochemistry, Marine/Coastal Science

**Advocates:** Miriam E. Katz; Dorothy K. Pak

This session brings together proxy and modelling studies to improve our understanding of rapid ocean and climate events, and shifts between long-term climate states, within the context of normal climate variability throughout Earth’s history.

**T121. Landscape Responses to Neogene Climate Change**

**Cosponsors:** *GSA Sedimentary Geology Division; GSA Soils and Soil Processes Division; SEPM (Society for Sedimentary Geology)*

**Disciplines:** Paleoclimatology/Paleoceanography, Sediments, Clastic, Paleontology, Paleoecology/Taphonomy

**Advocates:** William E. Lukens; Anthony L. Layzell; Tara M. Smiley

This session will gather records of continental paleoclimate and paleoenvironments from the Neogene, with emphasis on outcrop-based landscape reconstructions. We welcome presentations from the fields of sedimentology, paleopedology, paleolimnology, paleobotany, and isotope geochemistry.

### T122. Insights from Microfossils and Their Modern Analogs: From Traditional to Emerging Approaches (Posters)

**Cosponsors:** *Cushman Foundation; Paleontological Research Institution*

**Disciplines:** Paleoclimatology/Paleoceanography, Geochemistry, Paleontology, Biogeography/Biostratigraphy

**Advocates:** Miriam E. Katz; Chiara Borrelli; Megan K. Fung

Traditional applications of microfossils are central to many studies, while novel approaches (especially geochemistry) utilizing microfossils have expanded recently. This session highlights traditional and innovative microfossil applications in terrestrial and marine environments, including modern analogs.

### T123. Cushman Foundation Symposium: Addressing Coastal Concerns with Micropaleontological Applications to Environmental Proxies, Reconstructions, and Deep-Time Analogs

**Cosponsors:** *Cushman Foundation; Paleontological Society*

**Disciplines:** Paleoclimatology/Paleoceanography, Marine/Coastal Science, Paleontology, Paleoecology/Taphonomy

**Advocates:** Laurel S. Collins; Zoë R.F. Verlaak; Maria N. Sider  
Natural and anthropogenic changes to marine coastlines will be investigated with micropaleontology that develops paleoclimate analogs and environmental proxies for problems such as extreme storm events, pollution, acidification, and sea-level rise.

### T124. Advances in Ocean and Climate Reconstructions from Environmental Proxies

**Cosponsors:** *Paleontological Society; GSA Karst Division; GSA Sedimentary Geology Division; GSA Geoarchaeology Division; Geochemical Society*

**Disciplines:** Paleoclimatology/Paleoceanography, Geochemistry, Karst

**Advocates:** Meghan Zulian; Natasha Leclerc; Bryan Black

This will be a common forum for sclerochronologists, dendrochronologists, and others using increment-yielding proxies to share recent methodological advancements and multidisciplinary applications of paleoenvironmental reconstructions, including proxies such as tree rings, corals, mollusk shells, and speleothems.

## ARCHAEOLOGICAL GEOLOGY

### T125. The Geologic Substrate on Which Maya Civilization Developed

**Cosponsor:** *GSA Geoarchaeology Division*

**Disciplines:** Archaeological Geology, Karst, Hydrogeology

**Advocates:** Eugene C. Perry; Sheryl Luzzadder-Beach; Timothy P. Beach; Nicholas P. Dunning; David T. King Jr.

What we can learn from the Maya, who built a civilization that lasted more than two millennia in a land ill-suited for conventional agriculture, lacking common metal resources, with a problematic climate.

### T126. Geoarchaeological Insights into Paleoenvironmental Reconstruction and Cultural Dynamics

**Cosponsors:** *GSA Geoarchaeology Division; GSA Quaternary Geology and Geomorphology Division; GSA Soils and Soil Processes Division*

**Disciplines:** Archaeological Geology, Geomorphology, Soils

**Advocates:** Laura R. Murphy; Brendan Fenerty

This session is a forum for those using geoarchaeological approaches to understand the relationship between landscapes, paleoenvironments, and the archaeological record. We welcome papers concerning human-landscape interactions, site formation processes, and paleoclimate and paleohydrology reconstructions.

## LIMNOGEOLOGY

### T127. The Importance of Minerals in Recording Paleoenvironmental Conditions and Governing the Biogeochemistry of Lacustrine Systems

**Cosponsors:** *GSA Limnogeology Division; Mineralogical Society of America*

**Disciplines:** Limnogeology, Mineralogy/Crystallography, Geochemistry

**Advocates:** Jason R. Price; David W. Szymanski

Detrital and diagenetic minerals in lake-bottom sediments provide paleoenvironmental proxy data, and present-day mineral weathering provides sources and sinks of solutes to lake water. This session highlights cutting-edge research at the nexus of mineralogy and limnogeology.

### T128. Lakes of the World through Time and Space

**Cosponsor:** *GSA Limnogeology Division*

**Disciplines:** Limnogeology, Stratigraphy, Paleontology, Paleoecology/Taphonomy

**Advocates:** Scott W. Starratt; Michelle F. Goman

This session celebrates lacustrine research across the globe. Lakes contain important historical records because their sediments are archives of global change, local human impact, and ecological succession.

### T129. From Snowy Peaks to Desert Floor: Paleohydrological Connections between West Coast Mountain Lakes and the Lakes of the Western Great Basin

**Cosponsor:** *GSA Limnogeology Division*

**Disciplines:** Limnogeology, Paleoclimatology/Paleoceanography, Stratigraphy

**Advocate:** Scott W. Starratt

This session will highlight the effect of precipitation variability in West Coast watersheds on the paleohydrological records in the terminal lakes of the western Great Basin using geochemical, physical, biological proxies and their integration into modeling studies.



**KARST**

 **T130. Understanding Caribbean Karst Processes and Speleology**

**Cosponsor:** *GSA Karst Division*

**Disciplines:** Karst, Geochemistry

**Advocates:** Angel A. Garcia Jr.; Angel A. Acosta Colón

This session will focus on the processes and development of Caribbean karst. Processes include evolution of karst landscapes, speleothem development, and cave survey.

**T131. Pseudo-Karst Processes and Features**

**Cosponsors:** *GSA Karst Division; National Cave and Karst Research Institute*

**Discipline:** Karst

**Advocates:** Andrew J. Luhmann; Jason S. Polk

This session will address the origin, development, depositional processes, biogeology, and management of landscapes and features that morphologically or in other ways resemble karst; examples include caves formed by wave action, fracturing, gravitation movement, melting or cooling of materials, and exotic chemistries.

 **T132. Karst Sedimentary, Paleoclimate, and Historical Records**

**Cosponsors:** *GSA Karst Division; GSA Sedimentary Geology Division; GSA Quaternary Geology and Geomorphology Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Geochronology Division; National Cave and Karst Research Institute*

**Disciplines:** Karst, Stratigraphy, Paleoclimatology/Paleoceanography

**Advocates:** Andrew J. Luhmann; Jason S. Polk

This session will cover cave deposits (sediments, speleothems, tufa, etc.), karst environmental records (sedimentary, underwater deposits, carbonate stratigraphy, etc.), and geoarchaeological and historical investigations to reconstruct or interpret past climates, landscapes, extreme events, land-use histories, and similar phenomena and model or predict future changes.

 **T133. Karst Processes and Speleology**

**Cosponsors:** *GSA Karst Division; GSA Quaternary Geology and Geomorphology Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; National Cave and Karst Research Institute*

**Disciplines:** Karst, Geomorphology, Geochemistry

**Advocates:** Andrew J. Luhmann; Jason S. Polk

This session will cover the myriad of cave-and-karst forming processes, geomorphic evolution of karst landscapes, and cave system development, including geochemical, morphological, and cave survey studies. Carbonate weathering, diagenesis,

hypogene processes, carbonate mineralogy, structural controls, and other related topics are included.

 **T134. Karst Hydrology and Hydrogeology**

**Cosponsors:** *GSA Karst Division; GSA Hydrogeology Division; GSA Environmental and Engineering Geology Division; Karst Waters Institute; National Cave and Karst Research Institute*

**Disciplines:** Karst, Hydrogeology

**Advocates:** Andrew J. Luhmann; Jason S. Polk

This session will include abstracts themed around the fundamental aspects of fluid-rock interactions within karst landscapes, including geologic, hydrogeologic, and hydrologic investigations. Appropriate topics range from dye tracing and aquifer processes to surface-subsurface hydrologic interactions and quantitative modeling.

  **T135. Karst Hazards and Monitoring**

**Cosponsors:** *GSA Karst Division; GSA Environmental and Engineering Geology Division; GSA Geophysics and Geodynamics Division; National Cave and Karst Research Institute*

**Disciplines:** Karst, Engineering Geology

**Advocates:** Andrew J. Luhmann; Jason S. Polk

This session will cover hazards (sinkholes, groundwater pollution, radon, development, urbanization) and monitoring approaches (data collection, data logging, GIS applications, historical data analyses) in karst landscapes, including technical applications (e.g., LiDAR, 3D scanning, geodatabase development) and management implications (resource management, education, policy, regulation).

    **T136. Evaporite Karst in the Greater Permian Evaporite Basin of Texas, New Mexico, Oklahoma, Kansas, and Colorado**

**Cosponsors:** *GSA Karst Division; GSA Hydrogeology Division; GSA Environmental and Engineering Geology Division*

**Disciplines:** Karst, Hydrogeology, Environmental Geoscience

**Advocates:** Kenneth S. Johnson; Lewis Land; David D. Decker

Natural and human-induced evaporite-karst processes are significant features and potential geohazards in the Greater Permian Evaporite Basin region. We encourage submissions related to evaporite-karst phenomena in Permian strata in the five-state region.

 **T137. Biogeochemical Interactions in Caves and Karst**

**Cosponsors:** *GSA Karst Division; GSA Geobiology & Geomicrobiology Division; GSA Hydrogeology Division; GSA Environmental and Engineering Geology Division*

**Disciplines:** Karst, Geomicrobiology, Environmental Geoscience

**Advocates:** Daniel Jones; Laura Rosales Lagarde

**INDUSTRY TRACKS** Look for these icons, which identify sessions in the following areas:



Economic Geology



Energy



Engineering



Hydrogeology and Environmental Geology

We encourage submissions that explore how biology intersects with geology in caves and karst landscapes over diverse spatial and temporal scales. Topics may include microbe-mineral interactions, metal transport and nutrient cycling, and critical zone biogeochemistry.

## HYDROGEOLOGY

### T138. Remote Sensing Applications in Hydrology

**Cosponsors:** *GSA Hydrogeology Division; GSA Geoinformatics and Data Science Division; GSA Geology and Society Division*

**Disciplines:** Hydrogeology, Geoscience Information/Communication, Environmental Geoscience

**Advocates:** Richard H. Becker; Ryan G. Smith

Recent innovations have broadened the capabilities of remote sensing in hydrology, introducing new challenges along the way. We encourage novel contributions utilizing all types of remote sensing data to characterize hydrologic systems.

### T139. Regional Groundwater Availability and Sustainability Studies: Advances in Methods and Approaches

**Cosponsor:** *GSA Hydrogeology Division*

**Disciplines:** Hydrogeology, Environmental Geoscience, Structural Geology

**Advocates:** Jesse E. Dickinson; Melissa D. Masbruch; Donald S. Sweetkind

This session encourages discussion on new advances, methods, and approaches by hydrologists, geologists, and numerical modelers for quantifying regional groundwater availability and sustainability in diverse regional settings.

### T140. Mountain Groundwater

**Cosponsors:** *GSA Hydrogeology Division; International Association of Hydrogeologists U.S. National Chapter*

**Disciplines:** Hydrogeology, Geochemistry, Environmental Geoscience

**Advocates:** Andrew H. Manning; Lyndsay B. Ball; Katherine H. Markovich

A recent increase in the study of mountain aquifers is providing new insights into these important yet poorly understood systems. We welcome presentations on mountain groundwater across all scales, utilizing field-based, modeling, and interdisciplinary approaches.

### T141. Modeling the Hydrosphere: From Aquifers to Atmosphere

**Cosponsors:** *GSA Hydrogeology Division; GSA Soils and Soil Processes Division*

**Discipline:** Hydrogeology

**Advocates:** Andrea E. Brookfield; Mary C. Hill; Pamela L. Sullivan

Modeling methods have evolved to include many natural and anthropogenic hydrosphere components and interactions between them. We encouraged research related to innovative simulation of water quantity and quality and novel applications.

### T142. Innovations in Research of Springs and Other Features at the Groundwater–Surface–Water Interface

**Cosponsors:** *GSA Hydrogeology Division; GSA Karst Division; Karst Waters Institute*

**Disciplines:** Hydrogeology, Karst, Environmental Geoscience

**Advocates:** Abraham E. Springer; Dorothy Vesper

Presentations are welcome from multidisciplinary, collaborative studies of the characterization, monitoring, modeling, stewardship, management, and education of stakeholders and citizens to improve the understanding of springs, associated ecosystems, and anthropogenic users.

### T143. Improving Scientific Literacy and Dispelling Misconceptions about Wicked Water Resource Problems

**Cosponsor:** *GSA Hydrogeology Division*

**Disciplines:** Hydrogeology, Geoscience Education, Environmental Geoscience

**Advocates:** Peter E. Riemersma; Peter J. Wampler

This session solicits abstracts describing efforts to educate the public about groundwater and surface-water contamination and supply problems. Community engagement often requires overcoming conceptual misunderstandings and simplifying complex problems for effective communication.

### T144. Hydrogeology, Hydrology, and Related Societal and Environmental Issues in the Upper Santa Cruz River Basin, Arizona and Sonora: Challenges and Opportunities for Understanding and Managing a Stream–Aquifer System Subject to Climate Change and Differing Binational Priorities

**Cosponsors:** *GSA Hydrogeology Division; GSA Geology and Society Division*

**Disciplines:** Hydrogeology, Geoscience and Public Policy, Geology and Health

**Advocates:** Mark W. Bultman; Olga E. Hart; James B. Callegary

This is an interdisciplinary forum for all aspects of ground- and surface-water availability, sustainability, quality, management, and associated social and environmental issues in the upper Santa Cruz basin, Arizona and Sonora.

### T145. Hydrogeology and Energy

**Cosponsor:** *GSA Hydrogeology Division*

**Disciplines:** Hydrogeology, Energy Geology, Environmental Geoscience

**Advocates:** Andrew J. Stumpf; Grant Ferguson; Kevin M. Ellett

This session seeks a broad array of hydrogeology-energy topics including geothermal, hydrocarbon-water, and other water energy issues. Preference is given to work on causative interrelationships or complex interactions that govern occurrence and evolution of subsurface energy resources.




### T146. Field Tracer Studies for Aquifer Characterization

**Cosponsors:** *GSA Hydrogeology Division; GSA Karst Division*

**Disciplines:** Hydrogeology, Environmental Geoscience, Geochemistry

**Advocate:** Charles J. Paradis

The use of tracers is important for the accurate characterization of physical, chemical, and biological processes in aquifers. This technical session aims to share examples of applications and research involving tracers for aquifer characterization.

   **T147. Evolution of Paleo to Modern Fluid Flow Systems in the Colorado Plateau and Other Sedimentary Environments**

**Cosponsor:** *GSA Hydrogeology Division*

**Disciplines:** Hydrogeology, Geochemistry, Structural Geology

**Advocates:** Jennifer C. McIntosh; Mark Person; Peter W.

Reiners; George H. Davis; Mark D. Barton; Grant Ferguson

This session aims to integrate multiple geologic, hydrologic, and geochemical approaches to discover couplings, consequences, and emergent properties of subsurface paleo to modern fluids and mass/energy transfer between Earth's lithosphere and Critical Zone.


  **T148. Coastal Hydrogeology in an Age of Rising Seas**

**Cosponsors:** *GSA Hydrogeology Division; GSA Environmental and Engineering Geology Division; GSA Karst Division; American Geophysical Union; American Geosciences Institute; Consortium of Universities for the Advancement of Hydrologic Science Inc.; National Ground Water Association; International Association of Hydrogeologists; Soil Science Society of America; GSA Soils and Soil Processes Division*

**Disciplines:** Hydrogeology, Engineering Geology, Geoscience and Public Policy

**Advocates:** Michael C. Sukop; Martina Rogers; Shellie L. Habel

As sea levels rise, hydrogeology is crucial in coastal areas. Seawater intrusion can lead to loss of potable or agricultural water supplies. Water table rise from sea-level rise can increase flooding and affect infrastructure.



 **T149. Arsenic in Global Groundwater-Based Drinking Water Systems—Source-Water Characteristics, Safe Limits, Human-Health Impacts, Innovative Treatment Systems, and Policy Instruments**

**Cosponsors:** *GSA Hydrogeology Division; GSA International; GSA Geology and Health Division; International Society of Groundwater for Sustainable Development (ISGSD); IWA Specialist Group Metals and Related Substances in Drinking Water (METRELS); GSA Karst Division*

**Disciplines:** Hydrogeology, Geology and Health, Geoscience and Public Policy

**Advocates:** Prosun Bhattacharya; Arslan Ahmad; Dina L. Lopez; Saugata Datta; Mohammad Alauddin; Jochen Bundschuh

This session will lead to a deep understanding of the fate and behavior of arsenic and other geogenic co-contaminants in groundwater systems, treatment innovations, epidemiological impacts, human health impacts, and policy instruments.

  **T150. Advances in Understanding Processes at or near the Groundwater–Surface-Water Interface**

**Cosponsors:** *GSA Hydrogeology Division; GSA Soils and Soil Processes Division*

**Disciplines:** Hydrogeology, Environmental Geoscience

**Advocates:** Reza Soltanian; Robert Ritzl

The session will convey new insights on processes taking place at or near the interface between groundwater and surface water, including fluid, energy, nutrient fluxes, and biogeochemical processes. Field and lab studies, analysis, and computational research are to be included.


 **T151. Advances in Geophysical, Geological, and Geochemical Investigations of Hydrological Systems in the Basin and Ranges/Rio Grande Rift Basins**

**Cosponsor:** *GSA Geophysics and Geodynamics Division*

**Disciplines:** Hydrogeology, Geophysics/Geodynamics, Geochemistry

**Advocates:** Lin Ma; Shari Kelley; Diane I. Doser

This session seeks contributions from across disciplines to investigate valuable water resources in the Basin and Range/Rio Grande rift basins using a broad array of geophysical, geologic, and geochemical tools to better understand aquifers, geothermal resources, and surface waters in the extensional terranes.

 **T152. A Showcase of Undergraduate Research in Hydrogeology (Posters)**

**Cosponsors:** *GSA Hydrogeology Division; GSA Geoscience Education Division*

**Discipline:** Hydrogeology

**Advocates:** Laura K. Rademacher; Samuel J. Smidt; Tyler V. King

This session is designed for undergraduates presenting research and senior theses in the field of hydrogeology. Prizes will be awarded for top presentations. Employers and graduate advisers are encouraged to attend.

**ENVIRONMENTAL GEOSCIENCE**

  **T153. Urban Geochemistry**

**Cosponsor:** *International Association of GeoChemistry*

**Disciplines:** Environmental Geoscience, Geochemistry, Geology and Health

**Advocates:** W. Berry Lyons; David T. Long

This session encourages presentations that qualify and quantify the geochemical and biogeochemical impacts (temporal and spatial) of urbanization and urban activities on soil, water, and air resources, as well as on human and ecosystem health.

    **T154. Sigma Gamma Epsilon Student Research (Posters)**


**Cosponsor:** *Sigma Gamma Epsilon*

**Disciplines:** Environmental Geoscience, Sediments, Clastic, Structural Geology

**Advocates:** Diane Burns; James Walters




All Sigma Gamma Epsilon student members are encouraged to submit their research to this poster session to compete for awards. All geological investigations, from archaeological geology to volcanology, are encouraged to be entered.

 **T155. Mineral Dissolution and Precipitation in Subsurface CO<sub>2</sub> Storage and CO<sub>2</sub>-Plume Geothermal Energy Capture: Experimental and Modeling**

**Disciplines:** Environmental Geoscience, Energy Geology, Geochemistry

**Advocates:** Liwei Zhang; Christina Lopano

This topical session aims to capture recent progress in investigations of the pore-scale geochemical processes associated with CO<sub>2</sub> geological storage and CO<sub>2</sub>-plume geothermal energy capture, which are recently hot research topics in geoscience.

 **T156. Microplastics in the Environment: Methods, Findings, and Implications**

**Cosponsors:** *GSA Environmental & Engineering Geology Division; GSA Hydrogeology Division; GSA Limnogeology Division; GSA Geology and Health Division; GSA Geology and Society Division; GSA Soils and Soil Processes Division*

**Disciplines:** Environmental Geoscience, Hydrogeology, Marine/Coastal Science

**Advocates:** Jacqueline A. Smith; Brian E. Bodenbender

Evidence for microplastic pollution in marine, freshwater, and terrestrial environments continues to mount. This session encompasses all aspects of microplastic research, including field and lab methodology, findings, education, and implications for health and environmental stewardship.

 **T157. Intersections of Sustainability and Geosciences**

**Cosponsor:** *GSA Hydrogeology Division*

**Disciplines:** Environmental Geoscience, Geoscience Information/Communication, Geoscience and Public Policy

**Advocates:** Leslie A. North; Robert Brinkmann

Papers are sought for a special session on sustainability and the geosciences. The session seeks to highlight works that combine the fields of sustainability and geoscience to examine or educate about environmental and/or societal problems.


 **T158. Incorporating Place-Based Knowledge in Geoscience Research and the Classroom**

**Cosponsors:** *GSA Geology and Society Division; GSA Diversity in Geosciences Committee; GSA Environmental & Engineering Geology Division; GSA Geoscience Education Division; National Association of Geoscience Teachers*

**Disciplines:** Environmental Geoscience, Geoscience Education, Geoscience and Public Policy

**Advocates:** Michael A. Phillips; Pauline W.U. Chinn

This session will explore the use of indigenous and other place-based knowledges to develop an understanding of earth processes and human impacts on those processes through primary research and field and classroom instruction.

 **T159. Bio-Geochemistry of Petroleum-Produced Water: Challenges and Opportunities toward Its Beneficial Use and Safe Disposal**

**Cosponsor:** *GSA Hydrogeology Division*

**Disciplines:** Environmental Geoscience, Geochemistry, Hydrogeology

**Advocates:** Javier Vilcaez; Tracy M. Quan; Omar R. Harvey

This session is to gather researchers and practitioners working on various aspects of produced water, including its chemical and microbiological characterization, treatment, beneficial use/reuse, and/or safe disposal.

## ENGINEERING GEOLOGY

 **T160. Landslide Inventories, Hazard Assessments, and Risk Reduction**

**Cosponsors:** *GSA Environmental & Engineering Geology Division; GSA Quaternary Geology and Geomorphology Division; U.S. Geological Survey Landslide Hazards Program*

**Disciplines:** Engineering Geology, Geomorphology, Geoscience Information/Communication

**Advocates:** Matthew M. Crawford; Stephen L. Slaughter

This session will discuss landslide inventories that support sophisticated efforts of hazard and risk assessment. Landslide hazard assessment techniques yield not only variable landslide behavior but also advancements and challenges of data resources and communication.

 **T161. Environmental & Engineering Geology Division Student Research Competition (Posters)**

**Cosponsors:** *GSA Environmental & Engineering Geology Division; Association of Environmental & Engineering Geologists*

**Disciplines:** Engineering Geology, Environmental Geoscience

**Advocates:** Stephen L. Slaughter; Anne C. Witt; Robert J. Mitchell

We encourage graduate and undergraduate students to submit poster presentations on topics related to applied research in environmental and engineering geology. Monetary awards will be given to the top presenters at the Division awards ceremony.

 **T162. Environmental & Engineering Geology Division**


**Cosponsor:** *GSA Environmental & Engineering Geology Division*

**Disciplines:** Engineering Geology, Environmental Geoscience

**Advocates:** Anne C. Witt; Stephen L. Slaughter; Robert J. Mitchell

The oral session for the Environmental & Engineering Geology Division gives an opportunity to the geoscience community to present their research, data, and work pertaining to environmental and engineering geology.

## ENERGY GEOLOGY

 **T163. Utilizing Field Tests and Numerical Simulations for Reservoir Characterization, Risk Analysis, or Uncertainty Quantification of Engineered Fluid Systems**

**Disciplines:** Energy Geology, Engineering Geology, Hydrogeology

**Advocates:** Richard Jayne; Yingqi Zhang

## GSA 2019 ANNUAL MEETING & EXPOSITION

This session will explore research associated with characterizing engineered reservoirs, including enhanced oil recovery, enhanced geothermal systems, carbon capture and sequestration, and induced seismicity.

### T164. **The Unconventional Shale Systems: From Source-Rocks to Reservoirs**

**Cosponsor:** *GSA Energy Geology Division*

**Disciplines:** Energy Geology, Economic Geology, Geochemistry

**Advocates:** Fang Hao; Qinhong Hu

This session will present the research frontiers in hydrocarbon generation-migration-expulsion, geochemical and isotopic characteristics of kerogen-bitumen-oil-gas, genesis and evolution of multi-scale pores and fractures, as well as petrophysical characterization and fluid-shale interactions across scales.

### T165. **The Fluvial-Marine Transition in Space and Time—Rivers, Deltas, and Marginal Marine Systems from Outcrop, Model, and Subsurface**

**Cosponsors:** *GSA Energy Geology Division; GSA Geoinformatics and Data Science Division; GSA Sedimentary Geology Division*

**Disciplines:** Energy Geology, Sediments, Clastic, Stratigraphy

**Advocates:** Dario Harazim; Lisa Reneé Goggin; Sarah Baumgardner

This session presents the latest scientific advances related to the fluvial-marginal marine transition. We seek papers on numerical forward stratigraphic modeling, aerial photogrammetry, and remote sensing within the fields of coastal geomorphology, process stratigraphy, and sedimentology.

### T166. **Mineral and Energy Extraction: Impacts on Society and Health**

**Cosponsors:** *GSA Energy Geology Division; GSA Geology and Society Division; GSA Geology and Health Division*

**Disciplines:** Energy Geology, Geology and Health, Environmental Geoscience

**Advocates:** Harshad Kulkarni; Jackie D. Horn; Sinjini Sinha; Shari Kelley; Leah N. Thompson; Susan Stover; Robert B. Finkelman; Saugata Datta

This session explores the consequences of extraction of energy resources, groundwater, and minerals, including environmental degradation and impacts on housing, crime, employment, population, animal, and human health.

### T167. **Geologic Energy Research**

**Cosponsor:** *GSA Energy Geology Division*

**Disciplines:** Energy Geology, Economic Geology, Engineering Geology

**Advocates:** Travis L. McLing; Richard A. Esposito; Laura S. Ruhl

This is the general session of the GSA Energy Geology Division and highlights research into geologic-based energy resources. Topics include coal geology, petroleum geology, geothermal, uranium, and the environmental impacts from energy utilization.

### T168. **Environmental Impact Studies for Energy Resources**

**Cosponsor:** *GSA Energy Geology Division*

**Disciplines:** Energy Geology, Environmental Geoscience, Hydrogeology

**Advocates:** Laura S. Ruhl; Travis L. McLing; Richard A. Esposito

This session will explore research relating to environmental issues associated with energy geology, including exploration practices, extraction of resources, and waste disposal.

### T169. **Carbon Sequestration in Underground Reservoirs**

**Cosponsors:** *GSA Hydrogeology Division; GSA Karst Division*

**Disciplines:** Energy Geology, Environmental Geoscience, Engineering Geology

**Advocates:** Jolante W. van Wijk; Robert Will; Paige Czoski

Carbon sequestration is long-term storage of carbon dioxide in subsurface geologic formations. This session focuses on the storage process, physical and chemical changes of the reservoir rock, and monitoring of the sequestered CO<sub>2</sub>.

### T170. **Advancements in Energy Geology: The Best of American Association of Petroleum Geologists Technical Talks 2018**

**Cosponsors:** *GSA Energy Geology Division; American Association of Petroleum Geologists*

**Discipline:** Energy Geology

**Advocates:** Michael Grammer; Robbie Gries; Laura S. Ruhl

This session highlights cutting-edge applications of various geological disciplines in the petroleum industry. Presentations will showcase some of the highest-rated talks at the 2018 American Association of Petroleum Geologists ACE meeting in Salt Lake City.

## GEOINFORMATICS

### T171. **Recovery to Discovery: Data Rescue Workflows in the Geosciences (Posters)**

**Cosponsors:** *GSA Geoinformatics and Data Science Division; American Geosciences Institute; Earth Science Information Partners, Data Stewardship Committee; Research Data Alliance, Data Rescue Interest Group; EarthCube; American Geophysical Union; American Association of Petroleum Geologists; GSA Geology and Society Division*

**INDUSTRY TRACKS** Look for these icons, which identify sessions in the following areas:



Economic Geology



Energy



Engineering



Hydrogeology and  
Environmental Geology

**Disciplines:** Geoinformatics, Geoscience Information/Communication, Geoscience and Public Policy

**Advocates:** Denise J. Hills; Simon Goring; Stephen Diggs; Christopher Keane

Have you ever lost access to data through loss of access, degradation of media, or other reasons? How did you overcome that? This session welcomes you to share your data rescue stories and workflows.

💰 🔌 ⚙️ 🌊 **T172. Information Systems and the Geological Sciences: Reaching for the Future**

**Cosponsor:** *GSA Geoinformatics and Data Science Division*

**Discipline:** Geoinformatics

**Advocates:** Mary C. Hill; Suzanne A. Pierce; Basil Tikoff

Geoscience defines our world. Data, information, models, and visualizations can make the world more accessible, understandable, compelling, and pervasive, and help create workable solutions. We encourage presentations on the future of digital data in geoscience.

## HISTORY AND PHILOSOPHY OF GEOLOGY

🕒 **T173. History of the Study of Climate Change and Its Causes**

**Cosponsors:** *GSA History and Philosophy of Geology Division; History of Earth Sciences Society*

**Disciplines:** History and Philosophy of Geology, Paleoclimatology/Paleoceanography

**Advocates:** Joanne Bourgeois; Eric J. Steig

From the recognition in the 18th century that climate changes, historians and scientists have examined the evidence for such change and its causes. We encourage historical treatments of climate-change studies from the Precambrian to the present.

💰 **T174. Great Concepts and Controversies in Geosciences since Steno's Introduction of the Principles of Stratigraphy in 1669**

**Cosponsors:** *GSA History and Philosophy of Geology Division; GSA Sedimentary Geology Division; GSA Structural Geology and Tectonics Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Geochronology Division; GSA Geophysics and Geodynamics Division; History of Earth Sciences Society; The Mineralogical Society; Association for Women Geoscientists; SEPM (Society for Sedimentary Geology)*

**Disciplines:** History and Philosophy of Geology, Tectonics/Tectonophysics, Paleontology, Diversity, Extinction, Origination

**Advocates:** Yildirim Dilek; Victor R. Baker; Michiko Yajima

In celebration of the 350th anniversary of Steno's publication of *Prodrumus* (which led to *Principles of Stratigraphy*), we welcome contributions discussing the evolution of significant concepts/controversies and how our current dialectic thinking is driving future concepts/controversies in modern geosciences.

**T175. Geology and Ethnology of the Canyon Lands**

**Cosponsors:** *GSA History and Philosophy of Geology Division; GSA Geoaerchaeology Division*

**Disciplines:** History and Philosophy of Geology, Geomorphology, Archaeological Geology

**Advocates:** Stephen G. Pollock; Yildirim Dilek; Nathan D. Hamilton

This overarching session delves into all aspects of earth and human processes that affect the Southwestern canyon lands with emphasis on ideas and philosophies relating to the geology and ethnology of the Southwest.

## GEOSCIENCE INFORMATION/COMMUNICATION

💰 **T176. Tell Us What Is New in Your Library, Information Center, Company, Organization, Research Institution, or University!**

**Cosponsor:** *Geoscience Information Society*

**Disciplines:** Geoscience Information/Communication, Geoscience Education, Geoinformatics

**Advocate:** Emily C. Wild

Do you have successes (or failures) you would like to share with others? This session is an opportunity to discuss what is new within your institution's collections, instruction, space, outreach, mapping, data, and scholarly communications.

⚙️ 🌊 **T177. Innovative Tools for Mapping, Modelling, and Sharing 3D Geological Data: Drones, Photogrammetry, LiDAR, Virtual, and Augmented Reality**

**Cosponsor:** *GSA Geoinformatics and Data Science Division*

**Disciplines:** Geoscience Information/Communication, Geomorphology, Structural Geology

**Advocates:** Antoine Triantafyllou; Benjamin R. Jordan; Christopher J. Crosby; Ramon Arrowsmith

This session aims to provide new insights into the use of innovative tools for 3D geological mapping and modelling, from new methodological approaches to challenging geological case studies/field acquisition, data interpretation, and distribution.

**T178. Geologic Maps and Their Derivatives (Posters)**

**Cosponsors:** *Association of American State Geologists; GSA Geoinformatics and Data Science Division; GSA Planetary Geology Division*

**Disciplines:** Geoscience Information/Communication, Economic Geology, Engineering Geology

**Advocates:** Richard Berg; Harvey Thorleifson

This poster session will highlight new geologic maps, mapping programs, and innovations in geological mapping, including data management, Web accessibility, 3-D, and applications in water and land management.

**T179. Evidence-Based Theory and Practice of Science Communication in the Geosciences: New Methods, Avenues, and Audiences**

**Disciplines:** Geoscience Information/Communication, Geoscience Education

**Advocates:** Lisa Lundgren; Gabriel-Philip Santos



## GSA 2019 ANNUAL MEETING & EXPOSITION

Learning geoscience with diverse audiences requires agile and novel methods, including using social media and creating pop-up museums. This session addresses the design, development, implementation, and assessment of such communication methods in the geosciences.

### T180. Contentious Communication from the Classroom to the Chat Room: How to Have Productive Conversations about Emotionally Charged Topics

**Cosponsors:** *GSA Geology and Society Division; GSA Committee on Geology and Public Policy; National Earth Science Teachers Association; National Association of Geoscience Teachers; GSA Geoscience Education Division*

**Disciplines:** Geoscience Information/Communication, Geoscience Education, Geoscience and Public Policy

**Advocates:** Wendy Bohon; Beth Bartel; Justin Samuel

This session will examine the dynamics of communicating contentious topics in the geosciences, with implications for more scientifically based policy decisions, better learning outcomes in classrooms, more productive online conversations, and greater appeal to diverse audiences.

### T181. Collaborations between Science, Emergency Management, and the Public—Successes and/or Learning Experiences

**Cosponsors:** *GSA Environmental & Engineering Geology Division; GSA Geology and Society Division*

**Disciplines:** Geoscience Information/Communication, Geology and Health, Geoscience and Public Policy

**Advocates:** Brian Terbush; Stephen L. Slaughter

Before, during, and after natural hazards occur, scientists, safety officials, and the public must work together to limit casualties and protect property. Share your own lessons learned, or come to learn from others' experiences.

## GEOSCIENCE AND PUBLIC POLICY

### T182. Practical Ways to Promote an Ethical, Diverse, Inclusive Culture across the Geosciences

**Cosponsors:** *GSA Geology and Society Division; Association for Women Geoscientists; GSA Diversity in the Geosciences Committee; GSA Geology and Public Policy Committee; Earth Science Women's Network*

**Disciplines:** Geoscience and Public Policy, Geoscience Education

**Advocates:** Nan Stout; Billy M. Williams

Geoscientists are responsible for creating a professional culture based on a commitment to ethics, diversity, and inclusion. This session focuses on practical ways to drive culture change through presentation of case studies and educational strategies.

### T183. Geoscience and Hydrology of Your Public Lands: STEM Internships, Research, Science, Mapping, Resource Management, and Education

**Cosponsors:** *GSA Hydrogeology Division; National Park Service; U.S. Forest Service; Bureau of Land Management; GSA Karst Division*

**Disciplines:** Geoscience and Public Policy, Geoscience Information/Communication, Hydrogeology

**Advocates:** Jason P. Kenworthy; Matthew Dawson; Limaris R. Soto; Johanna Kovarik; F. Edwin Harvey; Scott E. Foss

This is an interdisciplinary forum for earth scientists, land managers, Geoscientists-in-the-Parks and GeoCorps™ America participants or sponsors, and educators to present their work and describe its relevance to the public and land managers.

### T184. Geoheritage: Sharing Earth's Legacy for Scientific, Societal, and Economic Advancement

**Cosponsors:** *GSA Geology and Society Division; GSA History and Philosophy of Geology Division; Association of American State Geologists; National Association of Geoscience Teachers; American Geosciences Institute; National Park Service; U.S. Geological Survey; U.S. National Committee for the International Union of Geological Sciences; National Academy of Sciences; GSA Geoscience Education Division*

**Disciplines:** Geoscience and Public Policy, Geoscience Information/Communication, History and Philosophy of Geology

**Advocates:** Terri L. Cook; Tom Casadevall; Suzette Kimball

This session will highlight the relevance of geoheritage; explore the history, current status, and future of the geoheritage movement; and explore geoheritage's potential for boosting rural economic development and increasing public interest in the geosciences.

## GEOSCIENCE EDUCATION

### T185. Time to Explore: Actively Engaging with Rigorous Three-Dimensional Learning Materials

**Cosponsors:** *GSA Geoscience Education Division; American Geosciences Institute; American Geophysical Union; National Association of Geoscience Teachers; National Earth Science Teachers Association*

**Discipline:** Geoscience Education

**Advocates:** Aida Awad; Carla McAuliffe; Ed Robeck

This active learning, hands-on approach session will allow participants to engage with curriculum materials and sample activities from several organizations that are unified by their attention to Next-Generation Science Standards–aligned, three-dimensional instruction that takes a phenomenon-based approach.

### T186. The Importance of Place to Effective K–16 Geoscience and Climate-Change Education

**Disciplines:** Geoscience Education, Geoscience and Public Policy, Environmental Geoscience

**Advocate:** Sadredin Cyrus Moosavi

This session will explore the unique role of place in effective education in the geosciences.

### T187. The Evolution and Diversity of Virtual Fieldwork Experiences

**Cosponsors:** *National Association of Geoscience Teachers; GSA Geoscience Education Division*

**Disciplines:** Geoscience Education, Geoscience Information/Communication

**Advocates:** Don Haas; Wendy L. Taylor; Frank Granshaw

Changing technologies are making capturing and sharing aspects of field experiences easier and richer. How has virtual fieldwork changed and diversified over time? Do we know what students are learning from using and making Virtual Fieldwork Experiences?

    **T188. Taking Control of Your Geoscience Career Path**

**Cosponsors:** *GSA Geology and Society Division; American Geophysical Union; American Institute of Professional Geologists; Association for Women Geoscientists; GSA Geoscience Education Division*

**Disciplines:** Geoscience Education, Geoscience Information/Communication

**Advocates:** Carolyn Wilson; Christopher Keane

This panel session will present lessons learned by current geoscientists as they navigated their career path, as well as discuss factors that influenced their career decisions. The panel will include a discussion with session attendees.

**T189. Research and Strategies to Build a K–12 Geoscience Teacher Workforce**

**Cosponsors:** *National Earth Science Teachers Association; National Earth Science Teachers Association–TED*

**Discipline:** Geoscience Education

**Advocates:** Cheryl L.B. Manning; Carla McAuliffe; Belinda E. Jacobs

This session explores research and strategies that contribute to a well-prepared geoscience teacher workforce. We examine how experiences in strong pedagogy and rigorous science coursework, including research and field experiences, enable both confidence and competence.

**T190. Making Sense of Methodologies and Theoretical Frameworks in Geoscience Education Research**

**Cosponsors:** *National Association of Geoscience Teachers; National Association of Geoscience Teachers Geoscience Education Research Division*

**Disciplines:** Geoscience Education, Geoscience Information/Communication

**Advocates:** Katherine Ryker; Karen McNeal; Leilani Arthurs; Emily M. Geraghty Ward

Methods and theoretical frameworks can come from within and outside of geoscience education research to shape our field. Presenters are encouraged to highlight their decision-making process in research studies that advance the field. New approaches and applications of established methods/frameworks are welcomed.

**T191. International Geoscience Education**

**Cosponsors:** *GSA Geoscience Education Division; International Geoscience Education Organization; National Association of Geoscience Teachers; National Earth Science Teachers Association; International Association for Geoscience Diversity*

**Discipline:** Geoscience Education

**Advocates:** Mary E. Dowse; Steven W. Anderson; Sharon Locke

Geoscience educators working in international settings at all levels, formal and informal, are encouraged to present their experience in this session. The programs of the International Geoscience Education Organization (IGEO) will be highlighted.

**T192. Improving College Student Education by Mentoring through Peers, Faculty, and Professionals (Posters)**

**Cosponsor:** *GSA Geoscience Education Division*

**Discipline:** Geoscience Education

**Advocates:** Lixin Jin; Diane I. Doser; Joshua Villalobos

This geoscience education session aims to share experiences in implementation and evaluation of formal and informal mentoring from the perspective of the mentors and the protégés.

  **T193. Importance of Involving Undergraduate and High School Students in Geoscience- and Environmental Science–Based Research (Posters)**

**Cosponsors:** *National Association of Geoscience Teachers; GSA Geology and Society Division; GSA Sedimentary Geology Division; GSA Geology and Health Division; GSA Quaternary Geology and Geomorphology Division; GSA Energy Geology Division*

**Disciplines:** Geoscience Education, Environmental Geoscience, Geoscience Information/Communication

**Advocates:** Nazrul I. Khandaker; Arif M. Sikder; Stanley Schleifer

This session welcomes submissions from geoscience, environmental science, and other field- and laboratory-based programs that provide experiences for undergraduate and high school students.

**T194. Highlighting Research by 2YC and 4YCU Undergraduate Geoscience Students (Posters)**

**Cosponsors:** *GSA Geoscience Education Division; National Association of Geoscience Teachers; National Association of Geoscience Teachers 2YC Division; International Association for Geoscience Diversity*

**Discipline:** Geoscience Education

**Advocates:** Adrienne A. Leinbach; Gretchen L. Miller; Stephanie M. Rollins

This session is designed for two-year college (2YC) and four-year college and university (4YCU) students presenting research posters in any subdiscipline of geoscience.

**T195. Hands-On Teaching Demonstrations That Combine Geoscience and Societal Issues: Audience Participation Requested!**

**Cosponsors:** *GSA Geoscience Education Division; National Association of Geoscience Teachers*

**Discipline:** Geoscience Education

**Advocates:** Elizabeth A. Nagy-Shadman; Tiffany A. Rivera

This is a geoscience education session that practices what it preaches. Authors present micro-demonstrations of effective teaching activities that integrate geoscience content with societal concerns. Presentations include audience participation, assessment results, and reflections on effectiveness.

**T196. Geoscience Curriculum in the Twenty-First Century: Adapting Programs to Meet Students' Evolving Needs**

**Cosponsor:** *GSA Geoscience Education Division*

**Disciplines:** Geoscience Education, Geoscience Information/Communication

**Advocates:** James H. MacDonald Jr.; Alayde A. Barbosa; Mary I. Abercrombie; Joanne Muller

Adapting the geoscience curriculum to meet evolving workforce needs while providing basic content knowledge and declining enrollments is challenging. We encourage submissions that review successful curriculum solutions and/or address successful recruitment strategies to geoscience programs.





    **T197. Geology ROCKS! And So Do You (Posters)**

**Cosponsors:** *GSA Geoscience Education Division; GSA Quaternary Geology and Geomorphology Division; GSA Geology and Society Division; GSA Soils and Soil Processes Division*

**Disciplines:** Geoscience Education, Geoscience Information/Communication, History and Philosophy of Geology

**Advocates:** Nicholas A. Sutfin; Jennifer L. Pierce

Have you written or performed songs or poems about geosciences in the classroom or by the campfire? Submit your poem or lyrics and be part of a new tradition at GSA. Spread the word!

    **T198. Extreme Impacts of Global Climate Change: Effective Communication for Geoscientists, Educators, Policy Makers, and the Press**

**Cosponsors:** *GSA Quaternary Geology and Geomorphology Division; GSA Energy Geology Division; GSA Environmental & Engineering Geology Division; GSA Geology and Health Division; GSA Geology and Society Division; GSA History and Philosophy of Geology Division; GSA Hydrogeology Division; International Union for Quaternary Research (INQUA)*

**Disciplines:** Geoscience Education, Geoscience Information/Communication, Geoscience and Public Policy

**Advocates:** Jennifer L. Pierce; George T. Stone

Effectively communicating causes and risks of climate change remains a challenge. Why? In this interactive session, we combine up-to-date science on extreme events with compelling presentations on climate communication and education.

**T199. Enhancing the Geosciences by Empowering Indigenous and Latinx Students**

**Cosponsor:** *GSA Geoscience Education Division*

**Disciplines:** Geoscience Education, Geoscience and Public Policy, Geoscience Information/Communication

**Advocates:** Darryl Reano; Angel A. Garcia Jr.

This session's objective is to empower indigenous and Latinx scholars to integrate their traditional knowledge systems with Western science in order to achieve a transformative educational experience that will enhance STEM concepts for all students.

**T200. Education and Outreach in the 21st Century: Using Imagery and Social Media to Engage Students and the Public**

**Cosponsor:** *GSA Geoscience Education Division*

**Disciplines:** Geoscience Education, Geoscience Information/Communication, Quaternary Geology

**Advocates:** Jacquelyn E. Hams; Callan Bentley; Anita M. Marshall

This session is for any sector of the geoscience community using imagery and social media for education and outreach or researching the influence of social media on the public's understanding of geoscience concepts.

**T201. Celebrating the Role of Heather MacDonald in Geoscience Education in Two-Year Colleges**

**Cosponsors:** *GSA Geoscience Education Division; Geo2YC Division of National Earth Science Teachers Association; National Association of Geoscience Teachers*

**Discipline:** Geoscience Education

**Advocates:** David H. Voorhees; Callan Bentley; Katrien J. van der Hoeven Kraft

This is a celebration of the long-term, significant contributions of Heather MacDonald to geoscience education at two-year colleges (2YCs), including SAGE2YC. Presentations should describe outcomes of workshops and programs inspired or organized for 2YCs by Heather.

**T202. Beyond the Road-Cut: Virtual, Local, and Nontraditional "Field" Teaching and Learning Experiences**

**Disciplines:** Geoscience Education, Environmental Geoscience, Geoscience Information/Communication

**Advocates:** Lauren Neitzke Adamo; Jacob Setera; Kelsey S. Bitting

Virtual exploration, museum-based assignments, and analysis of geoscience on campus can be more inclusive ways to enhance students' conceptual learning and motivation. This session welcomes presentations describing nontraditional "field" experiences and evidence of their effectiveness.

**INDUSTRY TRACKS** Look for these icons, which identify sessions in the following areas:



Economic Geology



Energy



Engineering

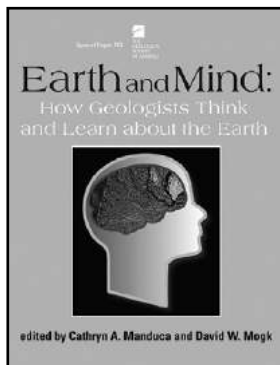


Hydrogeology and Environmental Geology

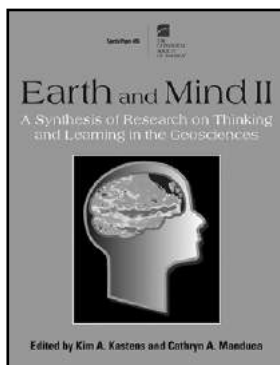


# Geology in the Classroom

If you're an educator looking for insight and inspiration to help keep you motivated, you'll want to check out these Special Papers from GSA. Both volumes, which are available for download from the GSA bookstore, explore how improved understanding of how humans think and learn about the Earth can help educators prepare the next generation of geoscientists.



***Earth and Mind: How Geologists Think and Learn about the Earth*** presents essays by geoscientists, cognitive scientists, and educators that explore how geoscientists learn and what the implications are for student learning. (SPE413P, 188 p., ISBN 0813724139, US\$9.99)



***Earth and Mind II: A Synthesis of Research on Thinking and Learning in the Geosciences*** explores the ways in which geoscientists use the human senses and mind to perceive, analyze, and explain the workings of the earth system and how to help students master the thought processes of the geosciences. (SPE486P, 210 p., ISBN 9780813724867, US\$9.99)



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# 2019 Joint Technical Program Committee

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**GSA Technical Program Manager:** Nancy Wright, nwright@geosociety.org

JTPC Contact(s)	Discipline	Review Group
Carole L. Ziegler	geoscience information/communication	Association of Earth Science Editors
Paul A. Baker		GSA Continental Scientific Drilling Division
Laura S. Ruhl; Travis L. McLing; Marc L. Buursink	energy geology	GSA Energy Geology Division
Anne Witt; Robert J. Mitchell	engineering geology	GSA Environmental & Engineering Geology Division
Richard Dunn; Laura Murphy	archaeological geology	GSA Geoarchaeology Geology Division
Lydia Schiavo Tackett	geomicrobiology	GSA Geobiology & Geomicrobiology Division
Alan Rooney	geochronology	GSA Geochronology Division
Frank Ramos	geochemistry	Geochemical Society
Matty Mookerjee; Leslie Hsu; Denise Hills	geoinformatics	GSA Geoinformatics and Data Science Division
Saugata Datta	geology & health	GSA Geology and Health Division
David Szymanski; Susan Stover	geoscience and public policy	GSA Geology and Society Division
Benjamin Drenth; Diane Doser	geophysics/geodynamics	GSA Geophysics and Geodynamics Division
Elizabeth Petrie; Kelly Lazar	geoscience education	GSA Geoscience Education Division
Cynthia L. Prosser	geoscience information/communication	Geoscience Information Society
Mary Hubbard		GSA International
Michael S. Smith; Yildirim Dilek	history of geology	GSA History and Philosophy of Geology Division
Randy Stotler; Jeffrey M. McKenzie	hydrogeology	GSA Hydrogeology Division
Andrew James Luhmann; Jason Polk	karst	GSA Karst Division
Jeffery Stone; Scott Starratt	limnogeology	GSA Limnogeology Division
Bernard J. Coakley	marine/coastal science	Marine/Coastal Geology
Rosemary Hickey-Vargas; Mark J. Caddick	mineralogy/crystallography; geochemistry; petrology, volcanology	GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division
Philip Brown	mineralogy/crystallography; petrology, igneous; petrology, metamorphic; volcanology	Mineralogical Society of America
John Taber	geoscience education	National Association of Geoscience Teachers
Miriam E. Katz	paleoclimatology/paleoceanography	Paleoceanography/Paleoclimatology

(continued)

(continued)

JTPC Contact(s)	Discipline	Review Group
Simon Darroch; Elizabeth Petsios; Matthew E. Clapham	paleontology, biogeography/biostratigraphy; paleontology, diversity, extinction, origination; paleontology, paleoecology/taphonomy; paleontology, phylogenetic/morphological patterns	Paleontological Society
Debra Needham; Sharon A. Wilson Purdy	planetary geology	GSA Planetary Geology Division
Julia Baldwin	Precambrian geology	Precambrian Geology
Grant Meyer; Martha Cary Eppes	geomorphology; Quaternary geology	GSA Quaternary Geology and Geomorphology Division
Ryan F. Morgan; Piret Plink-Bjorklund	sediments, carbonates; sediments, clastic; stratigraphy	GSA Sedimentary Geology Division
Piret Plink-Bjorklund	sediments, carbonates; sediments, clastic; stratigraphy	SEPM (Society for Sedimentary Geology)
Alan Rooney	economic geology	Society of Economic Geologists
Gary Stinchcomb; Zsuzsanna Balogh-Brunstad	soils	GSA Soils and Soil Processes Division
Paul Kapp; Paul J. Umhoefer; Nancye H. Dawers	structural geology; tectonics	GSA Structural Geology and Tectonics Division

# Give Wings to your Research

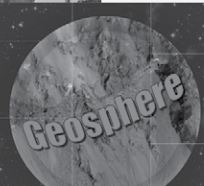
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Lithosphere



JOURNAL	Impact Factor		SUBMIT
	2019	5-YEAR	
GSA Bulletin	4.039	4.450	gsabulletin.msubmit.net
Geology	5.073	5.451	geology.msubmit.net
Geosphere	2.811	2.741	geosphere.msubmit.net
Lithosphere	2.766	3.195	lithosphere.msubmit.net
E&EG	0.318	0.730	http://eeg.allentrack.net/cgi-bin/main.plex

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## GSA Member Community, Powered by You

GSA members: Lend your voice to your community and interact with your peers—Sign up now to

GET CONNECTED...

“The GSA Member Community is a key part of the UTD Geoscience Studio’s dissemination strategy.” —*Bob Stern*

“Your new video is exceptional on all points. Nice job all!”  
—*David Gross*

“Thank you for your encouraging comments.” —*Ken Wolgemuth*

“This sounds like such a fantastic opportunity. Thanks for posting.” —*Suzanne OConnell*

...IN THE COMMUNITY



[community.geosociety.org](http://community.geosociety.org)

## GSA’s Associated Societies

GSA has a long tradition of collaborating with like-minded organizations in pursuit of mutual goals to advance the geosciences. As the Society looks to the future, it aims to build strong, meaningful partnerships with other societies and organizations across the country and around the world in service to members and the global geoscience community. National and international societies with consistent aims and missions of advancing the geosciences and/or science in general are invited to affiliate with GSA as an Associated Society.

GSA currently works with its 73 Associated Societies and 21 specialty science Divisions to build a dynamic Annual Meeting technical program and stimulating events during the meeting. Many of our Associated Societies will present their representative science, hold tailored events, and have exhibit booths during the GSA Annual Meeting & Exposition in Phoenix, Arizona, USA, this September. GSA is looking forward to hosting these valued partners and organizations. Members of Associated Societies also receive the GSA member registration rate to the Annual Meeting.

For more information about the GSA Associated Societies and a full list of current Associated Societies, go to <https://bit.ly/2T0JZtl>.

## Media Coverage

### Request an Annual Meeting Press Release

Each year, GSA works to highlight scientific presentations from the Annual Meeting that may be of wider interest beyond the GSA community. If you are presenting new research that you would like to share with science journalists and the audiences they write for, please let us know well in advance of the meeting. Submit a press release request at <https://bit.ly/2VAEvHr>.

### Media Registration

Complimentary meeting registration is available to journalists from bona fide news organizations and public information officers (PIOs) from geoscience-related organizations. Media registration provides access to all scientific sessions, the Exhibit Hall, and the newsroom. Get information about eligibility and request media credentials at [community.geosociety.org/gsa2019/connect/press/registration](http://community.geosociety.org/gsa2019/connect/press/registration).

# Schedule at-a-Glance

## Saturday, 21 Sept.

- ▶ Short Courses: 8 a.m.–5 p.m. (some begin on Friday)
- ▶ Pre-Meeting Field Trips (some begin earlier)
- ▶ Various business meetings of GSA, GSA Divisions, and Associated Societies
- ▶ PHOENIX ICEBREAKER: 5–7 p.m.

## Sunday, 22 Sept.

- ▶ Oral Technical Sessions: 8 a.m.–noon
- ▶ GeoCareers Center: 9 a.m.–5 p.m.
- ▶ GeoCareers Showcase: 9 a.m.–7 p.m.
- ▶ Poster Sessions: 9 a.m.–5:30 p.m.
- ▶ Lunch Break: noon–1:30 p.m.
- ▶ GSA Presidential Address & Awards Ceremony: noon–1:30 p.m.
- ▶ Oral Technical Sessions: 1:30–5:30 p.m.
- ▶ Exhibits Open: 2–7 p.m.
- ▶ Exhibits Opening Reception: 5:30–7 p.m.

## Monday, 23 Sept.

- ▶ Oral Technical Sessions: 8 a.m.–noon
- ▶ GeoCareers Center: 9 a.m.–5 p.m.
- ▶ GeoCareers Showcase: 10 a.m.–6:30 p.m.
- ▶ Poster Sessions: 9 a.m.–6:30 p.m.
- ▶ Exhibits: 10 a.m.–6:30 p.m.
- ▶ Lunch Break: noon–1:30 p.m.
- ▶ Feed Your Brain: 12:15–1:15 p.m.  
(*Lunchtime Enlightenment*, buy your food and take it in)
- ▶ Oral Technical Sessions: 1:30–5:30 p.m.
- ▶ Collaborations & Conversations—Posters: 4:30–6:30 p.m.
- ▶ Alumni Receptions: evening hours

## Tuesday, 24 Sept.

- ▶ Oral Technical Sessions: 8 a.m.–noon
- ▶ GeoCareers Center: 9 a.m.–5 p.m.
- ▶ GeoCareers Showcase: 10 a.m.–6:30 p.m.
- ▶ Poster Sessions: 9 a.m.–6:30 p.m.
- ▶ Exhibits: 10 a.m.–6:30 p.m.
- ▶ Lunch Break: noon–1:30 p.m.
- ▶ Feed Your Brain: 12:15–1:15 p.m.  
(*Lunchtime Enlightenment*, buy your food and take it in)
- ▶ Oral Technical Sessions: 1:30–5:30 p.m.
- ▶ Collaborations & Conversations—Posters: 4:30–6:30 p.m.

## Wednesday, 25 Sept.

- ▶ Oral Technical Sessions: 8 a.m.–noon
- ▶ GeoCareers Center: 9 a.m.–noon
- ▶ GeoCareers Showcase: 10 a.m.–2 p.m.
- ▶ Poster Sessions: 9 a.m.–6:30 p.m.
- ▶ Exhibits: 10 a.m.–2 p.m.
- ▶ Lunch Break: noon–1:30 p.m.
- ▶ Feed Your Brain: 12:15–1:15 p.m.  
(*Lunchtime Enlightenment*, buy your food and take it in)
- ▶ Oral Technical Sessions: 1:30–5:30 p.m.
- ▶ Collaborations & Conversations—Posters: 4:30–6:30 p.m.

## Thursday, 26 Sept.

- ▶ Post-Meeting Field Trips

# Registration

Registration will open in early May | **Early registration deadline:** 19 August | **Cancellation deadline:** 26 August

REGISTRATION FEES	Early (May–19 Aug.)	Standard/Onsite (after 19 Aug.)
Professional Member—Full Meeting	US\$430	US\$510
Professional Member—One Day	US\$265	US\$305
Professional Member—70+ Full Meeting	US\$305	US\$390
Professional Member—70+ One Day	US\$205	US\$230
Professional Nonmember—Full Meeting	US\$625	US\$700
Professional Nonmember—One Day	US\$370	US\$445
Early Career Professional—Full Meeting	US\$270	US\$340
Early Career Professional—One Day	US\$165	US\$199
Student Member—Full Meeting	US\$145	US\$180
Student Member—One Day	US\$100	US\$115
Student Nonmember—Full Meeting	US\$200	US\$235
Student Nonmember—One Day	US\$135	US\$155
High School Student	US\$50	US\$50
K–12 Professional—Full Meeting	US\$65	US\$75
Field Trip or Short Course Only	US\$45	US\$45
Guest or Spouse	US\$100	US\$110
Low Income Country*	50%	50%
*Participants from countries classified as “Low or Lower Middle Income Economies” by the World Bank need only pay 50% of the category fee for full-meeting or one-day registration. Online registration is not available for “Low or Lower Middle Income Economy” registrants. Please fill out a printable version of the registration form and mail it to GSA, P.O. Box 9140, Boulder, CO 80301-9140, USA.		

GSA strives to create a pleasant and rewarding experience for every attendee. Let us know in advance of the meeting if you have needs that require further attention. Most dietary considerations can be met without any extra charge. Be sure to check the box when registering online and describe your need in the space provided.

## Events Requiring Tickets/Advance Registration

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

## Don't forget to...

- Register for tours, special events, field trips, and short courses;
- Bring a copy of your meeting confirmation with you;
- STUDENTS: Be sure to apply for the travel grant program by 19 August;
- Make your hotel reservation; and
- Book your travel.

## TRAVEL GRANTS

Need assistance getting to the Annual Meeting? GSA Sections, Divisions, and Associated Societies are ready to help! Various groups are offering grants to help defray your costs for registration, field trips, travel, etc. Check the meeting website for application and deadline information. Eligibility criteria and deadline dates may vary by grant.

For meeting attendees who reside outside of North America, check the International Travel Grant webpage ([community.geosociety.org/gsa2019/attend/travel/international](http://community.geosociety.org/gsa2019/attend/travel/international)).

**Help a member participate in the GSA Annual Meeting by donating to the Student Travel Fund on your registration:** Interested in helping students participate in the meeting? Every year, a large percentage of students apply for travel grants for the meeting but do not receive an award due to a limited number of funds. You can help reduce this number by donating as little as US\$10 via your registration form. 100% of funds collected go to students.







## Student Volunteers

Sign-up will open in early July. Please wait to register for the meeting until you sign up as a volunteer, unless you want to reserve a space in a Field Trip or Short Course. Learn more at [community.geosociety.org/gsa2019/attend/registration/volunteers](http://community.geosociety.org/gsa2019/attend/registration/volunteers).

## Meet With Us on Social Media

(follow hashtag #GSA2019)

-  [twitter.com/geosociety](https://twitter.com/geosociety)
-  [instagram.com/geosociety](https://www.instagram.com/geosociety)
-  [facebook.com/GSA.1888](https://www.facebook.com/GSA.1888)
-  [community.geosociety.org](http://community.geosociety.org)

## Event Space & Event Listing Requests

### Deadline for first consideration: 6 MAY

Please let us know about your non-technical events via our online event space & event-listing database—connect via [community.geosociety.org/gsa2019/connect/events](http://community.geosociety.org/gsa2019/connect/events). Space is reserved on a first-come, first-served basis; in order to avoid increased fees, you must submit your request for meeting rooms by MONDAY, 6 MAY. The event space/event listing submissions should be used for meeting rooms to hold events (i.e., business meetings, luncheons, receptions, etc.):

- At the Phoenix Convention Center (PCC), Sheraton Grand Phoenix, or Hyatt Regency Phoenix—with no food/beverage minimum or room rental fee from the facility/hotel; and/or
- For off-site events (events that are not being held at the PCC, Sheraton Grand Phoenix, or Hyatt Regency Phoenix).

Ensure that your event is listed in the meeting program book, the personal scheduler, and the mobile app, as well as on the GSA website. Meeting room assignments will be made in early June.

## Childcare by KiddieCorp

**Location:** Phoenix Convention Center

**Hours:** Sun.–Wed., 7 a.m.–6 p.m. daily

**Ages:** Six months to 12 years

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

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

**More info:** [www.kiddiecorp.com/parents-guide/](http://www.kiddiecorp.com/parents-guide/)

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

**Reserve Childcare in Advance:** To ensure that the center is properly staffed and to facilitate planning of games and other

activities for the children, advance registration is required. On-site registration may be possible, at a slightly higher cost, if space is available. The deadline for advance childcare registration is **23 Aug. 2019**.

**Cancellations:** For a full refund, cancellations must be made to KiddieCorp prior to 23 Aug. Cancellations made after 23 Aug. will incur a 50% fee. No refunds after 4 Sept.

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

Contact: KiddieCorp  
+1-858-455-1718  
[info@kiddiecorp.com](mailto:info@kiddiecorp.com)



# Hotels

## Reservation deadline: 28 August

GSA has negotiated special hotel rates for GSA 2019 attendees. We appreciate your support by staying in the official GSA hotels; your patronage enables GSA to secure the meeting space at a greatly reduced cost, which in turn helps lower the cost of the meeting and your registration fees.

Orchid.Events (OE) is GSA's only official housing company for this meeting. To be included in the GSA room block and receive GSA rates, you must make your reservation through OE. Reservations are taken on a first-come, first-served, space-available basis. We recommend that you make your reservation early for the best opportunity to get the hotel of your choice.

## Reservation Options

**Online:** [community.geosociety.org/gsa2019/attend/travel/hotels](http://community.geosociety.org/gsa2019/attend/travel/hotels) (for new reservations, modifying an existing reservation, or cancelling).

**Phone:** Agents are available 7 a.m.–6 p.m. MST, Mon.–Fri.: +1-855-657-0547 (U.S. toll-free); +1-801-433-0661 (international).

**Print:** Download the form and fax (+1-801-355-0250; do not mail after faxing) or mail the completed form to Orchid.Events, 175 S. West Temple, Suite 30, Salt Lake City, UT 84101, USA.

## Critical Dates

19 Aug.: The last day to cancel rooms without a penalty;  
**28 Aug.: Reservations must be received by this date in order to guarantee rooms at special meeting rates;**  
12 Sept.: All changes, cancellations, and name substitutions must be finalized through OE;  
After 12 Sept.: You must contact the hotel directly with any changes or for new reservations.

Rates are in U.S. dollars and do not include the current applicable tax of 12.75%. Complimentary basic Internet will be provided in all guest rooms booked through GSA/OE. Please check [community.geosociety.org/gsa2019/attend/travel/hotels](http://community.geosociety.org/gsa2019/attend/travel/hotels) for details.

## Room Sharing

Use the GSA Travel & Housing Bulletin Board at [community.geosociety.org/gsa2019/attend/travel/rooms-rides](http://community.geosociety.org/gsa2019/attend/travel/rooms-rides) to share housing, airport shuttles, and/or carpool. You can also use this service to make arrangements to meet up with your colleagues.

## ALERT

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

## Special Requests

Please contact OE at +1-855-657-0547 or [help@orchid.events](mailto:help@orchid.events) if you have special requests, including if you need to book a suite. Some requests are not guaranteed and hotels will assign specific room types upon check-in, based on availability.

## Acknowledgments

OE will send reservation acknowledgments within 24 hours via email if you booked online or by telephone; fax and mail acknowledgments will be sent within 72 hours of receipt. If you do not receive your acknowledgment in this time frame, contact OE.

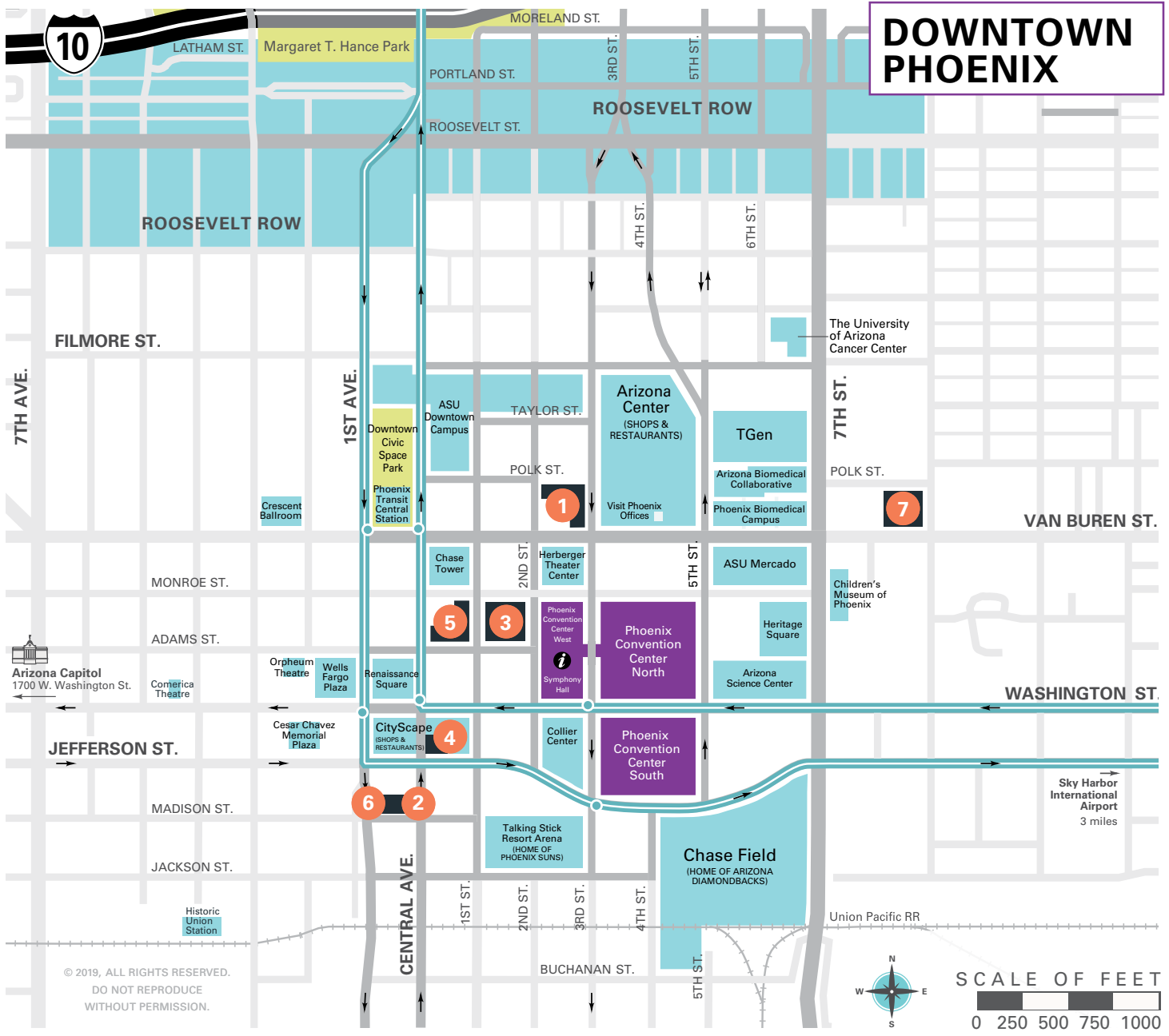
### **You will not receive a written confirmation from the hotel.**

The hotels will not access their room lists from OE until sometime between 29 Aug. and 11 Sept. Please do not contact the hotels directly regarding your reservation until after 11 Sept.

## Deposits, Cancellations, and Changes

All reservation requests must be accompanied by a credit card guarantee or check equaling the amount of one night's room and tax for each room reserved. Reservations cancelled after 20 Aug. but prior to 11 Sept. will be subject to a US\$25 fee for each room cancelled. Cancellations made after 11 Sept. will be subject to the hotel's cancellation policy. There is a 72-hour cancellation policy in place for all reservations. Failure to cancel a reservation 72 hours prior to arrival will result in a one-night non-refundable guest room charge plus applicable taxes posted to the attendee's credit card on file. Through 12 Sept., please send requests for changes and cancellations via email to OE at [help@orchid.events](mailto:help@orchid.events) or in writing by fax to +1-801-355-0250. After 12 Sept., contact hotels directly to make changes and cancellations.

### DOWNTOWN PHOENIX



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#### HOTELS

- 1 Sheraton Grand Phoenix (HQ)
- 2 Courtyard by Marriott Phoenix Downtown
- 3 Hyatt Regency Phoenix
- 4 Kimpton Hotel Palomar Phoenix
- 5 Renaissance Phoenix Downtown Hotel
- 6 Residence Inn by Marriott Phoenix Downtown
- 7 Springhill Suites by Marriott Phoenix Downtown

#### SINGLE/DOUBLE

- \$199
- \$189
- \$199
- \$179
- \$199
- \$209
- \$159

#### LEGEND

- LIGHT RAIL ROUTE
- LIGHT RAIL STATION
- VISITOR INFO CENTER
- CONVENTION CENTER
- POINT OF INTEREST
- HOTELS
- PARK



# Hotel Rates

Hotel	Rate (Single/Double)	Each Additional Adult (3rd & 4th Person)	Distance to PCC	Parking (24-hr)**
Sheraton Grand Phoenix (HQ Hotel)	US\$199	US\$20	1 block	Self US\$25; Valet US\$35
Courtyard by Marriott Downtown Phoenix	US\$189	US\$0	3 blocks	Valet US\$33
Hyatt Regency Phoenix	US\$199	US\$20	across the street	Self US\$23; Valet US\$33
Kimpton Hotel Palomar Phoenix	US\$179	US\$20	3 blocks	Self US\$25; Valet US\$33
Renaissance Phoenix Downtown Hotel	US\$199	US\$20	1 block	Valet US\$35
Residence Inn by Marriott Downtown Phoenix	US\$209	US\$10	3 blocks	Valet US\$33
SpringHill Suites by Marriott Phoenix Downtown*	US\$159	US\$0	3 blocks	Complimentary

\*Breakfast included in rate (check hotel website for specifics regarding breakfast menu)  
 \*\*Parking rates subject to change; additional fees for oversized vehicles  
 Note: PCC—Phoenix Convention Center

## Travel & Transportation



Photo © Visit Phoenix/Jill Richards.



### Phoenix Sky Harbor International Airport (PHX)

Sky Harbor, dubbed “America’s Friendliest Airport,” is the main airport for the greater Phoenix area. With 1,200 daily flights—about 500 of them nonstop—Sky Harbor is one of the most convenient airports in the United States. The airport is located in the middle of greater Phoenix, less than ten minutes from downtown.

Need to get from the airport to your downtown hotel? It will only cost you US\$2 one-way if you take Phoenix’s Valley Metro light-rail system (or US\$4 for an all-day pass). Learn more at [www.valleymetro.org](http://www.valleymetro.org).

The free PHX Sky Train people-mover transports you from the airport to the 44th Street/Washington Street light-rail station, and from there it is just a 15-minute air-conditioned ride to the downtown hotels and the convention center. The light-rail system is also the easiest way to get to downtown restaurants, museums, and other amenities.

The airport is also served by taxis, limousines, shuttle services, Lyft, and Uber.

### Phoenix-Mesa Gateway Airport

Phoenix-Mesa Gateway Airport, located in southeast Mesa, is a growing regional airport serving the greater Phoenix area. Gateway Airport serves about 1.3 million passengers per year to more than 35 nonstop destinations. It has convenient access to the Loop 202 Santan and U.S. 60 freeways, allowing passengers to connect to the entire metro area. Learn more at [www.gatewayairport.com](http://www.gatewayairport.com).



### Greyhound

Greyhound’s ([www.greyhound.com](http://www.greyhound.com)) iconic brand is synonymous with affordable long-distance travel in North America and a unique national network. The Phoenix bus station (2115 E. Buckeye Road, Phoenix, AZ 85034, USA) is three miles from the Phoenix Convention Center.

# Discover Phoenix



Photo © Visit Phoenix/Arizona Science Center.

## Arizona Science Center

The Arizona Science Center provides exploration, education, and entertainment for all ages. Nestled in the picturesque setting of Heritage and Science Park, the Science Center is a unique landmark designed by renowned architect Antoine Predock. The combination of ramps, hallways, galleries, and terraces in this 140,000-square-foot building creates an intriguing environment of investigation and discovery. The center contains four levels of exciting “hands-on” exhibits, a state-of-the-art planetarium, and a five-story-high giant screen theater. The exhibits and galleries are designed to educate and entertain kids of all ages—from pre-K to gray! Located in the heart of downtown Phoenix, the Science Center is within walking distance to nearby attractions, such as Heritage Square, the Phoenix Convention Center, Talking Stick Resort Arena, Chase Field, the Arizona Center, and more.

## Chase Field

Home to the Arizona Diamondbacks—come check them out as they host the St. Louis Cardinals on 23–24 Sept. at 6:40 p.m.

## Heard Museum

The tradition, culture, and history of 22 regional American Indian tribes converge in the Heard Museum’s immersive exhibits and authentic art shop. Through art and cultural objects, the museum’s ongoing exhibits tell the stories of native people of the Southwest, from early history to powerful memories of boarding schools.

## Phoenix Art Museum

Since it opened in 1959, the Phoenix Art Museum has become the largest art museum in the southwestern United States, providing access to visual arts and educational programs in

Arizona. In the past fifty years, millions have visited the museum to view the over four-hundred national and international exhibitions it has hosted. These are shown alongside the Phoenix Art Museum’s collection, which has grown to more than 17,000 objects of American, Asian, European, Latin American, Western American, modern and contemporary art, photography, and fashion design. The museum hosts photography exhibitions through its landmark partnership with The University of Arizona’s Center for Creative Photography in Tucson. Visitors can also enjoy the interactive PhxArtKids gallery and the lush Dorrance Sculpture Garden. Free admission on Wednesdays from 3–9 p.m.

## Pueblo Grande Museum

Pueblo Grande Museum is an archaeological site once inhabited by the Hohokam culture, just east of downtown Phoenix, next to Sky Harbor International Airport. It’s a National Historic Landmark and Phoenix Point of Pride accessible by the Sky Train and the light rail. Part of the City of Phoenix Parks and Recreation Department since 1929, it’s the largest preserved archaeological site in Phoenix. A fully accessible 2/3-mile trail takes you through a prehistoric Hohokam archaeological site with a platform mound, ball court, and replicated houses. Three galleries display artifacts and information on the Hohokam and village site, and the museum offers a hands-on children’s gallery. Purchase Native American gifts, art, and jewelry at the museum store. Closed Sundays and Mondays.



Photo © Visit Phoenix/Pueblo Grande Museum.

## Roosevelt Row

Roosevelt Row is downtown Phoenix’s walkable arts district, home to art galleries and studio spaces, restaurants, bars, and boutique shops in a landscape dotted by colorful street art.

# Guest Program



## Penrose Guest Hospitality Suite

Hours: Sun.–Wed., 22–25 Sept., 8 a.m.–5:30 p.m.

We warmly welcome all members of the GSA community to Phoenix! As part of that welcome, we offer registered guests and Penrose Circle Invitees a comfortable hospitality suite for rest and relaxation while technical sessions are happening. As a registered guest, you are welcome to attend your companion's technical session(s), and you will have admittance to the Exhibit Hall. Activities in the suite include complimentary refreshments, entertaining and complimentary seminars, and local experts ready to answer your questions about the area. Local tours and activities will also be offered for an additional fee. We hope you take advantage of the tours to learn about the area from one of the knowledgeable guides.

## Seminars

### Southwest Wildlife Exhibit

Sun., 22 Sept., 10–11 a.m.

Enjoy an up-close-and-personal look at the creatures that call the Southwest desert home. A sample of our native Sonoran reptiles, birds, and/or mammals will be available, along with their handler, for a brief presentation on life in the Arizona wild.

### Edible Gardening

Mon., 23 Sept., 10–11 a.m.

Often confined to the backyard, edible gardens are about to make their front-yard debut. A certified garden expert will introduce the concept of incorporating traditional landscape plants with edible plants to create a visually appealing and functional garden. Selecting the right plants and incorporating design into your garden will provide food season after season by using eco-friendly solutions to create an environment for them to flourish. The resulting productive crop of seasonal herbs and vegetables can become a part of your family's health and well-being as you learn where and how your food is produced.

### Desert Hacks & Facts

Tues., 24 Sept., 10–11 a.m.

Learn a potpourri of skills, techniques, tricks, and facts that make a walk in the desert enjoyable, interesting, and survivable. Want to enjoy that hike in the desert a bit more? Want answers to questions such as: "How do I find my direction when my GPS and cell phone don't work?" "Can I really start a campfire with a soda can?" "How do I know what type of animal track I am looking at?" "What is a glochid?" "How does a saguaro thrive?" "Where can I find pierogi?" This 60-minute stomp through unusual desert trivia will prepare you to fake being a desert denizen and impress your family and friends.



Twin-spotted Spiny Lizard (*Sceloporus magister*). Photo by Kaldari, Public Domain, via Wikimedia Commons.



# Local Tours

The following tours are open to all registered meeting attendees and guests.



Photo © Visit Phoenix/Jill Richards.

## Heard Museum

Sun., 22 Sept., 9:30 a.m.–1 p.m. US\$59; 20-person minimum.

We're off to the Heard Museum, which reigns as the leading exhibitor of the heritage and history and arts and crafts of the Native American people. You'll trace the development of the culture of the Southwestern Indians through the many art displays, including Kachina carvings, silver-smithing, rug weavings, pottery, and basketry, to name a few. Look in on a Southwestern Indian craftsman as they create an original work of art, and browse through the gift shop, offering one of the finest selections of original Indian crafts available in the Valley. We'll also include a tour of the surrounding neighborhood to familiarize you with the downtown convention center area.

## Desert Botanical Garden

Mon., 23 Sept., 8 a.m.–noon. US\$64; 20-person minimum.

Most of the world's 20,000 varieties of cacti and desert plants are displayed in this 145-acre living museum, along with succulents, trees, wildflowers, and shrubs from arid regions of Asia, Africa, Australia, and the Americas. Temporary art exhibits rotate throughout the year, and guests will enjoy the creations of both national and local artists with colorful and monumental exhibitions, which can be found throughout the garden. Our guide will be available during the self-guided tour to answer any questions. You won't want to miss "Plants and People of the Sonoran Desert," a three-acre trail through a saguaro cactus forest, a mesquite thicket, a desert stream environment, and an upland chaparral habitat that explores the many uses of desert plants for food, construction, tools, basket making, and more. As we travel through the city to the gardens, our guide will showcase various points of interest along the route.

## Taliesin, Frank Lloyd Wright's School of Architecture, and Carefree

Tues., 24 Sept., 8 a.m.–noon. US\$81; 20-person minimum.

Follow us to the foothills of Frank Lloyd Wright's Taliesin West, the architectural school and foundation of the legendary master. You'll look in on his architects of tomorrow and their blueprints for the future and view a slide show highlighting the past works created by Wright. During this 90-minute tour, you'll visit the Wrights' private living quarters, the gracious Taliesin West "garden room," the drafting studio, music pavilion, the cabaret cinema, and more while you enjoy a walking tour around the terraces and walkways with an experienced guide who will explain the history and importance of the architecture. From there, we'll head on to Carefree, a resort community north of the city, nestled in the Foothills, offering a rugged Western, yet upscale, vibe. We'll stop at some of the boutique shops and galleries and include plenty of sightseeing along the way.



Taliesin West, Scottsdale. Photo by Jwagg0309 via Wikimedia Commons.

## Hello Phoenix, Hello Scottsdale

Wed., 25 Sept., 9 a.m.–12:30 p.m. US\$42; 20-person minimum.

Join us for an introduction and overview to the 5th largest city in America, Phoenix, Arizona. Our experienced guide will keep you entertained and informed during our tour around the historic, financial, and entertainment districts surrounding the convention center and beyond. From past to present, you'll learn about our vibrant city, including a drive past the capitol building, the sports arena, and several historic Phoenix landmarks. We'll also travel to the Old Town/5th Ave. area of Scottsdale, where you'll have time to explore the unique Southwestern shops, boutiques, and galleries that make Scottsdale "The West's Most Western Town."

The Geological Society of America®

GEOCAREERS

If you are entering the job market or are supporting someone who is and want more information about career pathways in the geosciences, plan to attend one or more of the events below.

## GeoCareers

Registration for these events not necessary. Details will be online.

- Pre-Meeting Webinars
- Career Workshop (Sun.)
- Company Lightning Talks (Sun.)
- Panel Luncheon (Sun.)
- Résumé Bank & Interviews (Sun.–Wed.)
- Company Information Booths (Sun.–Wed.)

## GeoCareers Center

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

Visit [community.geosociety.org/gsa2019/connect/student-ecp/geocareers](https://community.geosociety.org/gsa2019/connect/student-ecp/geocareers) for event details, dates, and times.

## Mentoring at GSA

GSA offers a variety of opportunities to mentor a student or early career professional at the Annual Meeting. Graduate students, early career professionals, professionals, and retirees are welcome to serve as mentors.

Learn more at [community.geosociety.org/gsa2019/connect/student-ecp/mentor](https://community.geosociety.org/gsa2019/connect/student-ecp/mentor) and sign up at <https://goo.gl/forms/0Ep5HRI9KtC2BGJl2>.



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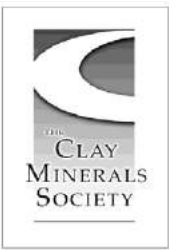

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## On To the Future

GSA is dedicated to attracting the best and brightest minds to our science. Since 2013, more than 500 students from diverse backgrounds have been funded to attend their first GSA Annual Meeting. Interested students can apply for a travel award to attend the Annual Meeting in Phoenix, Arizona, USA, 22–25 Sept. 2019. At the meeting, students will have special opportunities to be paired with a mentor, attend special morning sessions, and network with GSA leadership. GSA encourages low-income, minority, first-generation, non-traditional, women, LBGTQ, veterans, students with disabilities, and others to apply. Apply before 31 May.



[community.geosociety.org/OTF/home](http://community.geosociety.org/OTF/home)



Recent Minority Student Scholarship recipients. From left to right: David Davis, Lisa Duong, and Nora Soto Contreras.

## GSA Minority Student Scholarships

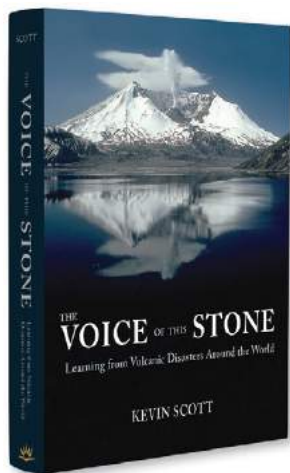
Expanding diversity and inclusivity is critical to innovation, scientific advancement, and solving tomorrow's geoscience challenges. GSA's Minority Scholarship awards six US\$1,500 scholarships to undergraduate students from minority backgrounds. Awardees also receive complimentary student membership and meeting registration for this year's Annual Meeting. Apply by 15 May at <http://bit.ly/2Du9z2S>. Email questions to [awards@geosociety.org](mailto:awards@geosociety.org).



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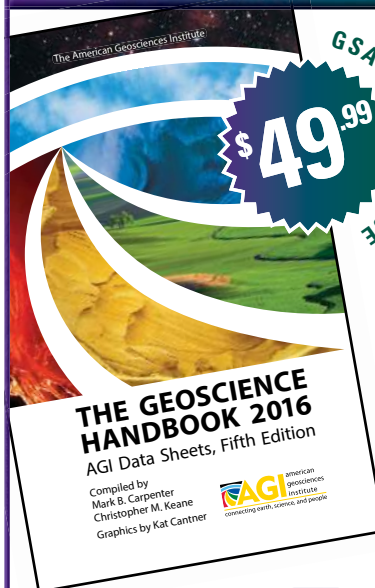
— Peter J. Baxter, M.D.  
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## Gear Up

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# Scientific Field Trips

Trip descriptions and leader bios are online at [community.geosociety.org/gsa2019/learn/field](http://community.geosociety.org/gsa2019/learn/field).

## 2. Pluton Construction in the Sierra Nevada Viewed Using the StraboSpot Field Data System. Wed.–Sat., 18–21 Sept.

Cosponsors: *GSA Structural Geology and Tectonics Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division*. Leaders: Allen F. Glazner, University of North Carolina; Basil Tikoff; John M. Bartley; Greg M. Stock; Drew S. Coleman.

## 3. What Is the Age of the Mazatzal Orogeny? Evidence for Mesoproterozoic ca. 1.47–1.45 Ga Regional Deformation in the Type Area of the Mazatzal Orogeny. Thurs.–Fri.,

19–20 Sept. US\$235. Cosponsors: *GSA Structural Geology and Tectonics Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division*. Leaders: Michael F. Doe, MF Doe Geoscience LLC.

## 5. Unraveling Volcanic and Related Processes Using Remotely Sensed Data Sets: Perspectives from a Miocene-Aged Volcanic Terrain in Northwest Arizona. Thurs.–Sat., 19–21 Sept.

Cosponsor: *GSA Planetary Geology Division*. Leaders: Nicholas P. Lang, Mercyhurst University; Susanne McDowell; Cole A. Nypaver; Briana D. Li-Vidal; Brandt M. Gibson.

## 6. Volcanology and Associated Hazards of the San Francisco Volcanic Field. Thurs.–Sat., 19–21 Sept. Leaders: Nancy Riggs, Northern Arizona University; Michael H. Ort; Charles Connor; Fabrizio Alfano; Michael Conway.

## 7. Back to the Jurassic: Architecture of Eolian and Wadi Facies of a Coastal Dune Field, Carmel Formation, and Seismites, Navajo Sandstone, Grand Staircase–Escalante National Monument and Paria Wilderness, Kane County, Southwest Utah. Wed.–Fri., 18–20 Sept. Cosponsor: *Pacific Section SEPM (Society for Sedimentary Geology)*. Leaders: Mario V. Caputo, San Diego State University; Thomas B. Anderson.

## 8. Exploring Arizona Earth Fissures: An Anthropogenic Geologic Hazard. Fri., 20 Sept. Leaders: Lorraine K. Carnes, Arizona State University; Joseph P. Cook.

## 9. Classic Springs and Karst Systems of Northern Arizona. Fri.–Sat., 20–21 Sept. Cosponsors: *GSA Hydrogeology Division; GSA Karst Division*. Leaders: Abraham E. Springer, Northern Arizona University; Benjamin W. Tobin.

## 10. Journey to the Grand Canyon: A Geologic and Hydrologic Excursion across Arizona's Magnificent Heartland. Fri.–Sat., 20–21 Sept. Leaders: Wayne Ranney; Marvin Frank Glotfelty.

## 12. Middle Proterozoic Rocks of the McDowell Mountains, Arizona, USA—Journey into the Magmatic Gap. Sat., 21 Sept. Cosponsor: *McDowell Sonoran Conservancy*. Leader: Steve Skotnicki.

## 13. An Educator's Look at Phoenix-Area Geology. Sat., 21 Sept. Cosponsors: *National Association of Geoscience Teachers (NAGT); NAGT Geo2YC Division; National Earth Science Teachers Association (NESTA)*. Leaders: Callan Bentley, North Virginia Community College; Merry Wilson, Scottsdale Community College; Carla McAuliffe; Aida Awad.

## 14. Tectonic Development of the Colorado Plateau Transition Zone, Central Arizona: Insights from Lower Crustal and Mantle Xenoliths and Volcanic Host Rocks. Sat., 21 Sept. US\$260. Cosponsors: *GSA Geochronology Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Structural Geology and Tectonics Division*. Leaders: Alan D. Chapman, Macalester College; Nancy Riggs; Mihai N. Ducea.

## 15. The Co-Evolution of Verde Valley and the Verde River, Central Arizona. Sat., 21 Sept. Cosponsor: *GSA Quaternary Geology and Geomorphology Division*. Leaders: Philip A. Pearthree; P. Kyle House; Kelin Whipple; Joseph P. Cook.

## 16. Geoarchaeology of Prehistoric Agriculture, Soils, and Floodplain Dynamics on the Lower Salt and Middle Gila Rivers, Arizona. Sat., 21 Sept. Leaders: Gary Huckleberry, University of Arizona; Kyle Woodson; Jonathan Sandor.

## 17. Lava and Pyroclastic Flows of the Miocene Goldfield-Superstition Volcanic Province, Central Arizona. Sat., 21 Sept. US\$120. Cosponsors: *GSA Mineralogy, Geochemistry, Petrology, Volcanology Division; Arizona Geological Society; Cereris Resource Development (Ft. Worth, Texas)*. Leaders: R.V. Fodor, North Carolina State University; Michael T. Mohr; Brian A. Dombroski.

**INDUSTRY TRACKS** Look for these icons, which identify sessions in the following areas:



Economic Geology



Engineering



Hydrogeology and  
Environmental Geology

## GSA 2019 ANNUAL MEETING & EXPOSITION

-  18. **Dust on a Dangerous Highway: Exploring Linkages between Landscape and Dust Emissions along Interstate-10 near Casa Grande, Arizona.** Sat., 21 Sept. Cosponsor: *GSA Quaternary Geology and Geomorphology Division*. Leader: Mark R. Sweeney, University of South Dakota; Eric V. McDonald, Desert Research Institute.
19. **Accessible Field Geology of Petrified Forest National Park.** Wed.–Thurs., 25–26 Sept. Cosponsors: *The International Association for Geoscience Diversity; GSA Geoscience Education Division; GSA Diversity in the Geosciences Committee*. Leaders: Christopher L. Atchison, University of Cincinnati; William G. Parker; Nancy Riggs; Steven Semken; Steven Whitmeyer.
20. **Catalina-Rincon Metamorphic Core Complex, Tucson, Arizona.** Wed.–Fri., 25–27 Sept. Leaders: George H. Davis, University of Arizona; George E. Gehrels; Jon Spencer.
21. **A River is Born: Highlights of the Geologic Evolution of the Colorado River Extensional Corridor and its River: A Field Trip Honoring the Life and Legacy of Warren Hamilton.** Wed.–Sat., 25–28 Sept. Cosponsors: *GSA Quaternary Geology and Geomorphology Division; GSA Structural Geology and Tectonics Division*. Leaders: Keith A. Howard, U.S. Geological Survey; P. Kyle House; Philip A. Pearthree; Barbara E. John; Ryan S. Crow.
22. **Sonoran Desert Landforms via Mountain Biking.** Thurs., 26 Sept. Leaders: Ronald Dorn, Arizona State University; Ian Walker, Arizona State University; Steve Skotnick, Hydrosystems Inc.
23. **The 2010 Schultz Fire—Immediate, Ongoing, and Long-Term Geomorphic, Ecological, and Societal Impacts of a Small, High-Severity Wildfire.** Thurs.–Fri., 26–27 Sept. Cosponsors: *Grant Meyer; GSA Quaternary Geology and Geomorphology Division; Stephen Slaughter; GSA Environmental and Engineering Geology Division*. Leaders: Ann M. Youberg, University of Arizona; Luke McGuire.
24. **Geology and Paleontology of the Mid-Pleistocene El Golfo Badlands, Sonora, Mexico.** Thurs.–Fri., 26–27 Sept. Leaders: Fred W. Croxen, Arizona Western College; Christopher A. Shaw.
25. **The Rise and Fall of a Laramide Deposystem: Structural Inversion and Regional Drainage Reversal across the Plateau Transition Zone in Eastern Arizona.** Thurs.–Fri., 26–27 Sept. Leader: Andre R. Potochnik, Grand Canyon Conservancy.
26. **Exploring Superimposed Laramide Contraction, Porphyry Copper Systems, and Cenozoic Extension in the Globe-Superior-Ray–San Manuel Area, East-Central Arizona.** Thurs.–Sat., 26–28 Sept. Cosponsor: *GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Structural Geology and Tectonics Division*. Leaders: Mark D. Barton, University of Arizona; Eric Seedorff, University of Arizona; Daniel Favorito; Roy Greig; Carson A. Richardson.
27. **The “Holey” Tour: Ron Greeley’s Introductory Planetary Geology Field Trip.** Thurs.–Sat., 26–28 Sept. Cosponsors: *GSA Planetary Geology Division; Arizona State University School of Earth and Space Exploration*. Leaders: David A. Williams, Arizona State University; Steven D. Kadel; R. Scott Harris.
-  28. **Mesozoic to Cenozoic Sedimentation, Tectonics, and Metallogeny of Sonora, Mexico.** Thurs.–Mon., 26–30 Sept. Cosponsors: *Roberto Molina Garza, National Autonomous University of Mexico (UNAM); Southern Copper Corp.; Fresnillo plc*. Leaders: Jason B. Price, California Institute of Technology; Thierry Calmus.
29. **Volcanic and Marine Stratigraphy along the El Alamo Canyon, Santa Rosalia Basin, Baja California.** Thurs.–Wed., 26 Sept.–2 Oct. Cosponsor: *Geophysics Institute, UNAM, Campi Morelia*. Leader: José Luis Macías, National Autonomous University of Mexico (UNAM).
30. **Walk in the Footsteps of the Apollo Astronauts.** Fri.–Sat., 27–28 Sept. Cosponsors: *U.S. Geological Survey; Flagstaff Festival of Science; Flagstaff Lunar Legacy; Lowell Observatory*. Leaders: R. Greg Vaughan, Astrogeology Science Center; Kevin Schindler; Jeanne Stevens; Ian Hough.
-  31. **An Introduction to the Pinal Terrain of Southern Arizona: A Paleoproterozoic Subduction Complex?** Fri.–Sat., 27–28 Sept. Cosponsor: *Arend Meijer*. Leader: Arend Meijer.
-  32. **A Comparison of Two Caves in Southern Arizona: Colossal Cave and Kartchner Caverns.** Thurs., 26 Sept. US\$90. Cosponsors: *Kartchner Caverns State Park; Colossal Cave Mountain Park*. Leaders: Sarah Truebe, University of Arizona; Lauren Hohl.





## Short Courses

*Learn and explore a new topic. Build your skills.*

**Learn:** Assessing geoscience animations and videos, tools for geoscientists to write better code, and data-rich introductory teaching modules.

**Explore:** Luminescence and detrital zircon geochronology, geoheritage, geological mapping, ground-penetrating radar, limnogeology, interpretation of natural gases, forensic geochemistry, structural geology, and petroleum systems fundamentals.

**Strengthen your research, data-collection, and fieldwork skills with courses that address:** High-resolution topography and 3D imaging, 3D hydrogeological modeling, geostatistical modeling, planetary image analysis with ArcGIS, using the StraboSpot Data System and the Topographic Analysis Kit (TAK) for TopoToolbox, drones in the geosciences, quantifying sediment budgets, and field safety leadership.

**Gain tips:** Writing for geologists whose native language is not English, inclusive and effective college science classrooms, and how to write an effective scientific paper.

**Students and early career professionals:** Learn about sequence stratigraphy, petroleum structural geology, planetary geologic mapping, the structure and stratigraphy used for basin exploration, and take a variety of career workshops.

**K–12 teachers:** Create hands-on activities and think scientifically in a changing world.

For details and course descriptions, check the upcoming June issue of *GSA Today* or go to [community.geosociety.org/gsa2019/learn/short](http://community.geosociety.org/gsa2019/learn/short).

*This is a great opportunity to earn continuing education credits!*



### GSA Meetings RISE to the Top

We support Respectful Inclusive Scientific Events and are committed to ensuring a safe and welcoming environment for all participants. We expect all meeting participants to abide by the GSA Events Code of Conduct in all venues at our meetings, including ancillary events, field trips, and official and unofficial social gatherings.

## GSA Events Code of Conduct

*Approved by GSA Council on 24 Sept. 2016*

GSA is a premier, international scientific society whose goals and mission are to advance geoscience research and discovery, to provide service to society, and to promote stewardship of Earth, within and beyond the geosciences profession. In fulfilling its goals and mission, and in keeping with its Diversity Position Statement, GSA meetings foster the exchange of scientific ideas, through open and respectful dialogues at oral and poster sessions, field trips, short courses, mentorships, and other GSA-supported programs. GSA promotes, provides, expects, and endorses a professional and respectful atmosphere and values a diversity of views and opinions.

All registrants, guests, volunteers, exhibitors, GSA staff, service providers, and others in attendance are expected to abide by this code of conduct, which outlines specific expectations for participants at GSA-supported events and is in addition to the provisions of the GSA Code of Conduct. To read the full GSA Events Code of Conduct, go to [www.geosociety.org/conduct](http://www.geosociety.org/conduct).



Portrait of Mary Anning with her faithful dog, Tray, who accompanied her on her fossil searches. Mary stands with her collecting basket and rock hammer with the Golden Cap outcrop in the background. Natural History Museum, London: This painting was owned by her brother Joseph, and was presented to the museum in 1935 by Miss Annette Anning. (Credited to Mr. Grey in Crispin Tickell's book *Mary Anning of Lyme Regis* [1996]. Public domain, via Wikimedia Commons.)

## Mary Anning: She Sold (Fossil) Sea Shells by the Seashore

*Renee Clary, Mississippi State University*

The third Mary Anning was born 21 May 1799 to Richard and Mary (Molly) Anning of Lyme Regis, England. Her sister, the second Mary Anning, died just five months before the third Mary was born, the result of a tragic fire accident. As the fourth child of Richard and Molly—and one of only two of their 10 children to survive to adulthood—Mary Anning was seemingly not destined for paleontological greatness. She was poor, uneducated beyond the village school, and a woman who lived during a time when geological theorizing was conducted within gentlemen's societies.

However, Mary Anning surpassed society's expectations. Three decades after her birth, a contemporary attempted to explain her intelligence through supernatural intervention. When Mary was only a year old, a downpour forced her nurse,

with Mary and two children, to shelter under a tree. Lightning struck the tree and only Mary survived. Roberts (1834) claimed that Mary was rather dull before this event, but became quite bright after surviving the lightning strike.

As a young girl, Mary and her older brother, Joseph, accompanied their father to search for fossils within the Jurassic strata of the Blue Lias cliffs along the Lyme Regis coast. Richard, a cabinet maker by trade, polished the fossil finds and set up a table of "curiosities" for sale to the tourists who visited Lyme Regis. Financial necessity probably drove the family business, in addition to Mary's and Joseph's interest in the local fossils. They became astute fossil gatherers under their father's tutelage.

In yet another tragedy for the Annings, Richard Anning fell from one of the cliffs and died from consumption and his injuries in 1810, when Mary was only 11 years old. Faced with debts and little income, the family was forced to turn to parish relief. Mary inherited the family's fossil business since Joseph worked as an upholstery apprentice.

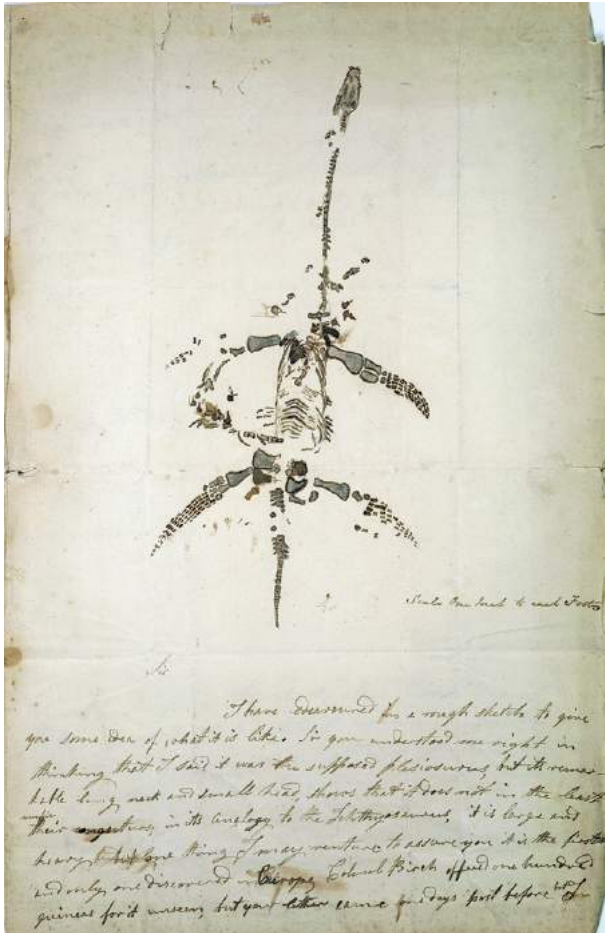
When Mary was 12 years old, Joseph found a large ichthyosaur skull. Because larger, unusual specimens commanded more money from gentleman collectors and museums, Mary searched for the remainder of the skeleton until she found it, higher in the cliffs. At the "mature" age of 12, she supervised workers to extract it. The ichthyosaur was the first Anning fossil to come to the attention of the scientific community. It was sold to a local gentleman, then to a collector, and eventually to the British Museum. Unfortunately, some parts of the specimen and its documentation did not survive.

Mary Anning continued her relentless pursuit of fossils. She uncovered more ichthyosaur fossils, and one of her specimens was published by Lieutenant Colonel Thomas Birch and illustrated in the Royal Society transactions. Upon learning the Annings were destitute to the point of selling their furniture, Birch organized a fundraiser auction in 1820 to sell the fossils he had purchased from the Annings, giving them the proceeds.

In 1823, Mary Anning found and excavated the first complete fossil plesiosaur, which was then described by gentlemen geologists William Conybeare and Henry De la Beche. The premier French paleontologist Georges Cuvier suspected it was a forgery with the large number of vertebrae in the creature's elongated neck. However, Cuvier eventually acknowledged the authenticity of the specimen. In 1828, Mary made yet another unusual discovery, this time of a pterosaur.

Mary Anning's fossil-collecting activities were not without risk. The storms that revealed new fossils also resulted in unstable cliffs and landslides. In 1833, she luckily escaped a collapsing cliff that crushed her faithful companion, Tray.

The larger fossil specimens brought greater income, but Mary continued to collect marine invertebrates to sell in the family fossil shop. She collected among the Blue Lias cliffs, which were especially productive after a storm. Among the common fossil finds were local ammonites and belemnites. Mary Anning and her friend Elizabeth Philpot cut the belemnites to reveal a tiny chamber with fossilized sepia. The ink, they hypothesized, likely served the same function for escape as in modern cephalopods. Mary, Elizabeth, and Henry De la Beche reconstituted the fossil ink with water and drew pictures of the fossils they had collected.



Mary Anning's 1823 sketch concerning her discovery of the first plesiosaurus. (Public domain, via Wikimedia Commons.)

Mary Anning also collected spiral-shaped stones and noted their placement within ichthyosaur skeletons. While William Buckland is credited with coprolite discovery and research, it seems likely that Mary's keen eye and attention to detail helped inform his identification of these spiral stones as ichthyosaur coprolites. Since women, especially poor ones, could not publish, we do not know the amount of data and insight Mary contributed to paleontological publications.

Even with important fossil discoveries, the Annings were still challenged with finances. De la Beche came to their rescue in 1830 when they were in dire straits. He drew a fanciful scene of Jurassic life, creatively adding flesh to the bones that Mary Anning collected, as he imagined the paleoecosystem of the Jurassic. De la Beche's watercolor was turned into a lithograph, and prints of *Duria antiquior* were sold to wealthy gentlemen to raise money for the Annings.

In acknowledgment of Anning's contributions to geology, William Buckland persuaded the government to recognize her. In 1838, the British government and British Association for the Advancement of Science allocated an annual pension to Mary Anning of £25. Unfortunately, she did not live a long life to enjoy the fruits of her labors, dying of breast cancer on 9 March 1847, a few months before her 48th birthday. Henry De la Beche, then president of the Geological Society of London, wrote an obituary for Anning, the only obituary afforded to a nonmember of the society. Later, the Geological Society memorialized her with a stained glass window in St. Michael's church in Lyme Regis. The stained glass panels represent the six corporal acts of mercy, recognizing Mary's compassion and generosity to those less fortunate.

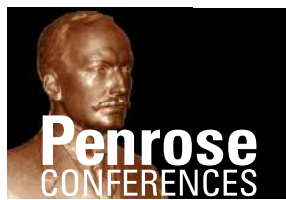
McCartney (1977) claimed that Mary Anning was the subject of the common tongue twister, "She sells sea shells by the seashore." If this is correct, then many school children have heard of her, although the vast majority are unaware of her significance. Anning has been referenced as the greatest fossilist ever and one of the first women paleontologists. Woodward (1907) called her "the most notable collector during the early part of the nineteenth century." However, Anning's contemporaries did not consider her one of their peers. She was a woman, uneducated, and poor.

Some historians argue that as an uneducated woman, Mary Anning could not possibly have contributed significantly to the scientific community. However, her correspondence with famous geologists testifies to her knowledge of the fossils she was collecting as well as to her importance within professional societies of the time—although she was denied admission to the same societies that benefited from her fossil finds. Mary's sketches are detailed and accurate, supporting the view that she was quite knowledgeable in paleontology and not merely a fossil finder.

## FOR FURTHER READING

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## ANNOUNCEMENT

# Climatic Controls on Continental Erosion and Sediment Transport: CLAST2019

4–10 August 2019 | Juneau, Alaska, USA  
[www.geosociety.org/penrose](http://www.geosociety.org/penrose)

### CONVENERS

**Tara N. Jonell**, *The University of Queensland, School of Earth and Environmental Sciences, St. Lucia, Australia, [tjonell@uq.edu.au](mailto:tjonell@uq.edu.au)*

**Peter D. Clift**, *Louisiana State University, Dept. of Geology and Geophysics, Baton Rouge, Louisiana, USA, [pclift@lsu.edu](mailto:pclift@lsu.edu)*

**Jan H. Blöthe**, *University of Bonn, Dept. of Geography, Bonn, Germany, [jan.bloethe@uni-bonn.de](mailto:jan.bloethe@uni-bonn.de)*

**Mengying He**, *Nanjing Normal University, School of Geography Science, Nanjing, China, [conniehe@njnu.edu.cn](mailto:conniehe@njnu.edu.cn)*

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### DESCRIPTION AND OBJECTIVES

The physical and chemical breakdown of continental crust into sediments by solid earth tectonic and climatically modulated forces are key steps in many global geochemical cycles. These processes control the compositional evolution of the continental crust and, ultimately, the recycling of material back into the upper mantle via subduction zones. The products of erosion and weathering are supplied to sedimentary basins within continents and to continental margins where they may be preserved, allowing reconstruction of tectonic and environmental histories of adjacent landmasses through the application of suitable proxies. Although tectonic forces are known to be a strong primary control on the generation of sediment, this meeting focuses on assessing the dynamic role of global and regional climate in controlling the production, transport, and deposition of sediments to basins over millennial to million-year time scales. How does climate mediate the sedimentary record and under what conditions can paleoenvironmental and paleoclimatic change be unambiguously deconvolved from the erosional signals preserved in the rock record?

There is no doubt that accelerated rock uplift can drive faster erosion rates of bedrock source terrains. What remains less clear, however, is how erosion and transport efficiency can be governed by climatic and earth-surface processes independent of tectonics, especially when changes in these processes often occur as a consequence of tectonic forcing.

Although it has typically been argued that stronger precipitation results in faster bedrock erosion, this relationship can be much more complex in many systems. This is because the simple model ignores factors such as seasonality and intensity/duration of precipitation, degree of soil and vegetation development, and/or topographic steepness, among many others. Often, understanding of several critical processes and their relative rates and distributions is required to define any relationship between climatic change and sediments produced as a result from that change. Yet, many equations for fundamental relationships in sediment transport and erosion still remain in the earliest stages of development. Furthermore, whether the same rules and conditions observed between climate, erosion, and sediment transport can be applied across different time scales is a source of considerable contemporary debate.

For this conference, we solicit talks that aid in understanding how climate can drive erosion and exhumation of source terranes, as well as the earth-surface processes that transport and deposit sediments in basins. Global Cenozoic climate, fluctuating sea level, and large-scale glaciation have pivotally affected our planet, from the physical evolution of mountain belts to the chemical breakdown of sediments distributed across margins. How do longer- and shorter-term climatic phenomena dictate rates of sediment supply and records of provenance? Sediments are rarely transferred immediately from bedrock to the deep sea because of intermittent storage and release. To what extent and over what time scales do environmental conditions mediate the periodic storage and transport of sediments between sources and final depocenters? Climatic control over sediment transport certainly extends to the offshore, so how do earth-surface processes dictate the supply, loading, and stratigraphic architecture along margins and into the deep sea? When, where, and how is it possible to isolate the erosional signals produced by tectonic forcing from those linked to climatic processes? And, under what conditions and time scales can precise and accurate climatic records be reconstructed from sediments?

This conference seeks to discuss these challenging questions. We particularly solicit contributions addressing erosion and/or environmental change from all earth-surface process disciplines that permit robust correlation between changes in climate, erosion, and sediment transport. Separating drivers and processes continues to be difficult, but is much improved in recent years as field studies are coupled with novel spatial and temporal control



**Left: Fireweed meadow with Mendenhall Glacier and the Towers. Photo by Gillfoto (Kenneth J. Gill) via Wikimedia Commons. Right: Tracy Arm, Alaska. Photo by Peter Mulligan via Wikimedia Commons.**

and further tested with dynamic landscape and stratigraphic models. This transdisciplinary meeting is intended to bring together sedimentologists, geomorphologists, landscape and stratigraphic modelers, as well as paleoclimatologists to showcase the current state of research, demonstrate contemporary evidence and methods from studies worldwide, and underline the research concerns remaining in our community.

### PRELIMINARY OUTLINE OF THEMATIC SESSIONS

1. From source to sink: tracing erosional signals;
2. Beyond the mainstream: continental deposition and erosion outside fluvial systems;
3. Cycles, thresholds, and feedbacks: the evolving atmosphere and biosphere;
4. From ice to the ocean;
5. Closing the gap: emergent tools and techniques for integrating earth-surface process and solid earth datasets across different time scales;
6. Moving forward: innovations in data sharing, visualization, and modelling to understand landscapes and climate; and
7. History matters: Reconciling tectonic, climate, and erosion histories.

### PRELIMINARY AGENDA

This seven-day meeting will start with an icebreaker in the evening of Sunday, 4 August, in the city of Juneau, nestled within the Coast Mountains of southeast Alaska, USA. It will end in fjordland, at the feet of Tracy Arm tidewater glaciers on the afternoon of Saturday, 10 August. The meeting will balance between invited talks, roundtable discussions, pop-ups, and poster presentations, with the first field trip occurring mid-week.

The mid-week field trip is structured to travel from the glaciated Coast Mountains to fjordland marine sinks and, in doing so, touch upon some of the dominant erosional and transport processes discussed during the meeting. This region of southeast Alaska is similar in setting to the beautiful Glacier Bay National Park to the west. Set within the Coast Mountains, Juneau features the Juneau Ice Field (including Mendenhall and Taku glaciers), abundant fjordland landscapes, uplifted glaciomarine sediments, some of the fastest ongoing glacial isostatic adjustment (~3 cm/yr), fault-controlled fluvial morphology, and a rich history of gold mining and salmon fishing. The field trip on the last day, via high-speed catamaran in Tracy Arm, will involve a casual geologic tour through the structure and evolution of the Coastal Shear Zone. Along the

way, notable views around some of the deepest fjordland in North America will incite discussion about fjord formation and sedimentation dynamics. Tours to Tracy Arm typically culminate in front-row seats to the Twin Sawyer glaciers to observe ice-calving and iceberg formation.

All nights will be spent at the Westmark Baranof Hotel, which is a 15-minute drive from the Juneau International Airport (JNU). Juneau is only a few hours' flight from several large, international aviation hubs.

### ATTENDEES AND ESTIMATE COSTS

The registration fee is estimated at US\$950–US\$1200 and will cover the cost of the meeting, hotel lodging for six nights (double occupancy; single occupancy may be possible with additional fees), the icebreaker reception, all lunches, coffee breaks, and poster refreshments, the mid-meeting conference dinner, and transportation and meals for the first field trip. The second field trip is optional; this cost is not included in registration and will be determined at a later date based on the number of interested participants. Airfare is not included, and participants must make their own travel arrangements.

### APPLICATIONS AND REGISTRATION

**Application period opens:** 1 March

**Application deadline:** 15 May

**Registration deadline:** 7 June

The conference will be limited to 70 participants, and each participant will have to commit to attending the first full six days of the conference, with an option to attend the field trip on the last day. To apply, please put together:

1. A brief statement of your interests and the relevance of your recent work to the conference themes (max. 300 words);
2. The tentative title of your proposed presentation;
3. An NSF-style (or similar format) curriculum vitae; and
4. Your contact information.

Submit your application to the conveners at [t.jonell@uq.edu.au](mailto:t.jonell@uq.edu.au) with “CLAST2019\_Lastname.Firstname” as the subject title. Interested graduate students, underrepresented researchers, and early career faculty are especially encouraged to apply. Once you have been selected to participate, you will be sent registration information.

For more information please visit the conference website at <https://clast2019.weebly.com>.

# Call for GSA Committee Service

Nominations due 15 June

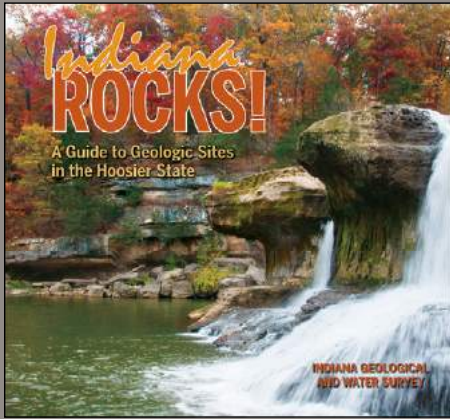
Learn more at [www.geosociety.org/Committees](http://www.geosociety.org/Committees), or contact Dominique Olvera at [dolvera@geosociety.org](mailto:dolvera@geosociety.org).

Terms begin 1 July 2020 unless otherwise noted.

COMMITTEE NAME	NO. OF VACANCIES	POSITION TITLE	TERM (years)
Academic and Applied Geoscience Relations (E, M)	1	Member-at-Large Industry	3
Arthur L. Day Medal Award (E, T)	2	Members-at-Large	3
Bascom Mapping Award (E, T)	1	Member-at-Large Government	3
	1	Member-at-Large Industry	
Diversity in the Geosciences (B, E, M)	2	Members-at-Large	3
	1	Member-at-Large Industry	3
	1	Member-at-Large Student	2
Education (B, E, M)	1	Undergraduate Student Representative	2
Geology and Public Policy (B, E, M)	2	Members-at-Large North America	3
	1	Member-at-Large Student	2
GSA International (E, M)	2	Members-at-Large	4
	1	Member-at-Large Outside North America	4
	1	Member-at-Large Student	2
Joint Technical Program (B, E) Term begins December 2019	1	Member-at-Large Precambrian Geology	2
	1	Member-at-Large Paleoclimatology & Paleooceanology	2
Membership and Fellowship (B, T)	1	Member-at-Large Industry	3
	1	Member-at-Large Student	3
Nominations (B, E)	2	Members-at-Large	3
North American Commission on Stratigraphic Nomenclature	1	Committee Representative	3
Penrose Medal Award (E, T)	2	Members-at-Large	3
Professional Development (E)	2	Members-at-Large	3
Public Service Award (E, T)	1	Member-at-Large	3
Publications (B, E, M)	1	Geoscience Information Society Library Representative	4
Research Grants (B, E, T)	12	Members-at-Large	3
Young Scientist Award (Donath Medal) (E, T)	2	Members-at-Large	3
	1	Member-at-Large (Councilor, former Councilor)	3

*Note:* Terms begin 1 July 2020 unless stated otherwise. B—Meets in Boulder or elsewhere; E—Communicates by phone or electronically; M—Meets at the Annual Meeting; T—Extensive time commitment required during application review period.





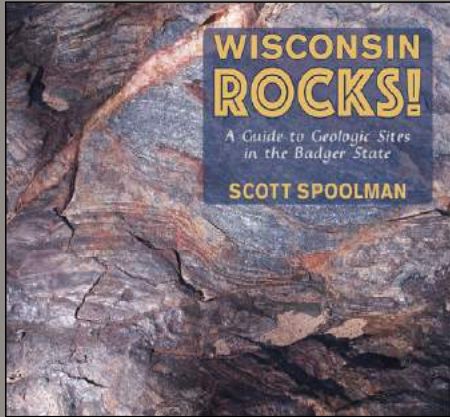
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## “Please keep helping more students come to GSA—we need your support!”

Your support makes On To the Future (OTF) a pivotal program that enables a cohort of diverse students to attend their first GSA Annual Meeting. Through the generosity of GSA members, both as mentors and donors, OTF continues to engage these students in ongoing career development and leadership opportunities. As we approach the program’s seventh year, we asked OTF alumni to reflect upon their experience with the program and its continued impact in their geoscience careers.



For **Crystal Tulley-Cordova**, OTF 2014, principal hydrologist for the Navajo Nation, “Participating in OTF allowed me to be introduced to others like me, under-represented individuals in the geosciences. Attending my first GSA Annual Meeting reaffirmed to me I have a unique perspective and contribution to offer to the geosciences as a Native American.” Crystal has remained active in GSA, presenting

research at the joint Rocky Mountain–Cordilleran Section Meeting in 2018, and deepening her commitment to mentoring undergraduate and graduate students across disciplines. For Crystal, there is no question, “OTF increases diversity in the geosciences and encourages participants to present their research, network with attendees, and to stay engaged with the scientific community.”



**Ángel A. García Jr.**, OTF 2015, visiting assistant professor at James Madison University, is grateful for the comprehensive support OTF provided: “Participating in GSA as an OTF student opened many opportunities. Besides the financial support the program offers and is much appreciated, being paired with a mentor during the Annual Meeting is really beneficial. *I cannot stress more how important this is.*”

Ángel’s OTF mentor not only helped him navigate the Annual

Meeting, but continues to provide professional support and friendship. This experience inspired Ángel to serve as a mentor during the GEOPATHS-IMPACT: Professional Development Pathways to Diversifying the Geosciences Workforce workshop for OTF students at the 2018 GSA Annual Meeting. Ángel is particularly grateful to GSA Foundation supporters: “Donor support of OTF means that more students from diverse cultural, academic, and financial backgrounds can go to the national meeting and become part of the society. Please keep helping more students come to GSA—we need your support!”



**Maria Bonilla**, OTF 2018, recently accepted a position with the Texas Commission on Environmental Quality—a decision that was directly impacted by her OTF experience. During a speaker panel on geoscience careers, Maria was inspired by an environmental geologist: “I had the opportunity to gain insights on the types of work in the environmental field, as well as how to prepare and stand

out during my job search. I was also exposed to research that sparked my interest in hydrogeology. Since then, I have been involved with projects in understanding and managing water resources.” Maria remains active in GSA and is excited to serve as an OTF mentor in the future: “OTF creates a sense of belonging in an organization with over 22,000 members, and it is an important program to support underrepresented minorities.”

**Crystal, Ángel, and Maria have benefitted from your support—will you help continue this legacy?** Your generosity cultivates the next generation of geoscientists and provides opportunities to underrepresented communities in the geosciences. **Make your gift today!** You can give online at [gsa-foundation.org/donate](http://gsa-foundation.org/donate), or to discuss in-depth ways that you can support On To the Future, please contact Clifton Cullen at +1-303-357-1007 or [ccullen@geosociety.org](mailto:ccullen@geosociety.org).



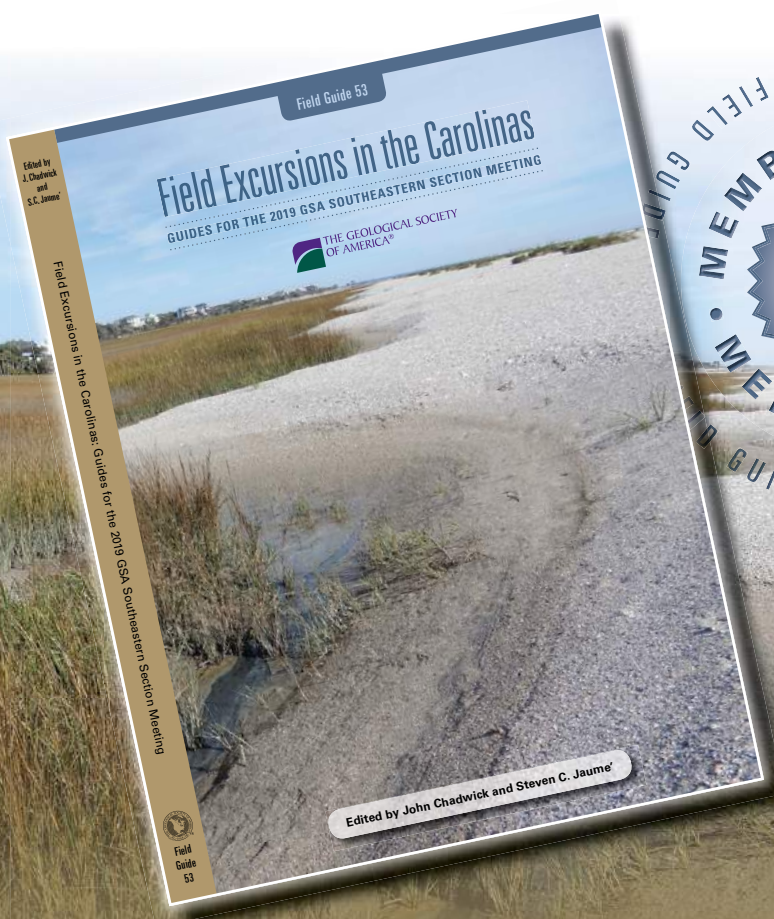
# Field Excursions in the Carolinas

GUIDES FOR THE 2019 GSA SOUTHEASTERN SECTION MEETING

Edited by John Chadwick and Steven C. Jaume'

This guidebook provides detailed itineraries of three field trips associated with the 2019 GSA Southeastern Section Meeting in Charleston, South Carolina. The first chapter outlines the fossiliferous deposits near Charleston historically referred to as the "Ashley Phosphate Beds," which include sharks, rays, sea turtles, whales, and other Oligocene to Pleistocene fossils. The second chapter explores how hydrology has shaped Charleston and how engineers, public officials, and citizens incorporate new technologies in design to increase community resiliency. The third chapter describes the variety of modern traces that can be observed in the coastal setting of Edisto Island near Charleston. These include burrows, tracks, borings, and other signs of terrestrial and marginal-marine invertebrates and vertebrates in sediments, shells, and wood.

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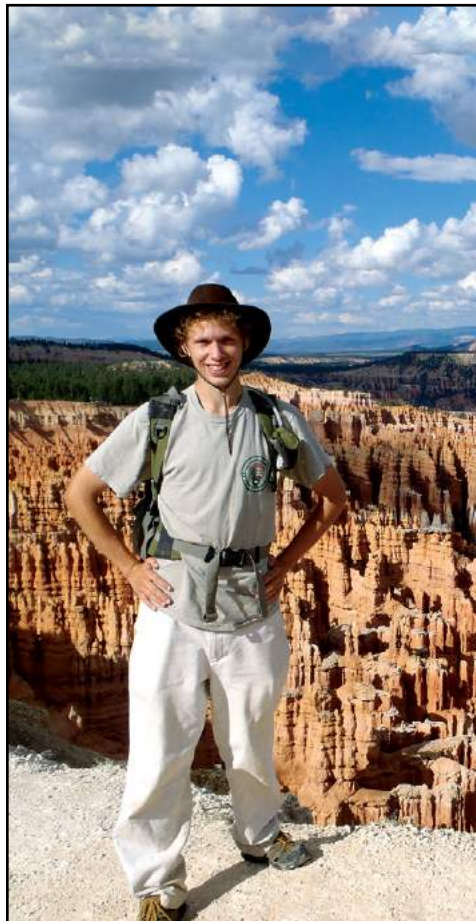
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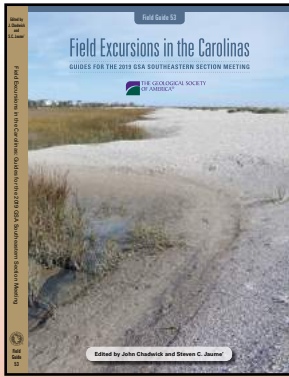
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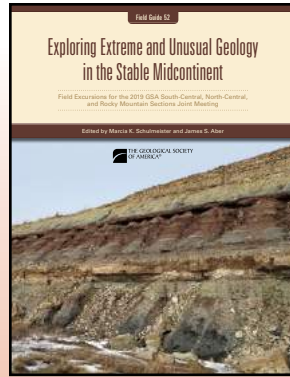
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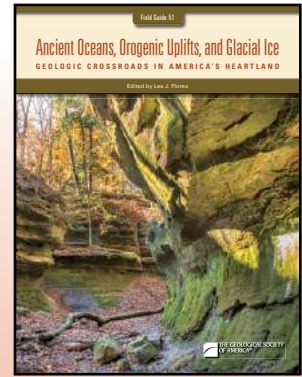
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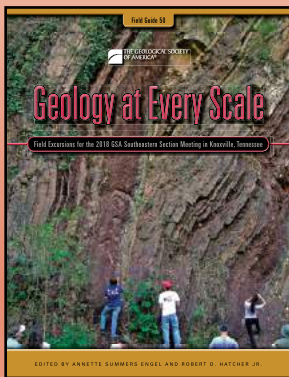
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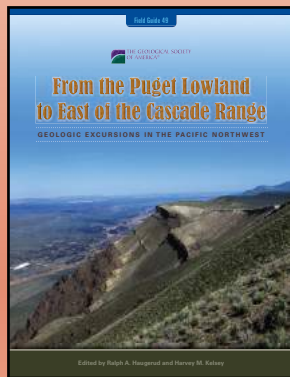
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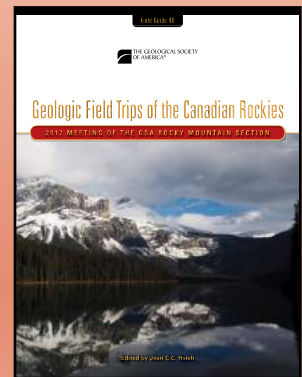
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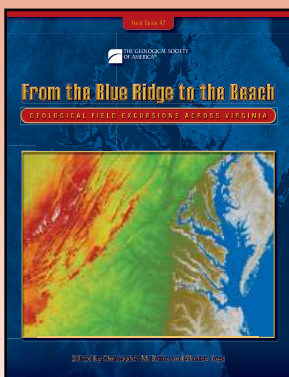
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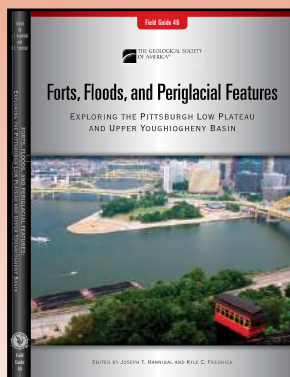
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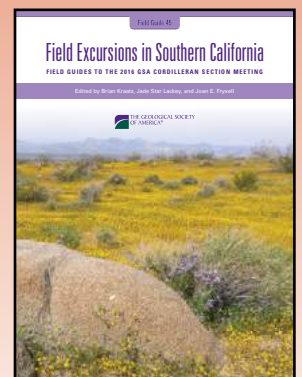
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