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GSA TODAY

THE GEOLOGICAL SOCIETY OF AMERICA®

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Creating Continents: Archean Cratons Tell the Story

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SCIENCE

Cover: Neoarchean continental arc granitoids exposed in the Wind River Mountains, Wyoming, USA. View of Shark's Nose from Shadow Lake. Photo credit: Carol Frost. See related article, p. 4–10.

GSA NEWS

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Creating Continents: Archean Cratons Tell the Story

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ABSTRACT

The record of the first two billion years of Earth's history (the Archean) is notoriously incomplete, yet crust of this age is present on every continent. Here we examine the Archean record of the Wyoming craton in the northern Rocky Mountains, USA, which is both well-exposed and readily accessible. We identify three stages of Archean continental crust formation that are also recorded in other cratons. The youngest stage is characterized by a variety of Neoarchean rock assemblages that are indistinguishable from those produced by modern plate-tectonic processes. The middle stage is typified by the trondhjemite-tonalite-granodiorite (TTG) association, which involved partial melting of older, mafic crust. This older mafic crust is not preserved but can be inferred from information in igneous and detrital zircon grains and isotopic compositions of younger rocks in Wyoming and other cratons. This sequence of crust formation characterizes all cratons, but the times of transition from one stage to the next vary from craton to craton.

INTRODUCTION

Continental crust that formed in the Archean eon (2.5 billion years or older) makes up less than 3% of Earth's surface today, but all continents contain crust of this age (Fig. 1). These ancient crustal blocks, commonly covered by long, uninterrupted stratigraphic sequences, are known as cratons and comprise the oldest coherent lithosphere on Earth. They record little to no penetrative deformation, calc-alkalic magmatism, or metamorphism for hundreds of millions of years (Mueller and Nutman, 2017). Geophysically, cratons represent a coupled crust-mantle system in which Archean crust is underlain by a thick (>150 km) keel of cold, neutrally buoyant, sub-continental, depleted lithospheric mantle of comparable age (e.g., Pearson et al., 2021). Cratons preserve an important record of crust formation and growth, provide the oldest record of processes that led to a differentiated Earth, and enable critical geologic observations for testing theoretical models of early Earth evolution (e.g., Korenaga, 2021). Although the timing of craton construction varies somewhat from craton to craton, we argue that most cratons are the cumulative result of three distinct stages of petrologic and geochemical evolution from which we infer the tectonic processes that formed them. Thus, cratons preserve a unique record of Earth's changing physiochemical conditions (e.g., global cooling) and tectonic regimes over the first two billion years of Earth's history. Starting with the youngest Archean rocks and working back in time, we use examples from the Wyoming craton to describe each stage in the development of a stable, Archean craton.

THE WYOMING CRATON

Although many cratons are in remote, relatively inaccessible locations with minimal

Figure 1. Global distribution of Archean cratons. Craton labeled "India" includes the Dhawar, Bastar, Bundelkhand, and Singhbham cratons. Modified from Bedle et al. (2021).

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topographic relief, the Wyoming craton is an exception. Archean rocks are exposed in Late Cretaceous to Eocene basement-involved uplifts that are readily accessible and expose kilometer-scale vertical, three-dimensional sections of Archean crust. The Wyoming craton preserves a four-billion-year record of geologic history, from the earliest events recorded in detrital and xenocrystic zircons dating back to ca. 4.0 Ga to magmatism associated with the Quaternary Yellowstone hotspot. The craton extends over an area >300,000 km^2 with crustal thickness up to 50 km (Fig. 2). The Archean rocks of the Wyoming craton are mostly quartzofeldspathic gneiss and granitoids with a paucity of mafic supracrustal assemblages. Geologic, petrologic, geochemical, and structural studies have led to the identification of three subprovinces: the Beartooth-Bighorn magmatic zone (BBMZ), dominated by ca. 3.5 to ca. 2.6 Ga granitoids and gneisses; the Montana meta-sedimentary terrane (MMT), an area of ca. 3.5 to ca. 2.7 Ga plagioclase-rich quartzofeldspathic gneisses intercalated with Neoarchean metasupracrustal rocks; and the Southern Accreted Terranes (SAT), which are composed of ca. 2.7 to 2.6 Ga juvenile graywacke, mafic rocks, and felsic intrusions (Mogk et al., 2022) (Fig. 2A). Seismic data suggest a >20-km-thick, high-density, lower crustal layer beneath much of the BBMZ and MMT. This layer is absent farther south beneath the SAT, where the Moho depth steps from ~60 km to ~40 km north to south across the BBMZ-SAT boundary (Fig. 2B). The lithosphere-asthenosphere boundary lies at ~200 km depth beneath the Wyoming craton (Bedrosian and Frost, 2022). Paleoproterozoic orogens surround the craton (Fig. 2A).

CONTINENT CREATION IN THREE STAGES

The End of Cratonization: Neoarchean Rock Assemblages Formed by Plate Tectonic Processes

The Neoarchean 2.8–2.5 Ga) record of the Wyoming craton preserves evidence of the final stabilization of the craton via modern tectonic processes, including examples of continental magmatic arcs, high-pressure continent-continent collisional zones, accreted terranes, and strongly peraluminous leucogranites formed by partial melting of aluminous metasedimentary rocks.

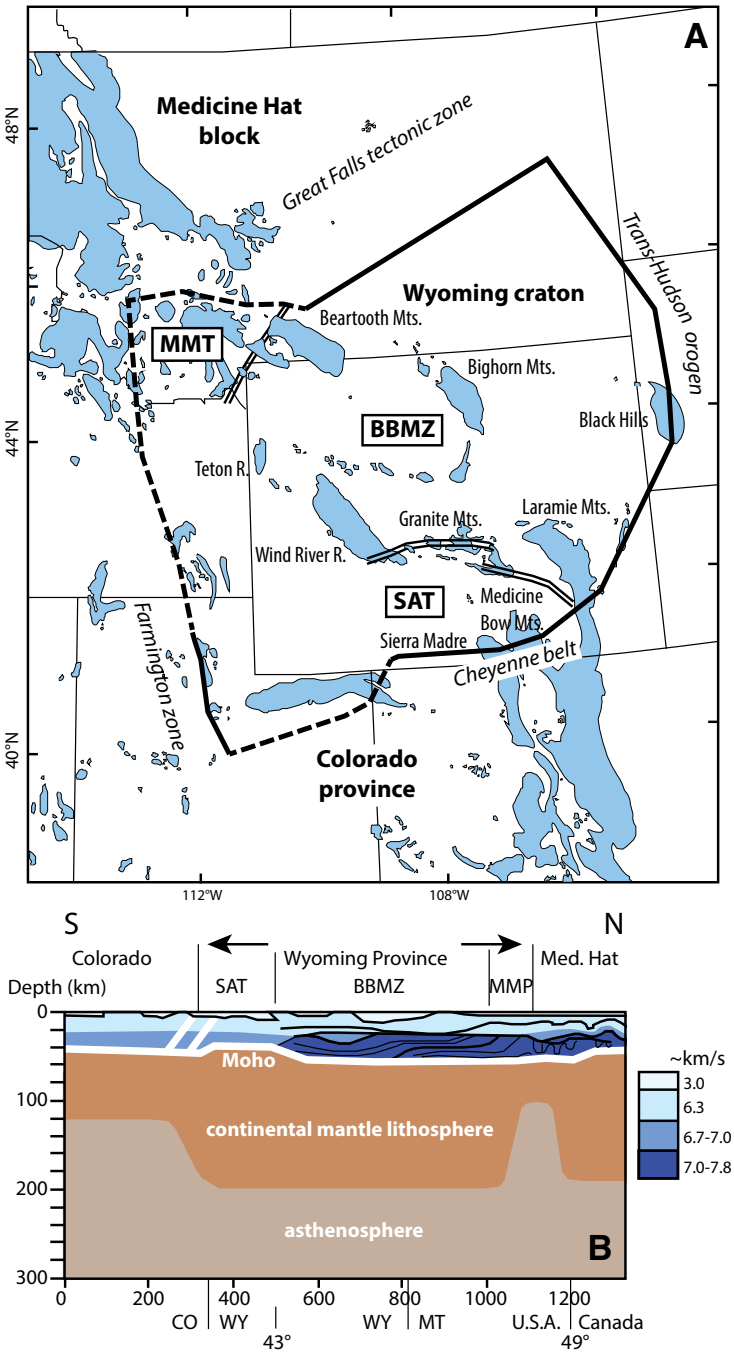

Figure 2. (A) Simplified geologic map of the Wyoming Province showing Precambrian outcrop in blue. Thick black lines indicate interpreted extent of the Wyoming Province. Double black lines mark the boundaries between subprovinces. BBMZ—Beartooth-Bighorn magmatic zone; MMT—Montana metasedimentary terrane; SAT—Southern Accreted Terranes. Modified from Bedrosian and Frost (2022). (B) Schematic cross section south-north along the Deep Probe seismic refraction/wide-angle reflection experiment (Snelson et al., 1998; Gorman et al., 2002). Crustal structure interpreted from seismic data shows greater lithospheric thickness beneath the Wyoming and Medicine Hat cratons compared to Colorado province and Paleoproterozoic Great Falls orogen that lies between the two cratons. Province boundaries and approximate thickness of the lithosphere are interpreted from electrical and seismic data by Bedrosian and Frost (2022).

Continental Arc Magmatism

Continental magmatic arcs form on continental crust above subducting oceanic lithosphere. They comprise voluminous calc-alkalic magmas with relative depletions in high field-strength elements across the compositional spectrum. Voluminous continental arc batholiths first appear in the

Wyoming craton in the Bighorn Mountains (2.86–2.84 Ga; Frost and Fanning, 2006) and Beartooth Mountains (2.83–2.79 Ga; Mueller et al., 2010). These batholiths range in composition from gabbro and diorite to granite, and like modern continental arcs, are magnesian and calc-alkalic (Figs. 3A–3C). Initial whole rock Nd isotopic compositions from these batholiths are intermediate between depleted mantle values and values of older continental crust (Fig. 4). The incorporation of juvenile material, either from depleted mantle or juvenile crust, indicates these continental arc batholiths record both continental growth and crustal recycling, similar to modern continental arcs.

High-Pressure Collisional Tectonics

Continent-continent collisions are a hallmark of modern plate tectonics. These collisional events produce thrust-oriented deformation zones that join terranes of distinctive ages, lithologies, and metamorphic grade. Peak metamorphism is generally at high-pressure granulite conditions (pressures >10 kbar and temperatures of >700 °C), conditions that are rare prior to the Neoarchean (Brown and Johnson, 2018). One of the best examples of Archean rock assemblages interpreted to have formed by Himalayan-style continent-continent collisional tectonics is preserved in the northern Teton Range, where two distinct gneiss units with contrasting geologic histories were juxtaposed at 2.68 Ga along mylonitic ductile shear zones that exhibit discontinuities in metamorphic grade that reach granulite facies (Frost et al., 2016; Swapp et al., 2018). Decompression melting after peak metamorphism produced leucogranites along the boundary between the gneiss units (Frost et al., 2016). These observations suggest a clockwise *P-T* path for the northern Teton Range, similar to high pressure granulite *P-T* paths recognized in the Himalayas (Fig. 5).

Accreted Terranes

Juxtaposition and accretion of disparate terranes is another process typical of modern plate tectonics. In the Wyoming craton, Neoarchean metaigneous rocks of oceanic affinity and immature metasedimentary rocks occur as allochthonous units along the southern margin of the BBMZ in the southern Wind River, Granite, Sierra Madre, and Medicine Bow Mountains. They accreted to the BBMZ at 2.65–2.63 Ga, prior to the emplacement of the Louis Lake batholith (Frost et al., 2006a; Souders and Frost, 2006). Neoarchean accreted terranes have been described from other cratons, including Superior (Jaupart et al., 2014), Slave (Davis et al., 1994), and North China (Kusky et al., 2016).

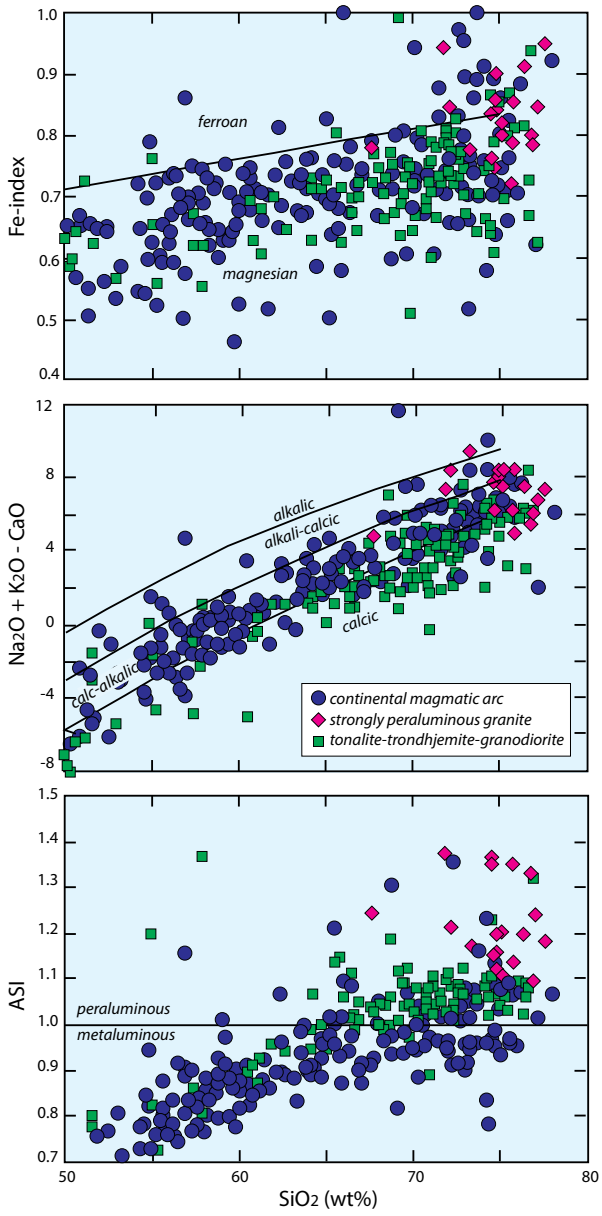

Figure 3. Fe-index, Na_2O+K_2O-CaO, and alumina saturation index (ASI) diagrams for Archean rocks from the Wyoming craton, including Long Lake Magmatic Complex and Louis Lake continental arc batholiths (navy circles); Bear Mountain and Rocky Ridge strongly peraluminous granite gneiss (pink diamonds); and trondhjemite-tonalite-granodiorite gneiss (green squares). Data sources: Frost and DaPrat (2021); Frost et al. (1998, 2006b, 2017); Gosselin et al. (1990); Mueller et al. (2010); and Wooden et al. (1988).

Strongly Peraluminous Leucogranites

Strongly peraluminous granites have an aluminum saturation index (ASI) of greater than 1.1; contain aluminous phases such as muscovite, cordierite, or garnet; and are commonly interpreted to be derived from aluminous sedimentary sources. Partial melting of such sources can produce granite with the strongly peraluminous compositions characteristic of collisional orogens (e.g., the Himalayas; Nabelek, 2020). Strongly peraluminous granites first become globally abundant in the Neoarchean (e.g., Bucholz and Spencer, 2019). In the Wyoming craton, two Neoarchean intrusive suites composed entirely of strongly peraluminous granite formed at 2.60 and ca. 2.64 Ga (Fig. 3; Frost and Da Prat, 2021; Gosselin et al., 1990). These ages suggest a relationship to the collision of the Wyoming and Superior provinces and creation of supercraton Superia (Ernst and Bleeker, 2010). Older (ca. 3 Ga) strongly peraluminous granites are present in other cratons, but most appear in the Neoarchean; e.g., in the Wyoming, Superior, Slave, and Yilgarn cratons (see Bucholz and Spencer, 2019, for a review).

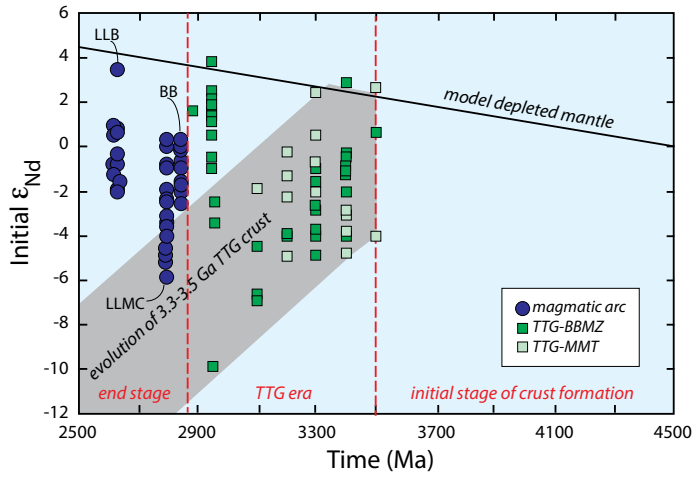

Figure 4. Initial Nd isotopic compositions of continental arc batholiths (Long Lake Magmatic Complex [LLMC], Louis Lake [LLB], and Bighorn batholith [BB]) and trondhjemite-tonalite-granodiorite (TTG) from the Wyoming craton. Data sources: Frost et al. (1998, 2006b, 2017); Mueller et al. (2010); P. Mueller, personal commun. (2022).

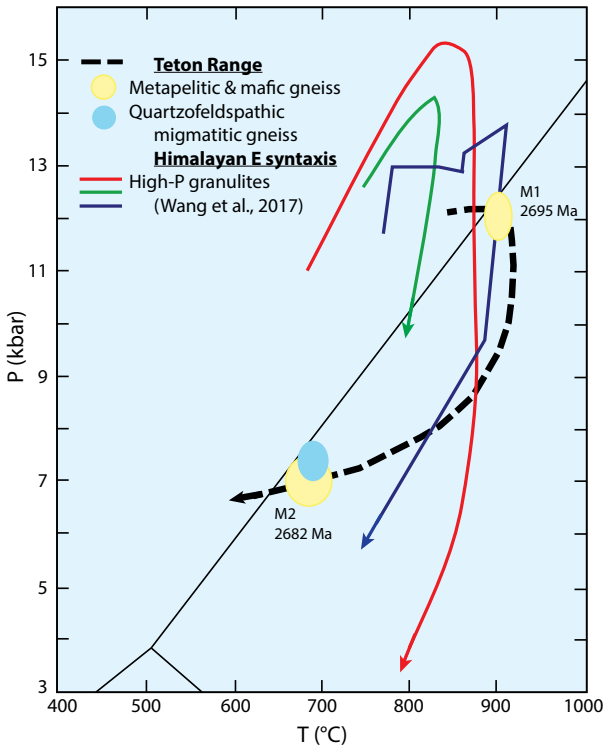

Figure 5. Comparison of the pressure-temperature-time (*P-T-t*) path inferred for the northern Teton Range (thick black dashed line) from Swapp et al. (2018) and *P-T-t* paths for high-pressure granulites from the eastern syntaxis of the Himalayas compiled by Wang et al. (2017) (red, green, and blue lines). Teton Range *P-T* conditions determined for the metapelitic and mafic gneiss package are indicated by yellow ovals, and *P-T* conditions determined for the quartzofeldspathic gneiss package are indicated by blue ovals.

The Trondhjemite-Tonalite-Granodiorite Era: Establishing Survivability

The survival of any individual craton depends on reaching a certain size (volume) and density. Globally, continental crust older than 2.9 Ga is dominated by the trondhjemite-tonalite-granodiorite (TTG) suite (Fig. 6) comprised of weakly peraluminous, magnesian, and calcic K-feldspar–poor quartzofeldspathic gneisses (Fig. 3) with typically younger granodiorite and minor mafic and ultramafic rock. These suites first appear in significant volumes on different cratons over a period of some 300 million years, from 3.8 to 3.5 Ga (e.g., Nutman et al., 2015). In Wyoming and globally, the characteristic light rare-earth-element (LREE)-enriched REE patterns with little to no Eu anomaly and very low heavy rare earth elements (HREE) distinguish them from modern rocks.

The oldest TTG associations in the Wyoming craton include 3500–3450 Ma trondhjemitic gneisses from the Beartooth and Granite Mountains (Frost et al., 2017; Mueller et al., 1996, 2014). Similar ages and compositions have been identified throughout the BBMZ and MMT, with a major event at ca. 3.3–3.2 Ga (Mogk et al., 2022). These rocks formed episodically over a protracted period of some 600 million years in Wyoming to produce an extensive continental nucleus. The slightly younger granodiorites in Wyoming's gray gneiss terranes have been interpreted to result from partial melting of older TTG, forming more potassic and silicic compositions (Frost et al., 2017).

The current consensus is that formation of TTG magmas requires melting a hydrated mafic source at pressures greater than 12 kb (e.g., Moyen and Martin, 2012; Rapp and Watson, 1995), implying a thick mafic crust similar to modern oceanic plateaus. The geodynamic setting that would promote partial melting of both mantle and crustal sources to produce voluminous TTG remains unresolved, with stagnant lid, mobile lid, and plume-based tectonics all proposed (e.g., Moyen and Martin, 2012). In the Wyoming craton, Nd and Hf isotopic values of TTG exhibit a range of initial compositions that largely plot below model depleted mantle values (Figs. 4 and 7). These data indicate that the TTG suite cannot be formed solely by rapid, sequential melting of mantle-derived magmas that would produce positive initial Nd and Hf isotopic compositions as in an oceanic arc, but instead is derived from a variety of both isotopically juvenile and older, isotopically evolved sources. This suggests that by the time the TTG era began, Earth had already differentiated into two or more silicate reservoirs, including a depleted mantle and an evolved crust. Hf and Nd isotopic data from the Wyoming craton show that this differentiation occurred before the oldest TTG gneisses formed (ca. 3.5 Ga).

Archean gray gneiss terranes comprise the bulk of most cratons and have survived for three billion years or more, suggesting that the formation of a thick, buoyant, and rigid lithospheric keel plays an important role in their survival. This cratonic mantle lithosphere is interpreted to have formed by the extraction and ascent of partial melts enriched in Fe/(Fe + Mg), Ca, and Al into the crust, leaving a residual lithospheric mantle that is less dense and more buoyant than fertile mantle. The extraction of partial

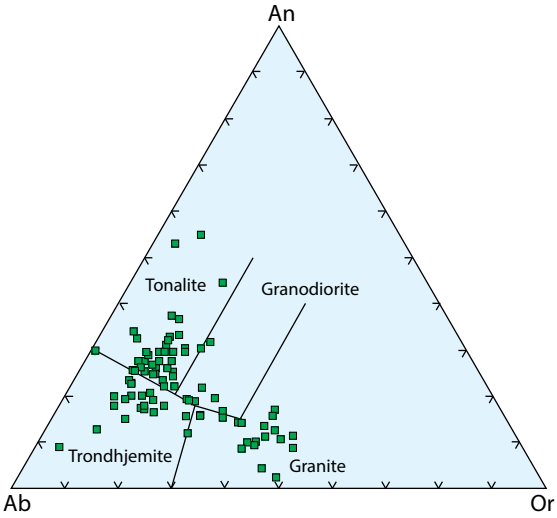

Figure 6. Normative An-Ab-Or compositions of trondhjemite-tonalite-granodiorite from the Wyoming craton. Data sources: Frost et al. (2017) and Wooden et al. (1988).

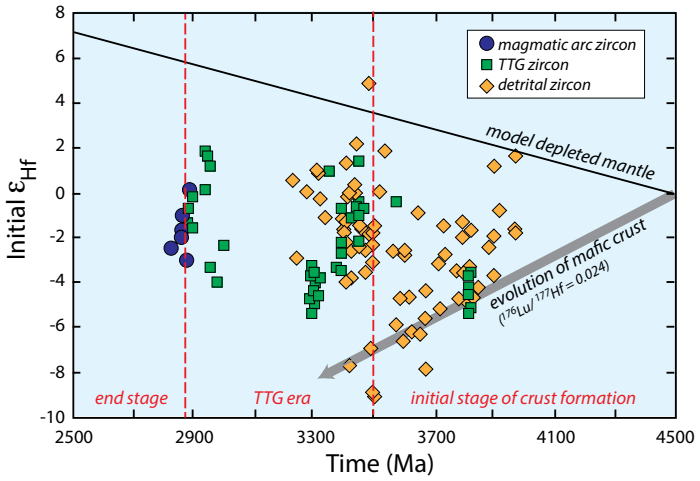

Figure 7. Initial Hf isotopic compositions of detrital zircon (diamonds), igneous and xenocrystic zircon from trondhjemite-tonalite-granodiorite (TTG; squares), and igneous zircon from magmatic arc rocks (circles) from the Wyoming craton. Data sources: Frost et al. (2017) and Mueller and Wooden (2012).

melt also would deplete the mantle of water and heat-producing elements, leaving it cold, strong, and viscous relative to the surrounding mantle (e.g., Jordan, 1988). Isotopic systematics of lithospheric mantle xenoliths and young igneous rocks from a number of cratons, including Wyoming, suggest that the keel formed contemporaneously with the overlying crust (e.g., Pearson et al., 2021). Such keels are present beneath most cratons and protect the cratonic lithosphere from erosion by the convecting mantle (Bedle et al., 2021). We suggest that the thick, rigid, and strong subcontinental lithosphere formed during the TTG-forming stage is a necessary precondition for the survival of the craton and subsequent production of Neoarchean rock assemblages by modern-style plate-tectonic processes observed in Wyoming and other cratons (e.g., Iaccheri and Kemp, 2018).

The Initial Stage: Formation and Influence of Earth's First Mafic Crust

Globally, very little crust older than 3.8 Ga survives, but what does remain marks the beginning of the TTG era on the planet. The oldest known rocks are the 4.03–4.00 Ga TTG gneisses of the Acasta terrane in the Slave craton of northern Canada (Bowring and Williams, 1999). Early Eoarchean rocks (3.9–3.8 Ga) are sparse but more widespread. Older Earth materials are limited to a few, scattered occurrences of Hadean detrital zircon grains dated at 4.0–4.4 billion years from a number of cratons, including Yilgarn, Kaapvaal, Sao Francisco, North China, and Enderby Land (Carlson et al., 2019, and references therein). The presence of these zircon grains indicates that melts saturated in zircon must have been present, although the limited number and occurrences of detrital zircon grains of this age suggest felsic rocks were sparse or did not survive later tectonism. In the northern Wyoming craton, the ages of detrital zircon grains of 4.0–3.2 Ga suggest that early crust-forming events occurred at ca. 3.7 and ca. 3.5 Ga (Maier et al., 2012; Mogk et al., 2022; Mueller et al., 1998). Eoarchean zircon xenocrysts (ca. 3.8 Ga) have also been reported from the Granite Mountains (Frost et al., 2017) and the Wind River Range (Aleinikoff et al., 1989) in the southern BBMZ.

Hf isotopic data from these ancient detrital and xenocrystic zircon grains provide important constraints on the timing, composition, and evolution of both Wyoming's and Earth's first crust. Initial Hf isotopic ratios from the Wyoming craton define an array of increasingly negative ε_{Hf} with time, a trend that is consistent with intra-crustal recycling of Hadean to Eoarchean mafic crust (Mueller and Wooden, 2012; Fig. 7). Initial ε_{Hf} data of zircon grains from many cratons define similar arrays (e.g., Mulder et al., 2021). Mafic crust would not likely contain significant zircon, but it may have contained small volumes of zircon-bearing plagiogranite, as does modern oceanic crust (Grimes et al., 2011). Pb isotopic compositions of some Archean rocks also preserve evidence of a mafic protocrust. In some cratons, including Wyoming, high initial $^{207}Pb/^{204}Pb$ isotopic ratios of younger Archean rocks with low U/Pb ratios require involvement of Pb from an ancient high U/Pb (high-mu) reservoir that was isolated from the mantle in the Eoarchean or earlier (Frost et al., 2006b; Mueller et al., 2014). Other cratons with suggestions of high-mu character include the western Slave, North Atlantic, Yilgarn, and Zimbabwe (Kamber, 2015).

In summary, although crust older than 4 Ga appears largely absent from the rock record, indirect evidence from the oldest detrital zircon grains, early TTG crust, and the Pb isotopic compositions of some Archean crust suggest the presence of a Hadean mafic crust. This early crust was thick and hot enough to partially melt at depth to form at least small volumes of tonalitic and trondhjemitic melts from which the oldest zircons crystallized. Because

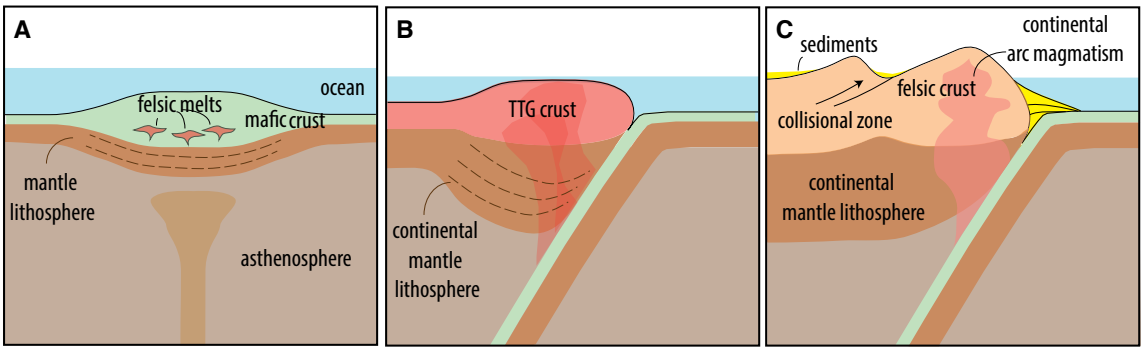

Figure 8. Summary cartoon showing the three stages of craton creation and stabilization, with the times at which these stages operated in the Wyoming craton (WC). (A) Initial stage in which thickened mafic crust, possibly formed over a mantle plume, partially melts at depth to form small volumes of zircon-bearing felsic melt. (B) Middle stage in which a trondhjemite-tonalite-granodiorite (TTG) crust forms from both mantle and crustal sources. Subduction is one potential mechanism for transporting mafic crust to depth for partial melting. (C) Final stage of Archean crustal evolution in which continental freeboard has increased and evidence of magmatic arcs, continent-continent collisions, and terrane accretion is abundant.

upwelling, decompressing, and partially melting mantle could form a thick mafic crust much like oceanic plateaus form above mantle plumes on Earth today, early global tectonics may have been dominated by vertical motion in the mantle (e.g., Korenaga, 2021; Mueller and Nutman, 2017).

DISCUSSION AND CONCLUSIONS

By studying the Archean record of the Wyoming and other cratons, we can identify three stages of crust formation that produced differentiated, thick, stable cratons.

- The first mafic crust formed early in Earth's history (Fig. 8A) and became thick enough in the late Hadean-Eoarchean that lower portions reached their melting temperatures, creating some felsic melt from which zircon crystallized. The Lu-Hf systematics of those zircon grains indicate that this mafic crust rapidly evolved to be isotopically distinct from contemporary mantle. In a number of cratons, including Wyoming, it has been shown that this early crust also had higher U/Pb than contemporary mantle or modern continental crust. As such, elevated initial $^{207}Pb/^{204}Pb$ ratios in younger rocks with low U/Pb are a fingerprint for the presence of Hadean mafic crust.
- Between 3.8 and 3.5 Ga the early mafic crust was augmented with TTG magmas in many cratons. Both Hadean mafic crust and mantle sources were involved in the production of large volumes of these TTG magmas. This process left a residual, melt-depleted, rigid, buoyant mantle lithosphere, which formed a thick, stable keel beneath the felsic TTG crust and enabled its survival through many later geodynamic cycles (Fig. 8B).
- The formation of this thick cratonic lithosphere enabled the third stage of continent formation, in which recognizably modern plate-tectonic processes operated. Starting at ca. 2.8 Ga, a number of rock assemblages characteristic of plate-tectonic environments are preserved in the Wyoming craton, including continental arc batholiths, assembly of contrasting continental blocks across continent-continent collision zones, accretion of exotic terranes, and production of strongly peraluminous granite from chemically mature aluminous metasedimentary rocks (Fig. 8C). As with the onset of TTG formation, this final plate-tectonic stage appears to have begun at somewhat different times on different cratons.

In summary, the Archean rock record of Wyoming and other cratons suggests that by 3.5 Ga Earth had developed distinct geochemical reservoirs and that by 2.5 Ga Earth's continental crust had recorded many essential characteristics of modern plate-tectonic processes.

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The Past, Power, and Our Future with the Earth

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I stand before you thankful for my family, grateful for good health, and in awe of our beautifully complex Earth.

On this afternoon, I would like to speak with you about many simple things. Not always about the earth, but always of the earth. I ask of you a willingness, if only for a few minutes, to wonder with me, to be speculative. To allow us to question ourselves together, and without judgement.

When I was growing up, I spent many weekends at thrift stores with my father looking for musical instruments, home organs in particular. I was not proficient on the keys, but I love to tinker and repair. Perhaps the most beautiful organ I ever found was built of natural maple with dual keyboards, a two-octave pedal board, and an array of switches and pulls. But like every organ I had, I eventually donated it. Parting with this particular organ was my first consciousness of "Princeville." My father suggested we donate the organ to an African Methodist Episcopal church in Princeville, North Carolina, because the town was recovering from devastating flooding in the wake of Hurricane Floyd. At the time, I may have been told that it was a very special place, in fact, the first town in the United States chartered by formerly enslaved Africans. But I was surely ignorant of the layered ways in which geomorphology and climate were implicated in its story. For like all places we humans inhabit, Princeville has an intertwined natural and human history.

***

I think I became a geologist for the wrong reasons. Among those who study the earth, I wanted to leave.

I wanted to travel among the stars, to set foot on another planet, a moon, or perhaps an asteroid. In my pursuit of becoming an astronaut, I found geology.

It was a dream to fly that eventually brought me down to earth.

My graduate work sought to understand and model how our continental crust deteriorates through chemical weathering and physical erosion. How these processes are connected, how they can be measured, how they can be modeled, and how they affect the long-term carbon cycle and sedimentation in the ocean.

I enjoyed research, but I didn't have the passion for it. I saw it in others, in my advisors, Rick O'Connell, Maria Zuber, and especially my good friend, Cin-Ty Lee. What I most enjoyed was the beauty, intellectual challenge, and profundity of deep time. So, after a couple of postdocs, I no longer did academic research. And since I wasn't much use to industry, I no longer worked in the geosciences.

But yet, here I am, addressing a congregation of scientists. And I am grateful for the opportunity.

I think perhaps you, of all the people in the world, might understand a bit of where I am coming from. While I may have become a geologist for the wrong reasons, I have remained one for reasons that may resonate with you.

I have a deep affection and aesthetic appreciation for places, not untouched by humans, but not yet destroyed by us—our mountains, rivers, deserts, oceans, and forests. My desire to explore space, to study the geosciences—even my current work imagining and building new economic futures—is all conceived from a deep sense of wonder.

***

When we weren't looking for organs in thrift stores, my father would take my sister and me to events among the First Nations of the southeastern woodlands. Many spring and fall Saturdays were spent in rural North Carolina, at powwows and gatherings, with the Meherrin, Saponi, and Waccamaw Siouan nations, in community among distant cousins with whom we shared a common history.

Today, working with Indigenous nations is an essential part of my work in economic development. My team has supported business, agriculture, and climate resiliency initiatives with Tribal governments and organizations. Each collaboration is characterized by different assets, challenges, cultures, histories, and legal structures, leaving perhaps only one consistent similarity across nations: the importance of land and connectedness to place. One of our most enduring, exciting partnerships is with the Coharie Tribe. This small nation is using their river to center a cultural renaissance, a youth workforce development initiative, and an ecotourism strategy. My team brings additional resources to this effort, representing both a commitment to being good stewards of the earth and to sovereignty for all Indigenous peoples. Goals which I believe to be indivisible.

***

To be clear—I was once a real geologist, in the way that many of you are. I collected samples on mountain slopes. Dissolved rock powders. Built models. Ran a mass spec. Taught students.

And GSA has played a key role in my career, providing the grants that supported my education, the opportunities to present my work at conferences, and a congressional science fellowship in D.C. that served as the transition to the work I have been doing these past ten years. And since I ceased being a "practicing" geoscientist, GSA has been the primary means by which I have stayed connected to the discipline. My service to the Society has been recompense for all those resources and opportunities afforded me.

Outside of the conferences and committees, my professional work is not obviously related to the geosciences. But they are in conversation, informing each other in ways I have only recently begun to understand.

I lead NCGrowth, a national center that is building a different, more equitable economy by creating good jobs and new wealth in distressed communities. We are building power, the means by which an individual or a community can construct its future. Power enables communities to declare their own measures of success and construct their own solutions to the challenges they define. And a community can draw its power from within, through the collective recognition of and respect for its own assets. We believe that empowering all peoples—be it through financial, political, or other means—is the clearest path to

economic equity, to addressing health disparities, to justice, and to environmental sustainability.

Today our team includes more than 40 full- and part-time staff based in North and South Carolina, Tennessee, and Washington, D.C. Our partnerships extend our reach across and beyond North America, from Cote D'Ivoire to China.

Our work is to wonder—in partnership with individuals, communities, and nations—what could be and to try to build it.

We help mountain communities leverage their geomorphology and ecology for responsible tourism development. We help rural manufacturers grow and hire more local people. We help legislators see the fullest potential of their constituents. And we help historic Black communities like Princeville and Indigenous communities like the Coharie Tribe achieve diversified revenue, and support business development opportunities for their citizens.

We use the past to envision a radically different future.

***

I eventually had the opportunity to work with the town of Princeville. In the intervening decades since donating that beautiful organ, I learned some of the history of the town and decided that I wanted the work of my center to include places, like Princeville, that were abundant in histories, cultures, languages, and ways, but that were also disrespected, devalued, disinvested, and denied. Applied economic justice, you might call it.

The town of Princeville has survived since 1865 on low-lying, flood-prone land—land unwanted by the European colonists who had stolen it a century and a half prior as spoils of war with the Tuscarora Nation. Located just south of Shiloh Landing, a bend in the Tar River where small boats left the ancestors of the founders of Princeville—and likely, some ancestors of mine—having made the journey south from Port of Richmond, and prior to that, west from the Gambia, Angola, Benin, Ghana, the Bight of Biafra, and other West African ports. This town, Princeville, was built on land that would forever bind the community to the fate of the river.

So, in 2015, when Mayor Bobbie Jones told me his wonderous vision of an economic revival inspired by their vibrant economic past, I was game! The plan included an amphitheater at Shiloh Landing, consecrating that place with a sanctuary for community events, historic tourism, and the memory of those lives who were left irrevocably altered by the transatlantic trade of human bodies. We even managed to secure a partnership with Skanska, an international construction firm that saw a manifestation of their corporate mission in the story of Princeville's resilience.

But within one year, this work was interrupted by another storm—Hurricane Matthew. That left the town under more than 10 feet of water for a week. In the flooding was despair.

***

All my work has been shaped by the methods I learned in studying and practicing the geosciences.

Almost always, we begin with an observation or measurement of something that is unknown, unusual, or uncertain. New hypotheses emerge from established theories. And, perhaps, in what most distinguishes geology from other sciences—we understand that the past creates everything that we see and that what we observe now will shape the future. The world is a complex, recursive function, each minute of output as input for the next. And this perspective colors my work. It has meant that my team's approach is very different than my colleagues with backgrounds in economics, public policy, economic development, or business.

The converse is true as well. My experiences with communities that are working to reimagine and realize new futures have changed my understanding of the sciences. Not of any particular conclusion or data point, but in the questions we choose to ask. The questions we dismiss. The possibilities we can't see. The conclusions we reject.

The European scientific revolution, Reformation, Age of Exploration, Enlightenment, and Market Capitalism have for more than 300 years laid the foundation for how we practice our science. Most extant nation states are founded on ideas birthed and cultivated by these philosophies. The arts, science, and wealth produced as a product of these movements are vast. But core to these ideas is a belief that mankind has been given the earth by God for its exploit. That value is only created when labor creates products. The erroneous thought that some homo sapiens—those least European in their appearance and culture—are demonstrably inferior, and are, like the flora and fauna, part of the natural world to be exploited as is God's will is also the heritage of geoscience. And despite the great progress made in the sciences to reject some of these ideas, I believe that the process and practice of science—separate from its conclusions—is still subject to these philosophies. Thus, science has a voice, a culture, and a subjectiveness that restricts how your knowledge and your ways of seeing wonder in this world could otherwise be called upon to contribute to humanity and to our planet.

An example: Geoscience is essential to understanding climate change and addressing its impacts through mitigation, remediation, adaptation, and low-carbon energy development. But in conversations among scientists, policymakers, and engineers about the "energy transition" or "green revolution," I am always left thinking that the promises of technology address the symptoms but obscure the underlying cause.

Fossil fuels are remarkable. The preserved energy of an ancient sun, captured in the bodies of billions of organisms, distilled through pressure, heat, and time into extraordinarily convenient energy sources.

But firewood is the original renewable energy.

And solar, wind, and geothermal power are all remarkable.

In our journey to transition from one to the next, we are running away. Running away from mass deforestation, air pollution, and global warming. Overlooked is the irreplaceability of an old-growth forest, the 300 million years of history in a lump of glinty anthracite, and the choreography of melting, crystallization, and weathering required to create a regolith rich in rare earth elements.

Perhaps we have been using too much too quickly? Perhaps we've constructed a pervasive system and culture that disincentivizes conservation and reuse? Perhaps the creativity and innovation that come from limitation and constraint remain ignored?

***

Since the flooding of 2015, Princeville has been on a long road to recovery, navigating FEMA, housing displaced citizens, and coping with collective emotional trauma. But Princeville is the aquatic corollary to the mythical phoenix, perennially rising from the receding waters. Just a few weeks ago, the town hosted a highly successful bike ride and farm tour event. For the past year, my team has been helping the mayor develop plans to move municipal services,

housing, and the business district to a higher tract of land, outside of the flood plain.

And we've had the great privilege of continuing our partnership with the Coharie Tribe—most recently discussing how their experience rejuvenating their river and nation can serve as a blueprint for other communities trying to build on their inherent assets.

***

The power of Indigenous knowledge lies in the information itself, and in its provenance. For example, the technical knowledge of nations like the Yurok, Karuk, Hoopa, and Wintun is preventing catastrophic forest fires in the state of California and is used by Cal Fire and the U.S. Geological Survey. And, for example, the complex hunting practices of the Mbuti, Baka, and Batwa peoples, practices that vary by species, season, gestational-state, and other factors, promote biodiversity and conservation in the forests of the Congo Basin.

But as useful as the information is, we can learn as much or more from understanding the ways in which it was created. Knowledge generated from many generations of a people inhabiting a place, observing, testing, and understanding will result in different approaches, questions, and possibilities. The ingenuity, innovation, and creativity that is derived from not being able to escape the consequences of one's actions over the course of generations is profound. A wonder in and respect for the earth are needed to exist, survive, and thrive in place.

***

That word, "wonder," is a good one. It means surprise, admiration, curiosity, and doubt—it is this feeling, evoked by our natural places, to which I am drawn and from which I draw motivation. Wonder, the emotional manifestation of taking that first breath in the face of a cold wind.

I think, that for many of you, it may also have been a feeling of wonder that initially brought you to study the earth. The topography of a landscape, one rock, the movement of the tides, all that surrounds us at once invokes the lexicon of the geosciences. And now raising children of my own, seeing their surprise, admiration, curiosity, and doubt in the face of nature, I am reminded that the ability to experience the wonder of this planet is primary.

Fjords and mountain lakes, rolling hills and ordinary cloudy skies, even Colorado's own red rocks populate the desktop backgrounds and locked screens of hundreds of millions of computers. The high and low, wet and arid, snowy and scalding places that humans dream of visiting are celebrated for their geology, whether or not people would use that word. The earth's ability to arouse us is basic.

Many of our colleagues emphasize the utility of the geosciences to garner student interest in a course or to solicit more funding in a national budget. And that's understandable given that geoscience is indispensable to understanding climate change, finding natural resources, and predicting earthquakes and other hazards. But more basic than any of those practical and existential subjects is the naked wondrousness of the earth itself—of those places not untouched by humans, but not yet destroyed by us. *That* brings the laity in closer communion with our work than anything else.




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Go to **www.geosociety.org/geocorps** to see available opportunities.

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

Spring/Summer 2023 opportunities now posted—Apply by 22 Jan.

View and apply for select projects at **www.geosociety.org/sip.**

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

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CONNECTS 2022
9–12 October
Denver, Colorado, USA
& Online Everywhere

Letter from the General Chairs

GSA Connects 2022 saw our return to the Colorado Convention Center after a six-year absence. Evidently, we missed the Big Blue Bear, because there were 4,874 attendees, with more than 400 more online, together representing 52 countries. These attendance numbers are just a few hundred less than our last pre-COVID meeting in Phoenix in 2019—a very good sign.

It is clear that as the pandemic (hopefully) winds down, there is strong interest in returning, at least in part, to traditional in-person activities, but with online options. This year, all oral sessions were hybrid and were recorded. This means that attendees like us, who spent a lot of time in meetings, can revisit talks presented during the meeting for the next year.

The meeting was well attended by students (2,075), of nearly 110 of whom were On To the Future scholars. The strong student showing meant that the mentoring and poster sessions, Campus Connection, and display areas were constantly busy. This year, individual posters were widely spaced, making discussions safer and navigation easier than in the past, a feature appreciated by many participants. The meeting included 10 field trips and 19 short courses, five of which were online.

Other signs of a return to GSA meeting "normalcy" were the number of in-person business meetings, the full house at the Presidential Address & Awards Ceremony, and enthusiastic attendance at alumni and scientific Division receptions. It's clear that many (most?) of us really value the opportunity to meet our colleagues and friends face-to-face and to discuss science in-person.

As with the previous two GSA Connects meetings, this year's event posed significant challenges, including attendee safety and access. Not least of these challenges was the fact that all oral sessions were hybrid in-person and virtual. Although there were a few glitches, the great majority of sessions ran smoothly and without interruption. This smooth operation of technical sessions, and the meeting as a whole, results from many hours of dedicated work by the Local Organizing Committee, yeoman efforts from GSA staff, and the work of a cadre of student volunteers. A hearty thank-you to all of these individuals.

This meeting marks the last GSA Connects that Vicki McConnell will lead as she stepped down as executive director of GSA at the end of October 2022. She successfully guided GSA through the pre-COVID years and met the unique challenges of leading GSA through the peak of the COVID years. We wish her the best in her future endeavors.

We now look forward to GSA Connects 2023, which will be held in Pittsburgh, Pennsylvania, USA, next October. The co-general chairs Gale Blackmer and Jessica Moore have our best wishes for a successful, exciting meeting in the Keystone State.


Jeff Lee and Cal Barnes
Co-General Chairs

Thank You to the Organizing Committee!

Jeffrey Lee: General Co-Chair
Cal Barnes: General Co-Chair
Robinson Cecil: Technical Program Chair
Patrick Burkhart: Technical Program Vice-Chair
Kevin Mahan: Field Trip Co-Chair
Lynne Chastain-Carpenter: Field Trip Co-Chair
Lindsay Powers: Special Events Chair
Caitlin Callahan: K-12 Chair
Danielle Olinger: Community Education Chair
Timothy Grover: Sponsorship Chair

Thank You to All the Mentors Who Volunteered Their Time at GSA Connects 2022

Mentors are integral to GSA's meetings and are a source of motivation and support for students and early-career professionals as they seek advice and information related to their academic and career pathways. The following are programs where mentors volunteered, along with selected comments from mentees.

- On To the Future (OTF) Mentors
- GeoCareers Day Mentor Roundtables
- GeoCareers Day Panelists
- Early-Career Professional Coffee
- Résumé Clinic Mentors
- Drop-in Mentors
- Networking Reception Mentors
- Women in Geology Panelists
- Women in Geology Mentors
- GeoCareers Corner Presenters

"I received invaluable advice on preparing my résumé to get through the USA Jobs algorithm."

"My mentor provided incredibly valuable insight on trying to get a job in my chosen field, plus additional careers I might be able to apply my training to. He was SO helpful!"

"I met with the same mentor twice during the span of the conference to review and receive feedback on my résumé, discuss career pathways for my desired career, and receive advice on graduate school applications and benefits. It was extremely helpful."

"The mentor I met with gave me excellent advice about how to approach the career field I am interested in."

By the Numbers

Total Attendees: 5,283
In-Person: 4,874
Online: 409
Professionals: 2,445
Early-Career Professionals: 616
Students: 2,075
K–12 Teachers: 27
International Attendees: 7.3%
GSA-Sponsored On To the Future Scholars: 51
NSF-Sponsored On To the Future Scholars: 56
Countries Represented: 52
Abstracts: 3,398
Short Courses: 19 (five online and 14 in-person)
Field Trips: 10
Exhibitors: 207

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MEMBERSHIP BENEFIT PARTNERS

Be a Part of GSA Connects 2023

Submit a short course and/or technical session proposal.

15–18 October | Pittsburgh, Pennsylvania, USA

GSA Connects 2023 will bring together the geological community to enable you to share your scientific research, network with leaders in the field, and keep your skills relevant in a rapidly changing world. Plan now to be part of this gathering by submitting a proposal for a short course and/or a technical session considering the themes "**Diverse Science for a Sustainable Future**" or "**Climate and Energy Transition**."

Present your evidence-based knowledge to a large international audience by organizing and chairing a technical session.

Proposals are being taken for Pardee Keynote Symposia and topical sessions. Please make your selection on the proposal submission form.

Deadline: 1 Feb. 2023
https://gsa.confex.com/gsa/2023AM/cfs.cgi

Gain recognition as an expert in your topic of research as an instructor of a short course.

Courses run the Friday and Saturday before the meeting and are typically a half day to two full days. Both online and in-person proposals are sought.

Deadline: 1 Feb. 2023
https://gsa.confex.com/gsa/2023AM/shortcourse/cfs.cgi

community.geosociety.org/gsa2023

Award & Nomination Deadlines

www.geosociety.org/gsa/awards/nominate.aspx

For details, see the October *GSA Today* or go to **www.geosociety.org/awards.** You can also email awards@geosociety.org.

2023 GSA MEDALS AND AWARDS

Nomination deadline: 1 Feb.

- Penrose Medal
- Day Medal
- Honorary Fellow
- Young Scientist Award (Donath Medal)
- GSA Public Service Award
- Randolph W. "Bill" and Cecile T. Bromery Award for Minorities
- GSA Distinguished Service Award
- Doris M. Curtis Outstanding Woman in Science Award
- Geologic Mapping Award in Honor of Florence Bascom

Nomination deadline: 1 Mar.

- GSA International Distinguished Career Award
- James B. Thompson, Jr., Distinguished International Lecturer Award

JOHN C. FRYE ENVIRONMENTAL GEOLOGY AWARD

Nomination deadline: 31 Mar.

In cooperation with the Association of American State Geologists and supported by endowment income from the GSA Foundation's John C. Frye Memorial Fund, GSA makes an annual award for the best paper on environmental geology published either by GSA or by a state geological survey. The 2022 awardee is Anna Fehling and David Hart, 2021, Potential Effects of Climate Change on Stream Temperature in the Marengo River Headwaters, Wisconsin Geological and Natural History Survey Bulletin 115, 74 p.

2022 COLE RESEARCH GRANT AWARDS

Application deadline: 1 Feb.

Learn more at **www.geosociety.org/post-doc.**

- The **Gladys W. Cole Memorial Research Award** for research on the geomorphology of semiarid and arid terrains in the United States and Mexico is awarded annually to a GSA member or Fellow between 30 and 65 years of age who has published one or more significant papers on geomorphology.
- The **W. Storrs Cole Memorial Research Award** for research on invertebrate micropaleontology is awarded annually to a GSA member or Fellow between 30 and 65 years of age who has published one or more significant papers on micropaleontology.

TIM W. WAWRZYNIEC FELLOWSHIP AT THE ROCKY MOUNTAIN BIOLOGICAL LABORATORY (RMBL)

This fellowship is intended to support research conducted by Ph.D.-holding investigators who have not previously worked through RMBL. This fund will award US$5,000 annually. Deadline for new proposals: 1 Feb. Deadline for the fellowship application: 15 Feb. Go to **http://www.rmbl.org/scientists/** to learn more or contact gis@rmbl.org.

AGI AWARDS

Nomination deadline: 1 Feb. 2023

Submit nominations for the following awards at **www.agiweb.org/direct/awards.html.**

- **AGI Medal in Memory of Ian Campbell for Superlative Service to the Geosciences** recognizes singular performance in and contribution to the profession of geology.
- **AGI Marcus Milling Legendary Geoscientist Medal** is given to a recipient with consistent contributions of high-quality scientific achievements and service to the earth sciences having lasting, historic value; who has been recognized for accomplishments in field(s) of expertise by professional societies, universities, or other organizations; and is a senior scientist nearing completion or has completed full-time regular employment.

OTHER NATIONAL AWARDS

For a list of other national awards and nomination forms, go to **www.geosociety.org/national-awards.** If you know of an award not listed, please send the details to awards@geosociety.org.

Call for GSA Fellowship Nominations

Deadline: 1 Feb.

Nominate a deserving colleague with the honor of GSA fellowship. GSA members are elected to fellowship in recognition of distinguished contributions to the geosciences. See election requirements by visiting **www.geosociety.org/Fellowship.**

J. David Lowell Field Camp Scholarships

GSA and the GSA Foundation are proud to announce that J. David Lowell Field Camp Scholarships will be available to undergraduate geology students for the summer of 2023. These scholarships will provide students with US$2,000 each to attend the field camp of their choice. Applications are reviewed based on diversity, economic/financial need, and merit. **Application deadline:** 31 Mar. 2023.

Learn more at **www.geosociety.org/field-experiences**. Questions? Contact Jennifer Nocerino, jnocerino@geosociety.org.

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McKenzie Miller (right), a 2022 J. David Lowell Field Camp Scholarship awardee.

GSA Division Awards

ENERGY GEOLOGY DIVISION

Gilbert H. Cady Award

Nominations due 1 Mar.

Submit nominations to the Cady Award chair.

The Gilbert H. Cady Award recognizes outstanding contributions in the field of coal geology that advance the science both within and outside of North America. Learn more at **community.geosociety.org/energydivision/awards/cady.**

Curtis-Hedberg Award

Nominations due 1 May.

Submit nominations to the Curtis-Hedberg Award chair.

The inaugural Curtis-Hedberg Award will be made for outstanding contributions in the field of petroleum geology. Learn more at **community.geosociety.org/energydivision/awards/curtishedberg.**

ENVIRONMENTAL AND ENGINEERING GEOLOGY DIVISION

Richard H. Jahns Distinguished Lecturer

Nominations due 31 Jan.

Submit email nominations or questions to the Division chair.

This lectureship was established in 1988 by the Division and the Association of Environmental and Engineering Geologists to commemorate Jahns and to promote student awareness of engineering geology through an annual series of lectures at academic institutions. The award is given to an individual who, through research or practice, has made outstanding contributions to the advancement of environmental and/or engineering geology. The awardee will speak on topics of earth processes and the consequences of human interaction with these processes, or the application of geology to environmental and/or engineering works. Award funds are administered by the GSA Foundation. Learn more at **community.geosociety.org/eegdivision/awards/jahns.**

E.B. Burwell, Jr., Award

Nominations due 1 Feb.

Submit nominations to Jim McCalpin at mccalpin@geohaz.com.

This award is made to the author or authors of a published paper of distinction that advances knowledge concerning principles or practice of engineering geology, or of related fields of applied soil or rock mechanics where the role of geology is emphasized. The paper that receives the award must: (1) deal with engineering geology or a closely related field, and (2) have been published no more than five years prior to its selection. There are no restrictions on the publisher or publishing agency of the paper. Learn more at **community.geosociety.org/eegdivision/awards/burwell.**

Distinguished Practice Award

Nominations due 31 Mar.

This award recognizes continuing contributions to the technical and/or professional stature of environmental and engineering geology. Learn more at **community.geosociety.org/eegdivision/awards/new-item3.**

GEOARCHAEOLOGY DIVISION

Application and nomination information is online at **community.geosociety.org/geoarchdivision/home.**

Rip Rapp Award

Nominations due 15 Feb.

Submit nominations to gsa.agd@gmail.com.

This award recognizes outstanding contributions to the interdisciplinary field of archaeological geology and is funded through the GSA Foundation. Nominations should include a biographical sketch, a statement of outstanding achievements, and a selected bibliography.

Claude C. Albritton, Jr., Award

Nominations due 15 Mar.

Submit nominations to gsa.agd@gmail.com.

The Albritton Award Fund, established with the GSA Foundation, provides scholarships and fellowships for research for graduate students in the earth sciences or archaeology. Recipients are students who have (1) an interest in achieving a master's or Ph.D. degree in earth science or archaeology, (2) an interest in applying earth-science methods to archaeological research, and (3) an interest in a career in teaching and academic research. Awards in the amount of US$650 are given in support of thesis or dissertation research, with emphasis on the field and/or laboratory aspects of the research.

Richard Hay Student Paper/Poster Award

Nominations due 1 Sept.

Submit nominations to gsa.agd@gmail.com.

The award is a travel grant for a student (undergraduate or graduate) presenting a paper or poster at GSA Connects. The grant is competitive and will be awarded based on the evaluation of the scientific merit of the research topic and the clarity of an expanded abstract for the paper or poster prepared by a student for presentation in the Division's technical session at the meeting.

GEOINFORMATICS AND DATA SCIENCE DIVISION

M. Lee Allison Award for Geoinformatics

Nominations due 15 Feb.

This award will be made to an individual who has contributed in an outstanding manner to geology through the application of the principles of geoinformatics. The individual should be a member of GSA. Learn more at **community.geosociety.org/geoinformaticsdivision/awards.**

GEOLOGY AND HEALTH DIVISION

Meritorious Award

Nominations due 15 Feb.

This award recognizes outstanding contributions to the mission of the Geology and Health Division. The awardee must be a member of the Division. Learn more at **community.geosociety.org/geologyhealthdivision/events32/upcoming-awards.**

Distinguished Career Award

Nominations due 8 Mar.

This award recognizes the recipient's lifetime contributions to the field of geology and health. The awardee does not need to be a member of the Division. Learn more at **community.geosociety.org/geologyhealthdivision/events32/upcoming-awards.**

GEOPHYSICS DIVISION

George P. Woollard Award

Nominations due 1 Feb.

Submit nominations to the Division chair.

This award recognizes outstanding contributions to geology through the application of the principles and techniques of geophysics. A highlight of the presentation is the honorary George P. Woollard Technical Lecture by the recipient before the award ceremony. To submit a nomination, please provide the nominee's name, contact information, and a short paragraph stating the nominee's qualifications, including a short summary of their work or specific outcomes and how these have contributed to geology. A curriculum vitae helps but is not required. Award funds are administered by the GSA Foundation. Learn more at **community.geosociety.org/geophysicsdivision/awards/woollard.**

GEOSCIENCE EDUCATION DIVISION

Biggs Award for Excellence in Earth Science Teaching

Nominations due 1 Mar.

The Biggs Award recognizes innovative and effective teaching in college-level earth science. Earth-science instructors and faculty members from any academic institution engaged in undergraduate education who have been teaching full-time for 10 years or fewer are eligible (part-time teaching is not counted in this requirement). Both peer- and self-nominations will be accepted. This award, administered by the GSA Foundation, is made possible by support from the Donald and Carolyn Biggs Fund, the GSA Geoscience Education Division, and GSA's Education and Outreach Program. An additional travel reimbursement is also available to the recipient to enable them to attend the award presentation at GSA Connects. Learn more at **community.geosociety.org/gedivision/awards/biggsaward.**

HISTORY AND PHILOSOPHY OF GEOLOGY DIVISION

Mary C. Rabbitt History and Philosophy of Geology Award

Nominations due 15 Feb.

Submit nominations to the Division's secretary/treasurer.

This award recognizes exceptional scholarly contributions of fundamental importance to our understanding of the history of the geological sciences. Achievements deserving of the award include, but are not limited to, publication of papers or books that contribute new and profound insights into the history of geology based on original research or a synthesis of existing knowledge. Neither the nominator nor the nominee need be a member of the Division or of GSA. The nomination packet should include (1) a letter detailing the contributions that warrant the award; and (2) the nominee's current curriculum vitae including name, title, affiliation, education, degrees, honors and awards, major career events, and contributions that warrant the award. Monies for the award are administered by the GSA Foundation. Learn more at **community.geosociety.org/histphildiv/awards/rabbitt.**

Gerald M. and Sue T. Friedman Distinguished Service Award

Nominations due 15 Feb.

Submit nominations to the Division's secretary/treasurer.

This award is presented for exceptional service to the advancement of our knowledge of the history and philosophy of the geological sciences. The service to the history and philosophy of geology may include, but is not limited to, the discovery of and making available rare source materials; comprehensive bibliographic surveys; organizing meetings and symposia in the history and philosophy of geology; and exceptional service to the Division. The nomination packet should include (1) a letter detailing the contributions that warrant the award; and (2) the nominee's current curriculum vitae including: name, title, affiliation, education, degrees, honors and awards, major career events, and the contributions that warrant the award. Monies for the award are administered by the GSA Foundation. Learn more at **community.geosociety.org/histphildiv/awards/dsa.**

History and Philosophy of Geology Student Award

Nominations due 15 June

Submit nominations to the Division's secretary/treasurer.

This award in the amount of US$1,000 is for a paper to be presented at GSA Connects. Oral presentations are preferred. The proposed paper may be (1) on the history or philosophy of geology, (2) a literature review of ideas for a technical work or thesis/dissertation, or (3) some imaginative aspect of the history or philosophy of geology we have not thought of before. Students should submit an abstract of their proposed talk and a 1,500–2,000-word prospectus for consideration. Monies for the award are administered by the GSA Foundation. Learn more at **community.geosociety.org/histphildiv/awards/student.**

HYDROGEOLOGY DIVISION

O.E. Meinzer Award

Nominations due 1 Feb.

Submit nominations to gsa.hydro.nominations@gmail.com.

This award recognizes the author or authors of a publication or body of publications that have significantly advanced the science of hydrogeology or a closely related field. The nomination must cite the publication(s) on which the nomination is based and describe the role of the publication(s) in advancing hydrogeology or a closely related discipline. Inclusion of up to three additional third-party letters in support of the nomination is encouraged. If you have questions, please contact gsa.hydro.nominations@gmail.com. Learn more at **community.geosociety.org/hydrodivision/awards/meinzer.**

George Burke Maxey Distinguished Service Award

Nominations due 1 Feb.

Submit nominations to gsa.hydro.nominations@gmail.com.

This award recognizes distinguished personal service to the hydrogeology profession and to the Hydrogeology Division. The award is based on a history of sustained creditable service to the hydrogeology profession and to the Division. Please submit a letter of nomination that describes the distinguished service that warrants the nomination. Supporting letters are helpful but not required. Learn more at **community.geosociety.org/hydrodivision/awards/serviceaward.**

Kohout Early Career Award

Nominations due 1 Feb.

Submit nominations to gsa.hydro.nominations@gmail.com.

This award will be presented to a distinguished early-career scientist (35 years of age or younger throughout the year in which the award is to be presented or within five years of receiving their highest degree or diploma) for outstanding achievement in contributing to the hydrogeologic profession through original research and service, and for the demonstrated potential for continued excellence throughout their career. The nomination package must include the following: (1) at least one letter of nomination with a description of the significant contributions or accomplishments, (2) a copy of the nominee's curriculum vitae with complete bibliography, and (3) at least four supporting letters. Learn more at **community.geosociety.org/hydrodivision/awards/kohout.**

Birdsall-Dreiss Distinguished Lecturer

Nominations due 1 Feb.

Submit nominations to gsa.hydro.nominations@gmail.com.

The lecturer will be selected based on outstanding contributions to hydrogeology or a closely related field through original research and public communication and the potential for continued contributions to the profession. Include at least one letter of nomination, a copy of the nominee's curriculum vitae, and at least two supporting letters describing the significant contributions or accomplishments constituting the basis for the nomination. Learn more at **community.geosociety.org/hydrodivision/birdsall/about2019.**

LIMNOGEOLOGY DIVISION

Israel C. Russell Award

Nominations due 1 Feb.

Submit nominations to Division treasurer David Finkelstein.

This award recognizes major achievements in limnogeology through contributions in research, teaching, and service. Nominations should consist of a letter describing the nominee's accomplishments in the field of limnogeology (broadly defined and including limnogeology, limnology, and paleolimnology), service to students and teaching, and contributions to GSA, as well as a curriculum vitae. Learn more at **community.geosociety.org/limnogeologydivision/awards/Russell.**

Kerry Kelts Research Award

Nominations due 1 Feb.

Submit nominations to the Division chair.

This award is for undergraduate or graduate student research related to limnogeology, limnology, or paleolimnology. Learn more at **community.geosociety.org/limnogeologydivision/awards/kerrykelts.**

MINERALOGY, GEOCHEMISTRY, PETROLOGY, AND VOLCANOLOGY (MGPV) DIVISION

MGPV awards emphasize achievements in geologic and multidisciplinary approaches. Geologic work is by nature generalistic and has an important field component, with Earth as the natural laboratory. Learn more at **community.geosociety.org/mgpvdivision/home.**

MGPV Distinguished Geologic Career Award

Nominations due 31 Mar.

This award goes to an individual who, throughout their career, has made distinguished contributions in one or more of the following fields of research: mineralogy, geochemistry, petrology, volcanology, with emphasis on multidisciplinary, field-based contributions. Nominees need not be citizens or residents of the United States, and GSA membership is not required. Learn more at **community.geosociety.org/mgpvdivision/awards/dgca.**

MGPV Early Career Award

Nominations due 31 Mar.

This award will go to an individual near the beginning of their professional career who has made distinguished contributions in one or more of the following fields of research: mineralogy, geochemistry, petrology, volcanology, with emphasis on multidisciplinary, field-based contributions. Nominations are restricted to those who are within eight years past the award of their final degree. Extensions of up to two years will be made for nominees who have taken career breaks for family reasons or caused by serious illness. Learn more at **community.geosociety.org/mgpvdivision/awards/earlycareer.**

PLANETARY GEOLOGY DIVISION (PGD)

Pellas-Ryder Award

Nominations due 31 Jan.

This award, which is jointly sponsored with the Meteoritical Society, recognizes an undergraduate or graduate student who is first author of the best planetary science paper published in a peer-reviewed scientific journal during the year prior to the award. Potential topics are listed on the cover of *Meteoritics & Planetary Science*, and include asteroids, comets, craters, interplanetary dust, interstellar medium, lunar samples, meteors, meteorites, natural satellites, planets, tektites, and origin and history of the solar system. Learn more at **community.geosociety.org/pgd/awards/pellas-ryder.**

Ronald Greeley Award for Distinguished Service

Nominations due 1 Aug.

This award may be given to those members of the PGD, and those outside of the Division and GSA, who have rendered exceptional service to the PGD for a multi-year period. Nominations for the award, which should include a description of what the nominee has given to the PGD community, may be made by any PGD member to the management board. Learn more at **community.geosociety.org/pgd/awards/greeley.**

Eugene and Carolyn Shoemaker Impact Cratering Award

Nominations due 19 Aug.

This award is for undergraduate or graduate students, of any nationality, working in any country, in the disciplines of geology, geophysics, geochemistry, astronomy, or biology. The award, which will include US$2500, is to be applied to the study of impact craters, either on Earth or on the other solid bodies in the solar system. Areas of study may include but shall not necessarily be limited to impact cratering processes; the bodies (asteroidal or cometary) that make the impacts; or the geological, chemical, or biological results of impact cratering. Learn more at **community.geosociety.org/pgd/awards/shoemaker.**

G.K. Gilbert Award

Nominations due 15 Jan.

This award recognizes outstanding contributions to the solution of a fundamental problem(s) of planetary geology in its broadest sense, including planetary geology, geochemistry, mineralogy, petrology, and tectonics, geophysics, and the field of meteoritics. Such contributions may consist either of a single outstanding publication or a series of publications that have had great influence on the field. Learn more at **community.geosociety.org/pgd/awards/gilbert.**

QUATERNARY GEOLOGY AND GEOMORPHOLOGY DIVISION

Kirk Bryan Award for Research Excellence

Nominations due 1 Feb.

This award is bestowed upon the author or authors of a published paper of distinction advancing the science of geomorphology or some related field, such as Quaternary geology. The paper constituting the basis of the award must fulfill the following requirements: (1) the paper will deal with geomorphology or with a bordering field, and (2) the paper will have been published not more than five years prior to its selection for the award. Submit nominations, including (1) a letter (one to three pages long) by the chief nominator outlining the significance and importance of the nominated publication; (2) a copy of the publication; (3) reviews of the publication that have appeared in journals, newsletters, or books (if any); and (4) one or more letters from other supporters of the nomination, via email to the Division secretary. Learn more at **community.geosociety.org/qggdivision/awards/kirkbryanaward.**

Farouk El-Baz Award for Desert Research

Nominations due 1 Apr.

Submit nominations to Anne Chin, ann.chin@ucdenver.edu.

This award recognizes excellence in desert geomorphology research worldwide. It is intended to stimulate research in desert environments by recognizing an individual whose research has significantly advanced the understanding of the Quaternary geology and geomorphology of deserts. Although the award primarily recognizes achievement in desert research, the funds that accompany it may be used for further research. Any scientist from any country may be nominated. Neither nominators nor nominees need be GSA members. Monies for the award are administered by the GSA Foundation. Nominations should include (1) a statement of the significance of the nominee's research; (2) a curriculum vitae; (3) letters of support; and (4) copies of no more than five of the nominee's most significant publications related to desert research. Learn more at **community.geosociety.org/qggdivision/awards/el-baz.**

Distinguished Career Award

Nominations due 1 Apr.

Submit nominations to the Division secretary.

This award goes to a Quaternary geologist or geomorphologist who has demonstrated excellence in their contributions to science. Neither nominators nor nominees need be GSA members. Nominations should include (1) a brief biographical sketch; (2) a statement of no more than 200 words describing the candidate's scientific contributions to Quaternary geology and geomorphology; (3) a selected bibliography of no more than 20 titles; and (4) a minimum of four letters from colleagues supporting the nomination. Learn more at **community.geosociety.org/qggdivision/awards/distinguished-career.**

SEDIMENTARY GEOLOGY DIVISION

Laurence L. Sloss Award for Sedimentary Geology

Nominations due 15 Feb.

This award is given to a sedimentary geologist whose lifetime achievements best exemplify those of Larry Sloss—i.e., achievements that contribute widely to the field of sedimentary geology and service to GSA. Submit (1) a cover letter describing the nominee's accomplishments in sedimentary geology and contributions to GSA, (2) a curriculum vitae, and (3) any additional supporting letters. The fund is administered by the GSA Foundation. Learn more at **community.geosociety.org/sedimentarygeologydiv/awards/sloss.**

Sedimentary Geology Division and Structural Geology and Tectonic Division Joint Award: Stephen E. Laubach Structural Diagenesis Research Award

Nominations due 1 Apr.

This award promotes research combining structural geology and diagenesis and curriculum development in structural diagenesis. It addresses the rapidly growing recognition that fracturing, cement precipitation and dissolution, evolving rock mechanical properties, and other structural diagenetic processes can govern recovery of resources and sequestration of material in deeply buried, diagenetically altered and fractured sedimentary rocks. The award highlights the growing need to break down disciplinary boundaries between structural geology and sedimentary petrology. Graduate students, postgraduate, and faculty-level researchers are eligible. Learn more at **community.geosociety.org/sedimentarygeologydiv/awards/Laubach.**

STRUCTURAL GEOLOGY AND TECTONIC DIVISION

Career Contribution Award

Nominations due 1 Mar.

This award is for an individual who, throughout their career, has made numerous distinguished contributions that have clearly advanced the science of structural geology or tectonics. Nominees need not be U.S. citizens or residents, and GSA membership is not required. Nominations should include the following: (1) name of nominee, present institutional affiliation, and address; (2) summary statement of nominee's major career contributions to the science of structural geology and tectonics; (3) selected key published works of the nominee; and (4) the name and address of nominator. Learn more at **community.geosociety.org/sgt/awards/careercontribution.**

Outstanding Publication Award

Nominations due 1 Mar.

This award is given annually for a published work (paper, book, or map) of exceptional distinction that clearly advances the science of structural geology or tectonics. Nominations include (1) a full citation; (2) nomination (as short as a paragraph; letters or reviews may also be included); and (3) the name and address of the nominator. Learn more at **community.geosociety.org/sgt/awards/outstandingpublication.**

GeoCareers Programs at the 2023 Section Meetings

GEOSCIENCE CAREER WORKSHOPS

Part 1: Career Planning and Networking. Your job-hunting process should begin with career planning, not when you apply for jobs. This workshop will help you begin this process and practice your networking skills. Highly recommended for freshmen, sophomores, and juniors—the earlier you start your career planning the better.

Part 2: Geoscience Career Exploration. What do geologists in various sectors earn? What do they do? What are the pros and cons of working in academia, government, and industry? Workshop presenters and professionals in the field will address these issues.

Part 3: Cover Letters, Résumés, and CVs. How do you prepare a cover letter? Does your résumé need a good edit? Whether you are currently in the market for a job or not, learn how to prepare the best résumé possible. You will review numerous examples to help you learn important résumé dos and don'ts.

MENTOR PROGRAMS

GSA student members will have the opportunity to discuss career prospects and challenges with applied geoscientists from various sectors. Not a member? Join at **www.geosociety.org/join** today!

South-Central Section Meeting
13–14 March, Stillwater, Oklahoma, USA
Shlemon Mentor Program: Monday, 13 March
Mann Mentors in Applied Hydrology Program: Tuesday, 14 March

Southeastern & Northeastern Joint Section Meeting
17–19 March, Reston, Virginia, USA
Shlemon Mentor Program: Friday, 17 March
Mann Mentors in Applied Hydrology Program: Saturday, 18 March

North-Central Section Meeting
4–5 May, Grand Rapids, Michigan, USA
Shlemon Mentor Program: Thursday, 4 May
Mann Mentors in Applied Hydrology Program: Friday, 5 May

Cordilleran Section Meeting
17–19 May, Reno, Nevada, USA
Shlemon Mentor Program: Wednesday, 17 May
Mann Mentors in Applied Hydrology Program: Thursday, 18 May

Rocky Mountain Section Meeting
23–25 May, Fort Collins, Colorado, USA
Shlemon Mentor Program: Tuesday, 23 May
Mann Mentors in Applied Hydrology Program: Wednesday, 24 May

THE GEOLOGICAL SOCIETY OF AMERICA®

Mark Your Calendar for Meetings Closer to Home

South-Central Section

13–14 March
Stillwater, Oklahoma, USA
Todd Halihan, todd.halihan@okstate.edu
www.geosociety.org/sc-mtg

Edmon Low Library, Oklahoma State University.
Photo credit: rseigler0 from Pixabay.

Joint Southeastern & Northeastern Sections

17–19 March
Reston, Virginia, USA
Arthur Merschat, amerschat@usgs.gov; Patrick Burkhart, patrick.burkhart@sru.edu
www.geosociety.org/se-mtg

Reston Town Center water fountain.
Photo credit: J. Rodysill.

North-Central Section

4–5 May
Grand Rapids, Michigan, USA
Tara Kneeshaw, kneeshta@gvsu.edu; Ginny Peterson, petersvi@gvsu.edu
www.geosociety.org/nc-mtg

L.V. Eberhard Center at GVSU. Photo credit: Amanda Pitts, University Communications, Grand Valley State University.

Cordilleran Section

17–19 May
Reno, Nevada, USA
Stacia Gordon, staciag@unr.edu
www.geosociety.org/cd-mtg

Panorama from the Mono Lake South Tufa Area.
Photo credit: Dr. Philipp Ruprecht.

Rocky Mountain Section

23–25 May
Fort Collins, Colorado, USA
Rick Aster, rick.aster@colorado.edu
www.geosociety.org/rm-mtg

Pineridge Natural Area.
Photo credit: Jan Alexander from Pixabay.

2023

New and Updated Position Statements

In October 2022, GSA Council approved a new position statement, "Responsible Geologic Fieldwork Practices," and a major revision to the "Geosciences and Energy Policy" position statement. Minor revisions to three statements were also approved: "Data Access," "Geoscience Data Preservation," and "Improving Natural Hazards Policies and Response through Geoscience." Summary statements are below, and full versions of all position statements are online at **www.geosociety.org/positionstatements.** GSA members are encouraged to use the statements as geoscience communication tools when interacting with policymakers, students, colleagues, and the general public.

RESPONSIBLE GEOLOGIC FIELDWORK PRACTICES

This position statement provides guidance on GSA's best geologic fieldwork practices for both research and educational expeditions. GSA urges geoscientists to conduct fieldwork in an ethical, respectful, and sustainable manner that: (1) provides a safe, equitable, and inclusive environment for conducting responsible fieldwork; (2) respects the land rights and laws of local, state, tribal, and federal jurisdictions, Tribes, Indigenous peoples, local communities, and private landowners; (3) obtains the proper fieldwork and collection permission and follows all agreed-upon work as specified; and (4) minimizes destruction of outcrop and disturbance of landscape. GSA opposes fieldwork and the collection of geological samples (e.g., rock, mineral, sediment, soil samples, etc.) and fossils of any type in active conflict zones for any purpose, such as research, education, and public display (e.g., museums, publication, and sale).

GEOSCIENCES AND ENERGY POLICY

Development of a comprehensive energy policy that includes approaches for significant reduction of global greenhouse gas emissions is essential for the future economic vitality, environmental well-being, and health and security of the citizens of the United States as well as other nations. Geoscientists locate, quantify, and help develop energy and critical mineral resources required for the transition to a low-carbon future and, along with professionals in other disciplines, assess and mitigate the impact of energy-resource development, operations, and use on the environment. Accordingly, input from geoscientists must be an integral part of all energy policy deliberations.

DATA ACCESS

GSA strongly supports open access to scientific data to promote advancement in research, support education, and improve the economic progress, health, and welfare of society.

GEOSCIENCE DATA PRESERVATION

GSA supports the preservation of geoscience samples and data sets for the public good and urges public and private sector organizations and individuals to routinely catalog and preserve their collections and make them more widely accessible.

IMPROVING NATURAL HAZARDS POLICIES AND RESPONSE THROUGH GEOSCIENCE

This position statement (1) encourages increased public and private investments to reduce natural hazards vulnerability through better understanding of geologic processes; (2) emphasizes the crucial role of geoscience education and outreach in broadening the public's understanding of their risk from natural hazards and the options to reduce risk; and (3) promotes the active participation of geoscientists in implementing public policy that will improve society's resilience to natural hazards.

Developing a New Paradigm for the Mid-Cretaceous to Eocene North American Cordillera: An Obliquely Convergent Plate Margin

18–25 August 2023 | McCall, Idaho, USA
www.geosociety.org/penrose

CONVENERS

Basil Tikoff, University of Wisconsin–Madison, Dept. of Geoscience, Madison, Wisconsin, USA, basil@geology.wisc.edu
Stacia Gordon, University of Nevada–Reno, Dept. of Geological Sciences, Reno, Nevada, USA, staciag@unr.edu
Matthew A. Williams, University of Calgary, Institute of Earth Sciences, Calgary, Canada, wamatthe@calgary.ca
Elena Centeno-Garcia, Universidad Nacional Autónoma de México, Mexico City, Mexico, centeno@unam.mx

SPONSORS

The Geological Society of America
Divisions of The Geological Society of America (Geochronology; Geophysics and Geodynamics; Mineralogy; Geochemistry, Petrology, and Volcanology; Sedimentary Geology; Structural Geology and Tectonics)
Canadian Tectonic Studies Group
Geological Association of Canada Cordilleran Section
Sociedad Geológica Mexicana

DESCRIPTION AND OBJECTIVES

The issue of major right-lateral displacement throughout the North American Cordillera has been debated for 50 years. Paleomagnetic data from the western part of the Canadian Cordillera and some parts of the Pacific Northwest, during the interval ca. 110–40 Ma, have consistently suggested thousands of kilometers of northward displacement, while geological studies of fault movement indicate only hundreds. This discrepancy is unavoidable because faults tend to be on the margins of terranes, resulting in few unequivocal offset markers. Further debate includes the subduction polarity of the terranes with respect to the western margin of North America and the past size of the ocean basins that separated them. While this problem is most acute in the northern Cordillera, it has implications affect the entire North American margin. Recent data and analyses—including detrital zircons, mantle tomography, numerical modeling of plate motion, shear zone kinematics, and geochronology—have provided new insights. The objective of this Penrose Conference is to bring together a diverse community of open-minded scholars to discuss what is agreed upon and where future work is needed, but also to work collaboratively to evaluate how all the data sets can be reconciled into a coherent model for an obliquely convergent plate boundary.

PRELIMINARY AGENDA

The meeting will be held in Riggins and McCall, Idaho, USA. We will stay at the Best Western Hotel in Riggins, at the confluence of the main Salmon and Little Salmon rivers. This location will give us the opportunity to visit the Salmon River suture zone and the overprinting western Idaho shear zone. The remaining nights we will stay at the Quaker Hill Conference center in McCall, on the shores of Payette Lake. A second field trip day will explore the western Idaho shear zone in the glaciated, well-exposed mountains north of McCall.

The conference format will be a balance of oral presentations, poster presentations, and evening talks in preparation for field trips. Relative to other meetings, however, we will emphasize the working group discussions and report outs to the whole group. We will include a premeeting mentoring opportunity for early-career scientists. Attendees will be expected to observe the GSA Events Code of Conduct throughout the meeting. The conference will follow the COVID-19 protocols that GSA has established for meetings and field trips.

Meeting participants who are arriving by air will be shuttled from Boise Airport (BOI) to the conference venue on Friday, 18 August. It is approximately a three-hour ride by car. Day 1 of the conference (19 August) will focus on a broad overview of the problem, talks on the different methodologies, and a short introduction to the field trip on Day 2. A full-day tour of Salmon River suture zone—from North America, across the Salmon River belt, to the Wallowa terrane—will occur on Day 2, after which we will drive to McCall. Day 3 will begin with a morning session focused on the northern Cordillera, followed by an afternoon session on the southern Cordillera. Day 4 will start with the central Cordillera, and the afternoon session will be split, with half of the afternoon dedicated to a poster session to ensure that everyone has time to look at the posters. The rest of the afternoon will be background information to set the stage for the field trip on Day 5. Day 5 is the field trip to the western Idaho shear zone. Day 6 will include a jigsaw activity where we first organize by methodology discipline in breakout groups in the morning and then in the afternoon break up to talk by regions to recognize major issues within different sections of the Cordillera. Day 7 involves a morning of time-based, rather than place-based, breakout groups. The afternoon will include report out from groups, followed by a whole group discussion on what is agreed upon, what needs to be resolved, and organizational plans on how to continue working on this problem that necessarily crosses political divisions. We will leave for the Boise airport on the morning of Friday, 25 August.

ATTENDEES AND ESTIMATED COSTS

The anticipated registration fee will be announced at a later date and will cover seven nights of lodging, meals, transportation to/from Boise airport, transportation for field trips, and facility usage. Participants will be expected to pay for travel expenses from their home to the Boise airport and the return. However, we have funds allocated to support both the registration costs and the

Strongly foliated orthogneiss, deformed by the western Idaho shear zone, exposed in the canyon country of Idaho, USA. The view is to the south and the foliation dips steeply east, rotated from its pre-Miocene vertical orientation by normal faulting. Photo by Basil Tikoff.

travel expenses of some participants, which will be prioritized toward students, early-career professionals, and participants from underrepresented groups in the geosciences. All participants will be expected to make their own travel arrangements to arrive at the Boise airport prior to 3 p.m. on 18 August and in the afternoon on 25 August. Alternatively, attendees may choose to provide their own transportation to McCall, and they will be picked up there on 18 August; these participants will be expected to use conference-provided transportation for the remainder of the meeting.

APPLICATIONS AND REGISTRATION

Application period opens: 1 Dec. 2022
Application deadline: 1 March 2023
Acceptance notices: 24 March 2023
Registration deadline: 14 April 2023

GSA and the meeting conveners are committed to fostering diversity, equity, inclusion, and belonging in the geoscience community. We welcome and encourage applications from all gender identities, Black, Indigenous, Latinx, and People of Color, people with disabilities, LGBTQIA+ individuals, and other groups that are currently underrepresented within the earth-science community. We have dedicated funds to support conference participation for such individuals, as well as early-career researchers and students.
The conference will be limited to approximately 75 participants, and each participant will be expected to attend the full duration of the conference. Please submit your application through the form on the meeting website: **https://geoscience.wisc.edu/cordilleran-penrose-2023.**

As part of the application, you will be asked to prepare a brief statement of your interests and relevance of your work to the conference themes (300 words maximum), and a tentative title for a proposed presentation. Every participant will be expected to present at the conference. Applicants will be notified regarding attendance and presentation format (oral or poster) by or before 31 March 2023. Conference participants will be asked to submit full abstracts for presentations at the time of registration.

Please note that there will be sessions at the GSA Cordilleran Section Meeting in May 2023 that are thematically related to this Penrose Conference. These will include overview talks for new models recently proposed for North American Cordilleran margin. These sessions were designed to provide general background to facilitate synthesis on the Penrose meeting in Idaho.

Help Shape the Future of Geoscience— Serve on a Committee!

Deadline: 15 June 2023
Terms begin 1 July 2024 (unless otherwise indicated)

If you are looking for the opportunity to work toward a common goal, give back to GSA, network, and make a difference, then we invite you to volunteer (or nominate a fellow GSA member) to serve on a Society committee or as a GSA representative to another organization.

Learn more and access the nomination form at **www.geosociety.org/Committees.** Committee open positions and qualifications are online at **https://rock.geosociety.org/forms/viewopenpositions.asp.** GSA headquarters contact: Darlene Williams, GSA, P.O. Box 9140, Boulder, CO 80301-9140, USA; fax: +1-303-357-1060; dwilliams@geosociety.org.

ACADEMIC AND APPLIED GEOSCIENCE RELATIONS COMMITTEE

Member-at-Large Industry (3-year term; E, M)

This committee is charged with strengthening and expanding relations between GSA members in applied and academic geosciences. As such, it proactively coordinates the Society's effort to facilitate greater cooperation between academia, industry, and government geoscientists. **Qualifications:** Committee members must work in academia, industry, or government and be committed to developing a better integration of applied and academic science in GSA meetings, publications, short courses, field trips, and education and outreach programs. Professional interests: environmental and engineering geology, hydrogeology, karst, Quaternary geology and geomorphology, structural geology and tectonics, sedimentary geology. Members must also be active in one or more GSA Divisions.

ANNUAL PROGRAM COMMITTEE

Member-at-Large (4-year term; B, E, M)

This committee is charged with developing a plan for increasing the quality of the annual and other Society-sponsored meetings in terms of science, education, and outreach; evaluating the technical and scientific programs annually to identify modifications necessary for accomplishing the Society's long-range goals; conducting short and long-range planning for Society meetings as a whole; and developing a long-term logistical plan/strategy for the technical programs of all GSA meetings and other Society-sponsored meetings. **Qualifications:** This member-at-large should have previous meeting experience.

ARTHUR L. DAY MEDAL AWARD

Two Members-at-Large (3-year terms; E, T)

This committee selects candidates for the Arthur L. Day Medal. **Qualifications:** Members should have knowledge of those who have made "distinct contributions to geologic knowledge through the application of physics and chemistry to the solution of geologic problems." All the committee's work will be accomplished during the months of February and March. All committee decisions must be made by 1 April.

DIVERSITY IN THE GEOSCIENCES COMMITTEE

Three Members-at-Large; (3-year terms; E, M)

This committee provides advice and support to GSA Council, raises awareness, and initiates activities and programs that will increase opportunities for diverse groups in the geosciences, particularly in the dimensions of race, ethnicity, gender, and physical abilities. The committee is also charged with stimulating recruitment and promoting positive career development. **Qualifications:** Members must have professional or experiential knowledge of issues relevant to the goals of the committee. GSA strongly encourages nominations of members who are from the communities that this committee is expected to serve.

EDUCATION COMMITTEE

Undergraduate Student Representative (2-year term; B, E, M)

This committee works with GSA members representing a wide range of education sectors to develop informal, pre-college (K–12), undergraduate, and graduate earth-science education and outreach objectives and initiatives. **Qualifications:** Members of this committee must have the ability to work with other interested scientific organizations and science teachers' groups.

GEOLOGY AND PUBLIC POLICY COMMITTEE

Two Members-at-Large (3-year terms; E, M)

This committee provides advice on public policy matters to Council and GSA leadership by monitoring and assessing international, national, and regional science policy; formulating and recommending position statements; and sponsoring topical white papers. This committee also encourages the active engagement in geoscience policy by GSA members. **Qualifications:** Members should have experience with public-policy issues involving the science of geology; ability to develop, disseminate, and translate information from the geologic sciences into useful forms for the public and for GSA members; and familiarity with appropriate techniques for the dissemination of information.

GSA INTERNATIONAL

Two Members-at-Large (4-year terms; E, M); One Member-at-Large outside of North America (4-year term; E, M); One Member-at-Large, Student (2-year term; E, M)

Serve as GSA's coordination and communication resource seeking to promote, create, and enhance opportunities for international cooperation related to the scientific, educational, and outreach missions shared by GSA and like-minded professional societies, educational institutions, and government agencies. Build collaborative relationships with GSA Divisions and Associated Societies on international issues, and serve as channel for member generated proposals for international themes.

B—Meets in Boulder or elsewhere; **E**—Communicates by phone or electronically; **M**—Meets at GSA Connects; **T**—Extensive time commitment required during application review period

MEMBERSHIP AND FELLOWSHIP COMMITTEE

Member-at-Large, Industry (3-year term; B, E)

This committee contributes to the growth of the GSA membership, enhances the member experience, and serves a vital role in the selection of Fellows, with the goal of fostering a membership community as pertinent and global as our science. Committee members should understand what various segments of members want from GSA and should be familiar with outstanding achievers in the geosciences worthy of fellowship. **Qualifications:** Committee members should have experience in benefit, recruitment, and retention programs.

NOMINATIONS COMMITTEE

Two Members-at-Large (3-year terms; B, E)

This committee recommends nominees to GSA Council for the positions of GSA Officers and Councilors, committee members, and Society representatives to other permanent groups. **Qualifications:** Members must be familiar with a broad range of well-known and highly respected geoscientists.

NORTH AMERICAN COMMISSION ON STRATIGRAPHIC NOMENCLATURE

GSA Representative (3-year term; E, M)

The commission develops statements of stratigraphic principles, recommends procedures applicable to classification and nomenclature of stratigraphic and related units, reviews problems in classifying and naming stratigraphic and related unites, and formulates expressions of judgment on these matters. **Qualifications:** Members must be familiar with of the fields of paleontology, biostratigraphy, and stratigraphy. Term begins 1 Dec. 2024.

PENROSE CONFERENCES AND THOMPSON FIELD FORUMS COMMITTEE

Two Members-at-Large (3-year terms; E); One Member-at-Large, Early-Career Scientist (3-year term; E)

This committee reviews and approves Penrose Conference and Thompson Field Forum proposals and recommends and implements guidelines for the success of these meetings. **Qualifications:** Committee members must be early-career scientists/professionals.

PENROSE MEDAL AWARD COMMITTEE

Two Members-at-Large (3-year terms; E, T)

Members of this committee select candidates for the Penrose Medal Award. Emphasis is placed on "eminent research in pure geology, which marks a major advance in the science of geology." **Qualifications:** Members should be familiar with outstanding achievers in the geosciences worthy of consideration for the honor. All of the committee's work will be accomplished during the months of February and March. All committee decisions must be made by 1 April.

PROFESSIONAL DEVELOPMENT COMMITTEE

One Member-at-Large (3-year term; E)

This committee directs, advises, and monitors GSA's professional development program, reviews and approves proposals, recommends and implements guideline changes, and monitors the scientific quality of courses offered. **Qualifications:** Members must be familiar with professional development programs or have adult education teaching experience.

RESEARCH GRANTS COMMITTEE

Fourteen Members-at-Large with Various Specialties (3-year terms; B, T)

The primary function of this committee is to evaluate approximately 800 graduate student research grant applications and award specific grants to chosen recipients, including some named grants supported by funds within the GSA Foundation. **Qualifications:** Members may come from any sector (academia, government, industry, etc.) and should have experience in directing research projects and in evaluating research grant applications. GSA strongly encourages nominations of geoscientists from diverse backgrounds and institutions, particularly from minority serving institutions. **Extensive time commitment required 15 Feb.–15 April**; each member reviews approximately 40 applications. More information: www.geosociety.org/gradgrants.

YOUNG SCIENTIST AWARD (DONATH MEDAL) COMMITTEE

One Member-at-Large (3-year term; E, T)

Committee members investigate the achievements of young scientists who should be considered for this award and make recommendations to GSA Council. **Qualifications:** Members should have knowledge of young scientists with "outstanding achievement(s) in contributing to geologic knowledge through original research which marks a major advance in the earth sciences." All the committee's work will be accomplished during the months of February and March. All committee decisions must be made by 1 April.

GSA COUNCIL

Councilor (4-year term; E, M); Treasurer (3-year term; E, M); President-Elect (3-year term; E, M)

The management of the affairs and the property of the Society shall be the responsibility of Council. Council shall have the authority, power, and responsibility for the general management, control, and general supervision of the affairs, business, activities, property, and assets of the Society so that the corporate activities are consistent with the stated purposes of the Society and that no act is committed by the Society in contravention of its Articles of Incorporation or Bylaws. Primary duties are to attend and participate actively in all Council meetings, active membership on an average of two GSA committees per year, and to support the GSA Foundation. Further information about GSA can be found on the Who We Are page at **www.geosociety.org.**

Looking Back with Thanks; Leaping Ahead with Enthusiasm

With the bright outlook of a new year, the GSA Foundation is sincerely thankful for the generosity of our donors. Many GSA programs benefit from your support, and here are a few highlights from the past year.

Thanks to your contributions, the GSA Foundation was able to fund a record 30 J. David Lowell Field Camp Scholarships. Helping students obtain vital field experience remains a passion of GSA Foundation donors. GSA organizational partner Brunton upped their contribution to match this increase in scholarships by providing 30 personalized, engraved Transit compasses to recipients.

The Foundation's 2022 spring campaign focused on GSA's On To the Future program, bringing students from underrepresented groups to their first GSA meeting by covering registration, a year's membership, a travel stipend, and pairing with a one-to-one mentor. A longtime GSAF donor matched contributions up to US$10,000, a challenge this member has offered for several years in a row to bolster this important initiative.

Each year, we work with donors to create a number of new funds that often support research grants or awards. An example of a less-common fund created in the past year is the Christopher I. and Irene N. Chalokwu Travel Grant for Students in Africa. This fund provides support for students in Africa, working on any aspect of African geology, to attend and present their research at GSA Connects. Dr. Chalokwu and his wife, Dr. Irene Chalokwu, are outstanding examples of how individuals can create opportunity across geopolitical borders and realize impacts far beyond a single place or time.

Photo by D. Marcinkowski.

Looking Ahead

Over the past several years, GSAF's annual funding level to the Society has increased thanks to the kinds of generosity described above. Individuals, organizations, and companies recognize the need to help aspiring and established geoscientists pursue their work and make real contributions to the pressing challenges facing the world. The GSA Foundation Board of Trustees and staff are not only committed, but enthusiastic, energized, and poised to develop even greater levels of support for GSA and its programs. We are eager to expand our work with GSA in identifying engaging and effective resource-building strategies; now is the time to explore new partnerships and expand avenues of funding. With your help, we will continue to shape a strong future for GSA and the geoscience community.

To discuss ways that you can provide even greater support for GSA as we navigate new roads into evolving landscapes, we invite you to contact Debbie Marcinkowski at dmarcinkowski@geosociety.org or +1-303-357-1047.

www.gsa-foundation.org

2023 GSA Science Editors

GSA depends on the volunteer efforts of many science editors, associate editors, and editorial board members to ensure the timeliness and quality of our publications.

Thank you to our continuing editors:

GSA books, **Joan Florsheim,** University of California Santa Barbara (appointed to a second term)

GSA books, **Christian Koeberl,** University of Vienna

GSA books, **Nancy Riggs,** Northern Arizona University

GSA Bulletin, **Mihai N. Ducea,** University of Arizona

GSA Bulletin, **Brad S. Singer,** University of Wisconsin Madison

GSA Bulletin, **Wenjiao Xiao,** Chinese Academy of Sciences (appointed to a second term)

Geology, **Kathleen C. Benison,** West Virginia University

Geology, **William C. Clyde,** University of New Hampshire

Geology, **Marc D. Norman,** Australian National University

Geology, **Urs Schaltegger,** University of Geneva

Geology, **Rob Strachan,** University of Portsmouth

Geosphere, **David E. Fastovsky,** University of Rhode Island

Geosphere, **Andrea Hampel,** Leibniz University Hannover (appointed to a second term)

Geosphere, **Christopher J. Spencer,** Queen's University

GSA Today, **Peter Copeland,** University of Houston (appointed to a second term)

GSA Today, **James Schmitt,** Montana State University

Environmental & Engineering Geoscience, **Eric Peterson,** Illinois State University

GSA thanks **Gerald Dickens** (*Geology*), who has rotated off as editor, for his service to the Society, the journal, and the science.

Want to join our distinguished team of science editors? GSA is accepting applications for positions with terms beginning January 2024. Go to **www.geosociety.org/gsa/pubs/editorsCall.aspx** for details. Application deadline: 1 March 2023.

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

POSITIONS OPEN

Associate or Full Professor, Department of Earth and Atmospheric Sciences (Sedimentology), University of Nebraska-Lincoln

The Department of Earth and Atmospheric Sciences at the University of Nebraska-Lincoln invites applications for the endowed Mr. and Mrs. J.B. Coffman Chair in Sedimentary Geology. We seek an outstanding geoscientist with a record of impactful scholarly achievements within the broad field of sedimentary geology. We expect to make the appointment at the associate or full professor level with tenure, but extremely promising applicants at the advanced assistant professor level without tenure will also be considered.

The Department of Earth and Atmospheric Sciences (https://eas.unl.edu) offers B.S. degrees in Geology as well as Meteorology-Climatology and offers M.S. and Ph.D. degrees in Earth and Atmospheric Sciences with an optional specialization in Geology. Additional information about research and teaching in the Department can be found at the website above. The successful candidate will have opportunities to interface with, and potentially contribute to, multiple existing scientific research units at UNL. These include the Daugherty Water for Food Institute, the Nebraska Water Center, the Holland Computing Center, the Conservation and Survey Division (our Geological Survey), the University of Nebraska State Museum (our Natural History Museum), the School of Biological Sciences, and the School of Natural Resources.

The successful candidate will be expected to teach courses in the undergraduate and graduate geological sciences curricula, develop courses in their specific area of expertise, advise and direct graduate students, and carry out a nationally and internationally visible and externally supported research program.

Minimum Qualifications:

1. Ph.D. in Geology or a closely related field.
2. Demonstrated experience in research and associated activities with a primary focus on Sedimentary Geology, including a record of peer-reviewed research publications commensurate with the rank sought.
3. Research interests that complement and enhance existing departmental strengths and that catalyze new interdisciplinary directions.
4. Teaching experience at the undergraduate and graduate levels.
5. Commitment to building inclusive excellence in the department and institution.
6. A documented ability to obtain and manage external research funding.

Preferred Qualifications:

1. Demonstrated excellence in geoscience education and teaching.
2. Ability to develop research and educational activities with a field-based component.
3. Interest in using and expanding sedimentological and associated research facilities in the Department and University.
4. Interest and potential in developing new research collaborations that strengthen regional, national, and international linkages for the department.

The starting date for this position is August 14, 2023. Questions concerning the position or the Department can be addressed to the Department Chair, Clint Rowe by telephone (402-472-2663) or email (crowe1@unl.edu).

Review of applications will begin January 9, 2023; however, the search will continue until the position is filled. To apply, go to https://employment.unl.edu/postings/81791 and complete the Faculty/Administrative form. Applicants must attach 1) a cover letter; 2) a curriculum vitae; 3) a statement of teaching philosophy; 4) a statement of research achievements and goals, which includes a description of the applicant's future research foci and external funding potential for these foci; 5) a statement describing the applicant's experience and vision for enhancing diversity, inclusion, and equity in the department, institution, and profession; and 6) the names of at least three references. Combine the statements (items 3, 4, and 5) into a single document for upload

The University of Nebraska-Lincoln (UNL) seeks to achieve a working and learning environment that is open to all people. Diversity is the hallmark of great institutions of learning and has long been one of the strengths of our society. Dignity and respect for all in the UNL community are the responsibility of each individual member of the community. The realization of that responsibility across the campus is critical to UNL's success. The UNL Department of Earth and Atmospheric Sciences is committed to increasing the diversity of its faculty and students. We assure reasonable accommodation under the Americans with Disabilities Act; contact Cara Burberry at 402-472-2663 for additional information.

As an EO/AA employer, the University of Nebraska considers qualified applicants for employment without regard to race, color, ethnicity, national origin, sex, pregnancy, sexual orientation, gender identity, religion, disability, age, genetic information, veteran status, marital status, and/or political affiliation. See https://www.unl.edu/equity/notice-nondiscrimination.

Assistant Professors, Water-Earth Surface Processes Cluster Hire, University of Nevada, Las Vegas

The University of Nevada, Las Vegas (UNLV) invites applications for up to three tenure track positions in a Water-Earth surface processes themed Cluster Hire at the Assistant Professor level as part of an interdisciplinary cluster in the broad field of Sustainability in Arid Lands. Two of the positions will be in the fields of Water-Earth surface processes (Position Numbers P0023073, P0103372, and the third will include a charge to spearhead the development of an online MS program in Water Resources Management (Position Number P0027657). Full details are provided in the job announcement (link: https://nshe.wd1.myworkdayjobs.com/UNLV-External/job/UNLV1-Main-Campus-Las-Vegas/Assistant-Professor-in-Sustainability-of-Arid-Lands--Geoscience-Department--College-of-Science--R0133607-_R0133732).

Review of applications will begin on January 17th, 2023. Application materials must be submitted through the UNLV enterprise management software portal (link https://nshe.wd1.myworkdayjobs.com/UNLV-External/job/UNLV1-Main-Campus-Las-Vegas/Assistant-Professor-in-Sustainability-of-Arid-Lands--Geoscience-Department--College-of-Science--R0133607-_R0133732) we do not accept emailed materials. Questions about the application process can be directed to Dr. David K. Kreamer, Search Committee Chair.

Assistant Professor, Isotope Geochemistry, University of Nevada, Las Vegas

The Department of Geosciences at the University of Nevada, Las Vegas (UNLV) invites applications for a tenure track position in Isotope Geochemistry at the Assistant Professor level. We seek outstanding scholars who will establish an innovative research program focused on solution chemistry mass spectrometry. The position contains a start-up package that includes a Nu Sapphire inductively coupled plasma mass spectrometer with collision cell and facilities for clean solution chemistry. The successful candidate should show experience in operating comparable analytical equipment.

Application materials must include a 1) cover letter, 2) curriculum vitae, 3) proposed research plan (three-page limit), 4) statement of teaching philosophy and interests (two-page limit), 5) a statement of past or potential contributions to diversity, equity, and inclusion (one-page limit), 6) 1-4 representative publications, and 7) contact information for at least four referees.

Review of applications will begin on January 17th, 2023. Materials should be addressed to Dr. Kevin Konrad, Search Committee Chair, and must be submitted through Workday, as we do not accept emailed materials.

Chair and (Full or Associate) Professor of Geology and Geological Engineering, University of Mississippi

The School of Engineering at the University of Mississippi is seeking an experienced researcher, administrator, and faculty member for the position of Chair of Geology and Geological Engineering and tenured/tenure-track faculty in the Department of Geology and Geological Engineering. The faculty appointment will be at a rank commensurate with qualifications and experience. Position details and instructions to apply can be found here: [https://careers.olemiss.edu/job/University-Chair-and-FullAssociate-Professor-of-Geology-and-Geological-Engineering-MS-38677/956331200/]. Screening of applications begins February 1, 2023, and continues until the position is filled. The University of Mississippi embraces a meaningful and holistic commitment to advancing diversity, equity, and inclusion. The University of Mississippi is committed to embracing a collaborative, innovative, and inclusive community that affirms all employees.

Director of The Mississippi Mineral Resources Institute, and (Associate or Full) Professor of Geology and Geological Engineering or Civil Engineering, University of Mississippi

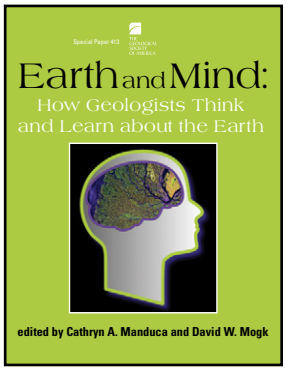
The School of Engineering at the University of Mississippi is seeking an experienced researcher, administrator, and faculty member for the position of Director of the Mississippi Mineral Resources Institute and tenured/tenure-track faculty in the Department of Geology and Geological Engineering or Civil Engineering. The faculty appointment will be at a rank commensurate with qualifications and experience. Position details and instructions to apply can be found here: [https://careers.olemiss.edu/job/University-Director-of-MMRI-and-FullAssoc-Professor-of-Geology-&-Geological-Engineering-or-Civil-Engineering-MS-38677/937107900/]. Screening of applications begins February 1, 2023, and continues until the position is filled. The University of Mississippi embraces a meaningful and holistic commitment to advancing diversity, equity, and inclusion. The University of Mississippi is committed to embracing a collaborative, innovative, and inclusive community that affirms all employees.

OPPORTUNITY FOR STUDENTS

Wilkes University Summer Geology Field Camp 2023. Wilkes University is offering a five-week, intensive, project-focused, international field camp located on the island of Newfoundland, Canada open to upper-level geoscience students from any college or university. Newfoundland offers a unique cross-section of major crustal segments that comprise the Appalachian mountain belt. Field camp curriculum is designed to meet the requirements of most undergraduate Geology B.S. programs and many state professional licensure programs. For more information, or to apply, visit https://www.wilkes.edu/fieldcamp.

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.



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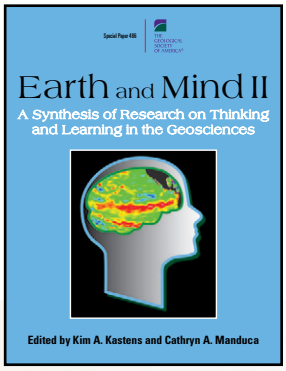

Earth and Mind II: A Synthesis of Research on Thinking and Learning in the Geosciences explores the ways in which geoscientists use the human senses and mind to perceive, analyze, and explain the workings of the earth system and how to help students master the thought processes of the geosciences. (SPE486P, 210 p., ISBN 9780813724867, US$9.99)

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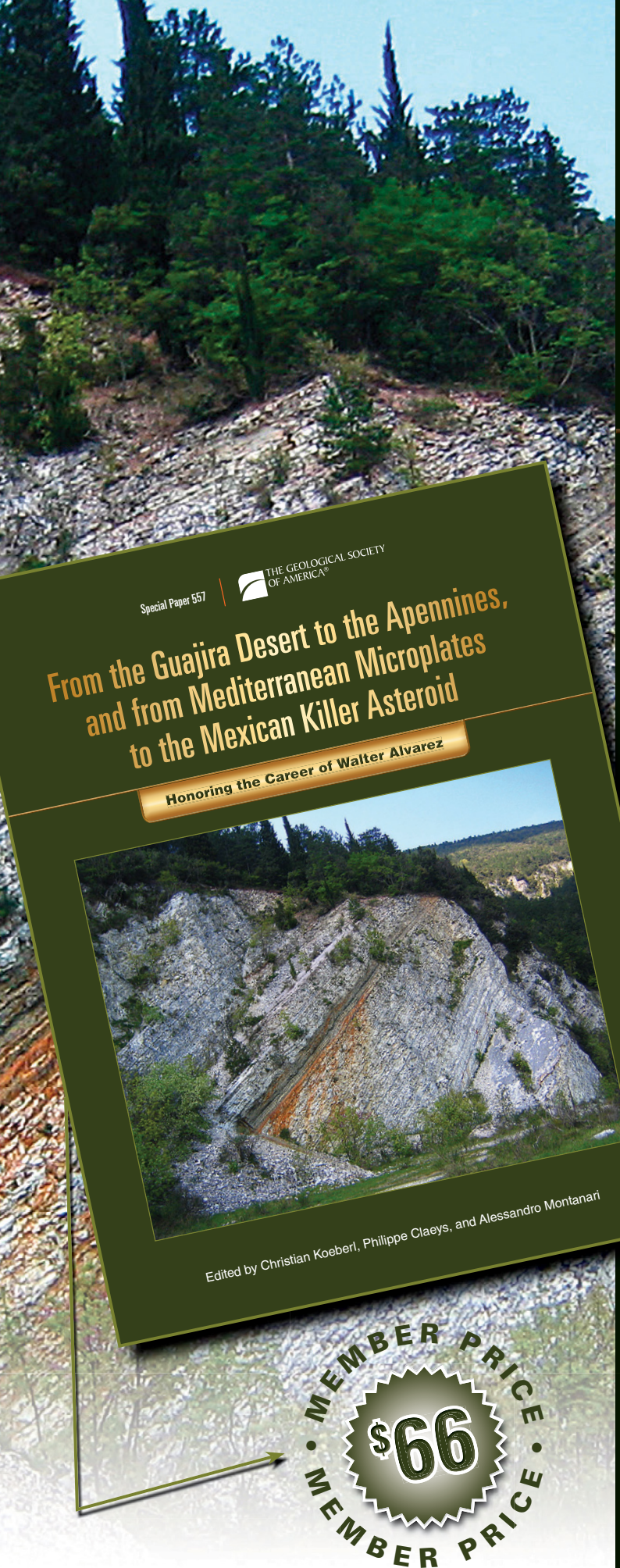

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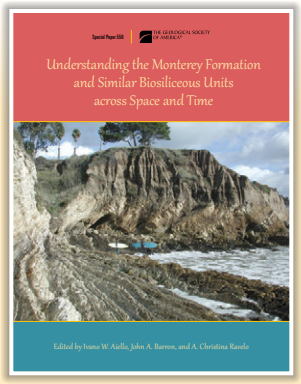

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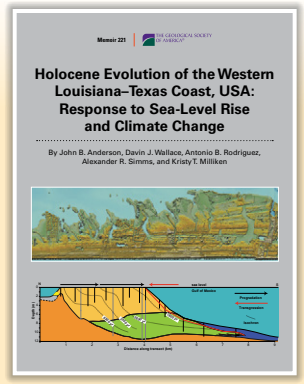

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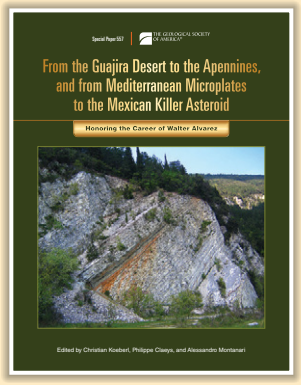

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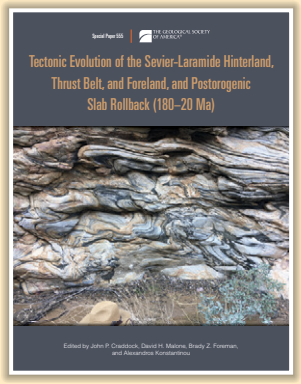

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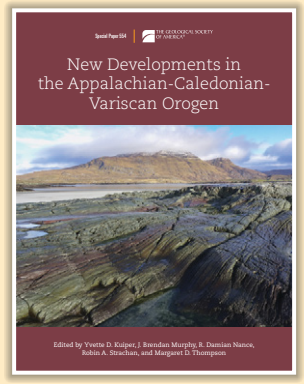

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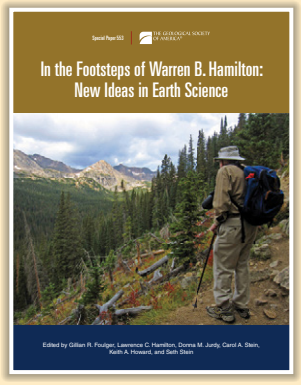

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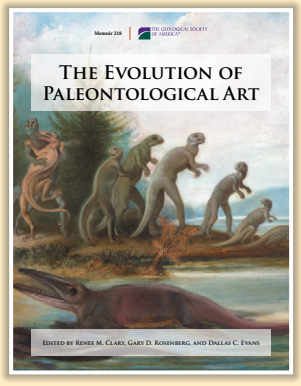

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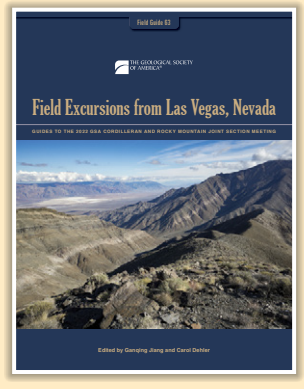

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