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# GSA TODAY

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# GSA TODAY

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Photo credit: Abstract Aerial Art / DigitalVision via Getty Images.

Stromatolites dot the shoreline of the Indian Ocean at Shark Bay, Western Australia. See related article on pages 26–29.

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GROUNDWORK

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# Volunteer-Led, Short-Term, Geophysical Field Experiment: Lessons for Inviting Broader Participation, Building Public Trust, and Communicating Science

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## INTRODUCTION

The geosciences have made no progress in the ethnic and racial diversity of U.S. Ph.D. graduates for decades (Bernard and Cooperdock, 2018). In the past two decades, only a few institutions have driven the increase in the racial and ethnic diversity of U.S. geoscience undergraduate degree recipients, with 40% of geoscience programs failing to graduate more than one student from a marginalized group per year (Beane et al., 2021). In contrast, the benefits of diverse groups in science, including unique approaches to problem solving and the framing of research questions, are well known (Guterl, 2014; Phillips, 2014). Diversity, equity, and inclusion are therefore critical in evolving research frontiers, such as the renewable energy transition (Pearl-Martinez and Stephens, 2016) and climate change mitigation (Burke et al., 2021). Studies have also shown the value of using local and Indigenous knowledge along with scientific knowledge in disaster risk reduction (Mercer et al., 2010). Homogeneous groups simply tend not to ask the same questions as diverse groups (Tilghman et al., 2021).

Despite the acknowledged potential benefits, real-world examples where diverse groups have played a critical role in spearheading innovation in geoscientific research are few. This situation raises the question of whether the geosciences can successfully recruit and retain diverse scholars into a discipline if they do not see themselves represented in leadership roles or do not have a sense of belonging. To improve, the geoscience workforce needs to take a more inclusive trajectory with the involvement of underrepresented groups in leadership roles. Following Todd et al. (2023), we define diverse groups as "those historically underrepresented, as a construct of ableism, gender, sexuality, cultural, and racial identities."

We demonstrate the importance of broad inclusivity through an unusual geophysical field experiment that was conducted in Louisiana, on the U.S. Gulf Coast, in 2022. The Southern Louisiana Micro-Seismicity (SOLAMS) Experiment (SOLAMS, 2022) involved hundreds of person-hours of fieldwork to site, install, and recover geophysical instruments. Typically, this work would be completed by members of an existing single research group or collaboration. Instead, we chose to offer these field experiences and research opportunities to nonspecialist STEM students, which attracted a more diverse research group of self-selected participants. The project's impacts were magnified by being a short-term offering that also involved public communication as an integral part of the experiment. Such a project is one step toward enhancing inclusivity and building public trust.

## IMPORTANCE OF THE U.S. GULF COAST

The Gulf Coast plays a critical role in the energy security of the U.S. Louisiana alone hosts close to 50,000 miles of pipelines that transfer oil and gas resources to the coast and international markets and northward for distribution across North America. The state also hosts two of the four sites of the U.S. Strategic Petroleum Reserve, the world's largest supply of emergency crude oil. The devastating impacts of

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natural and anthropogenic disasters and long-term and seasonal subsidence (Kent and Dokka, 2013; Luttrell et al., 2023) on Gulf Coast communities are also well documented. The damages are compounded by environmental concerns in the energy-intensive corridors, where communities continually adapt to natural or human-induced changes and extreme weather events (Anenberg and Kalman, 2019).

Historically, policies implemented in the Gulf Coast region do not include scientific objectives that engage citizens in formulating research questions, understanding their impacts, or contributing to research (Colten, 2017). Whether this discrepancy has stalled scientific progress in geographic areas that are not typically addressed by majority groups remains an open and important question. Engaging the local communities respectfully and effectively was a strong priority when planning this field experiment, and this engagement was both aligned with and supported by our goal of including a broad group of field participants.

## GEOPHYSICAL FIELD EXPERIMENT

To underscore the ability to engage a diverse group in solving geoscience problems, a geophysical field campaign was developed in southern Louisiana specifically to address many of the long-standing inequality challenges in conjunction with imaging the subsurface (SOLAMS Experiment, 2022; Schneida et al., 2023), with the goal of investigating the relationship between faults, large-scale subsidence, and groundwater flow. To engage a diverse STEM workforce, the campaign called for volunteers from five universities in Louisiana, Texas, and Mississippi and included a Historically Black College and University, specifically noting that no prior knowledge of geophysical fieldwork was required. All individuals who could attend on the dates of the experiment were involved. The self-selected group of 26 individuals was diverse in terms of race, ethnicity, gender, background, and expertise (Fig. 1). It included 12 females and 19 undergraduate and graduate students from six STEM fields, and more than half of the group were members of historically underrepresented ethnic or racial groups. The broad demographics of this group greatly strengthened the team's opportunities to connect meaningfully with residents.

To provide a baseline for operation, volunteers received training the day before the installation where technical and scientific aspects of the project were discussed. Each team of two was then solely responsible for interacting with the public, selecting locations where the small seismic instruments (called "nodes") would be installed, and, in some cases, convincing residents to allow them to install the node on their property for one month. Most volunteers had no prior experience with this type of field experiment and had not worked with each other before. The benefits of involving this broad group of researchers greatly outweighed any potential decrease in efficiency associated with expanding beyond the existing research group.

A record 378 nodes were installed in one weekend, about twice the number achieved over one weekend in similar campaigns (Clayton et al., 2019; Persaud et al., 2021); the final array consisted of 432 nodes located in private and public places. The encounters between the group and local people, which included discussions of the project and its connections to the community and the environment, were both highly engaging and technically successful for the project. The university research community conducting this experiment reflected society's diversity, and having them on residents' doorsteps could have long-lasting positive impacts on the community and on their perceptions of science. Additionally, involving this diverse group of STEM researchers in a geoscience project with strong local relevance and impact served as an important invitation for each to consider future participation in such work. These types of communication should become everyday events if people's images and expectations of the geosciences are to change.

Figure 1. Photos from the Southern Louisiana Micro-Seismicity (SOLAMS) Experiment.

## BROADER IMPACTS AND OUTCOMES

Motivated by the societal impacts of this research, volunteers found it straightforward to be convincing about the importance of the study. One selling point used by all groups was the fact that they were from universities in the Gulf Coast region and that residents would be contributing to the science that was being done. Each group found its own way of contextualizing and delivering a convincing message, which was critical to the success of the field experiment. As a result, many homeowners wanted to see and learn more about the research the group would do. Such societal outreach promotes engagement, interest, and successful education of the broader public.

Directly involving local communities shapes not just the science we do now but also what we understand as most urgent. It educates us about what is most impactful. Scientific research that is intentionally inclusive and is supported by local knowledge builds trust in science (Sidik, 2022), and it can also foster and strengthen public participation in policymaking. Participation of underserved and underrepresented groups in prioritizing the most pressing science questions is a new frontier in the geosciences, and changing perceptions of who does geoscience could be key to redefining and expanding our future workforce.

## ACKNOWLEDGMENTS

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# Lester Park: Global "Type Locality" for Stromatolite Fossils

Ed Landing*,[1] and Alexander J. Bartholomew[2]

**Lester Park and Stark's Knob in eastern New York State are the oldest outdoor scientific parks in North America. These Saratoga County sites were donated by local citizens to the New York State Regents via the New York State Museum during World War I to preserve them from development and for their use in education as "Scientific Reservations" (Flick, 1929). Much later (2019), they were designated New York State Geoparks by the state legislature. Lester Park and Stark's Knob illustrate distinct intervals in the geologic evolution of eastern North America (e.g., Landing, 2022).**


Figure 1. "*Cryptozoon* ledge" at Lester Park. Letters A and B mark 10 cm step made by glacial plucking of upper part of stromatolite domes; W–E shows roughly west–east alignment of stromatolite bases and erosion enhanced joints. Photo credit: Ed Landing.

Lester Park (Fig. 1) features shallow marine rocks of the Laurentian ("ancestral North American"), early Paleozoic, passive tropical margin (then ~35° south latitude). Stark's Knob provided the first record of volcanism on a subducting slab as NE Laurentia approached the trench in the Late Ordovician Taconian orogeny (locally ca. 460 Ma), with the Laurentian margin fracturing to release submarine pillow basalts (Landing et al., 2003; Schoonmaker et al., 2016; Landing and Bartholomew, 2024).

Not maintained for decades, both sites were restored (by EL) with removal of overgrowth and trees with the help of scout groups and volunteers, and interpretive signs were installed (Landing, 2004). Both Geoparks can be visited year-round. They must be seen as irreplaceable—do not damage or collect anything.

## LOCATION

Lester Park was deeded to the State Regents in 1915 in honor of the local lawyer Willard Lester. The park features a gently (5°) west-dipping carbonate rock succession (11.35 m thick) exposed on both sides of Lester Park Road. The broad (~500 m²) bedding surface on the east side of Lester Park Road (43° 05′ 32.14″ N, 73° 50′ 53.42″ W) is low in the Hoyt Member of the Little Falls Formation and has hundreds of light gray weathering stromatolite domes (Fig. 1). This is the traditional *Cryptozoon* ledge (Cushing and Ruedemann, 1914). It is 2.75 m above dolomitic sandstones of the Galway Formation and ~100 m above the nonconformity of Potsdam Formation sandstone with Mesoproterozoic, Grenville high-grade metamorphic rocks of the Adirondack massif (Landing, 1979, 2007).

This stromatolite-rich surface (Fig. 1) extends at least 1.0 km south to Petrified Sea Gardens, a long-closed tourist attraction now owned by Pompa Bros., Inc., a stone company. Slightly higher strata are exposed on the gentle curve just south on Lester Park Road, with the section continuing into the old Hoyt quarry in the woods ~75 m west of Lester Park Road. This limestone quarry was developed in the late 1800s by the Hoyt family for rock that was burned in

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the now tumble-down kiln on the west side of Lester Park Road. The lime was used to improve the local sandy soils for agriculture. (In Landing et al. [2021], Upper/Late Cambrian is a precisely defined, proposed subsystem/subperiod that replace the undefined, subsystem-level terms "upper"/"late" Cambrian of many authors.)

## GEOLOGIC SIGNIFICANCE

Lester Park offers a window into the primary depositional features of the lower Paleozoic of eastern New York and adjacent western New England and southern Quebec and Ontario. Throughout much of this region, carbonates of the middle Upper Cambrian–lower Middle Ordovician Beekmantown Group have commonly undergone hydrothermal dolomitization that obliterated primary textures and fossils. Field studies show that this dominant facies of massive, relatively featureless dolostones is laterally transitional into weakly to nondolomitized limestones. The Lester Park area escaped this strong diagenetic overprint apparently associated with the Late Ordovician Taconic orogeny (e.g., Landing, 2007, and references therein).

But for fractures and tiny faults filled with white calcite and brownish dolostone spar, the Lester Park sequence resembles coeval North American Midcontinent successions. However, the Lower Paleozoic of eastern New York has been exposed with the removal of ~7.5 km of younger rock. This burial depth included ~1.0 km of strata through the upper Middle Devonian in the Catskill Mountains to the south. A further ~6.5 km of burial are shown by the anthracitic plant remains and clay mineralogy of the Catskill highlands (Friedman and Sanders, 1982). This ~7.5 km of burial meant burial temperatures of at least 200 °C. Even higher burial temperatures are likely, as O'Reilly and Parnell (1999) suggested greater heat sources with maximum burial in the late Paleozoic Alleghenian orogeny (Heizler and Harrison, 1998). The fine internal lamination of the domes on the Lester Park surface (e.g., Hall, 1884; Lee and Riding, 2021a, b; Neuweiler et al., 2023) and delicate preservation of the Hoyt Member and underlying Galway Formation trilobites (Ludvigsen and Westrop, 1983) survived late burial metamorphism.

LESTER PARK OFFERS A WINDOW INTO THE PRIMARY DEPOSITIONAL FEATURES OF THE LOWER PALEOZOIC OF EASTERN NEW YORK AND ADJACENT WESTERN NEW ENGLAND AND SOUTHERN QUEBEC AND ONTARIO.

## THE "CLASSIC" STROMATOLITE

Steele (1825) first reported the isolated and coalesced domal structures of what is now called the Hoyt Member as nonbiologic concretions, and he recognized alternating dark blue to black "compact" and white "granular" laminae. James Hall, the workaholic head of the New York Geologic Survey and dominant nineteenth-century North American paleontologist, initially accepted this interpretation but changed his interpretation to "organic" and then "sea plants" in the 1840s. Hall (1884) finally came to believe the domes were colonial animals similar to the fossil hydrozoan *Stromatopora*. Thus, he named them *Cryptozoön proliferum*, or "proliferating hidden animal," with the lateral coalescence of the *Cryptozoon* domes (Fig. 2) suggesting the closely juxtaposed underground bulbs of the onion *Allium proliferum*. The caption of Hall's (1884, pl. 6) *C. proliferum* illustration refers to the Hoyt farm, which means that Lester Park, and not the Petrified Sea Gardens, was the source of his material.

Subsequently, finely laminated, biologically produced structures such as those at Lester Park were understood to be produced by sediment trapping, binding, and/or cementation by microbes (Walcott, 1914; Wieland, 1914), primarily cyanobacteria (commonly and incorrectly called "blue-green algae"). They are the oldest (ca. 3.4 Ga) body fossils on Earth and persist in modern aqueous environments (see thorough review in Grey and Awramik, 2020). These laminated biologic build-ups were termed "stromatoliths" by Kalkowsky (1908), which was anglicized to "stromatolite." This made *Cryptozoon proliferum* the first of many stromatolites given a Linnean (binomial) name. The Lester Park bedding surface is the "type locality" for this classic form.

## DEPOSITIONAL SETTING (NO GLACIAL EROSION) OF BUILD-UPS

The internal growth laminae of *C. proliferum* are exposed on the large bedding surface at Lester Park because the stromatolite domes have been truncated

Figure 2. Truncated *Cryptozoon* domes show internal growth laminae, with overlying coarse, brown weathering sandstone with stromatolite clasts (gray) and depressions of weathered clasts within yellow oval. Hammer 30 cm long. Photo credit: Ed Landing.

(Fig. 2). This truncation has been repeatedly and incorrectly explained by some sort of beveling by Pleistocene glacial activity (Goldring, 1938; Stauffer, 1945; Friedman, 2000, 2012; Lee, 2019; Lee and Riding, 2021a). However, continental ice sheets do not significantly grind down rocks, unlike mountain glaciers, and their primary method of erosion is that of plucking. A 10-cm step between the north and south parts of the Lester Park surface reflects this plucking (Fig. 1) and has detached the broader tops of the domes from their narrower bases on the southern end of the surface.

The actual truncation of the Lester Park *Cryptozoon* domes took place with shoaling and progradation of a thin (to 10 cm) coarse-grained quartz sandstone that was moved by waves and currents to abrade the *Cryptozoon* domes (Landing, 1979). This brownish sandstone is best seen at the north end of the Lester Park surface, where it has stromatolite fragments in it (Fig. 2). Burne and Moore (1993) compared the flat-topped *C. proliferum* domes at Lester Park with "micro-atoll" build-ups of thrombolites (noted below) in Western Australia. This interpretation is not valid, as their micro-atolls are not abraded and do not show internal laminae on their upper surfaces, which have grown up to the high tide level. The flat-topped Lester Park specimen they compared with their modern "micro-atolls" shows truncation of growth laminae on its top and sides and is embedded in a coarse sandstone with *Cryptozoon* fragments.

THE PRESERVATION OF STARK'S KNOB AND LESTER PARK AS SCIENTIFIC RESERVATIONS HAS NOT ONLY ASSURED THEIR USE IN EDUCATION AND SCIENTIFIC FIELD TRIPS BUT ALSO ALLOWED OPPORTUNITIES FOR NEW RESEARCH.

The Lester Park stromatolite surface is the top of a shoaling-up cycles. As noted above, the broad Lester Park surface was truncated by wave and current activity that moved sand across the domes. The abruptly overlying dark dolomitic mudstone with linguloid brachiopods at the base of the road cut further south at the curve on Lester Park Road reflects deepening. These mudstones shoal up into current cross-bedded dolomitic limestones with low (to 10 cm high) undulatory stromatolites (i.e., form species *Cryptozoon undulatum*; see Goldring, 1938) near the top of a second shoaling-up cycle.

Figure 3. Ellipses outline thrombolites in middle of Hoyt quarry section. Hammer is 30 cm long. Photo credit: Ed Landing.

## THROMBOLITES AT LESTER PARK

A second type of microbial build-up at Lester Park is very large (to 1.5 m high) domes in the middle of the Hoyt quarry (Fig. 3). These build-ups were reported as *Cryptozoon ruedemanni* by Rothpletz (1916) and Goldring (1938) but do not have the fine growth laminae of *Cryptozoon*. Rather, they show the weakly to nonlaminated clotted fabric that distinguishes the microbial build-ups termed a "thrombolite" by Aitken (1967; "clotted" rock). The terminology assigned to microbialite build-ups is frequently vague and even contradictory (Grey and Awramik, 2020), but "thrombolite" must include build-ups that show Aitken's cm-scale cavities to mm-sized voids (Riding, 2011). Thus, the term "stromatolite" is not appropriate for many modern microbial build-ups, including most of the build-ups in hypersaline facies in Shark Bay, Western Australia; the domal build-ups in fresh water at Green Lakes State Park near Syracuse, New York; and large build-ups in tidal channels in the Bahamas and in coastal Saudi Arabia (Vahrenkamp et al., 2024). All of these build-ups have well-developed internal cavities and should be termed "thrombolites" as Burne and Moore (1993) recognized.

The thrombolites in the Hoyt quarry are surrounded by fossiliferous limestone granule, and ooid-rich limestone that is well burrowed and the primary bedding is disrupted. This limestone is banked against the margins of the thrombolite build-ups, which indicates the tops of the thrombolites formed low domes on the Late Cambrian sea floor.

The rock surrounding the "*Cryptozoon* ledge" stromatolites and the thrombolites in the Hoyt quarry has an abundant fauna with current and wave-fragmented trilobites, echinoderm sclerites, and calcareous and rarer phosphatic brachiopods. The occurrence of stromatolites in normal marine facies at Lester Park illustrates the interpretation that diverse and abundant metazoan grazers, which would have destroyed microbial mats and limited stromatolites to hypersaline or freshwater habitats, had not appeared by the Late Cambrian.

## MODERN RESEARCH

The preservation of Stark's Knob and Lester Park as Scientific Reservations has not only assured their use in education and scientific field trips but also allowed opportunities for new research. Collecting is prohibited at Lester Park, but the New York State Museum (NYSM) allows material in museum collections, such as its trilobites (Ludvigsen and Westrop, 1983), to be put into geological context.

The alternating black-and-white lamination described by Steele (1825, noted above) has fueled a controversy as to whether the "type" stromatolite *C. proliferum* is not merely a microbial consortium. An alternative explanation is that *C. proliferum* includes a non-spiculate (keratose) sponge that formed the black laminae with a distinctive microfabric of curved, vesicular areas of calcite spar in micritic limestone (Lee, 2019; Lee and Riding, 2021a, b). This would mean that the origin of *Cryptozoon* is tied to the origin of early metazoans in the Cambrian Evolutionary Radiation. Alternatively, a similarly vesicular microfabric extends into far older Proterozoic stromatolites before the origin of metazoans (e.g., Grey and Awramik, 2020). Thus, the vesicular and micritic texture is also viewed as diagenetic in origin (Neuweiler et al., 2023) or reflects an origin that cannot be assigned with certainty to biotic or diagenetic controls (Kershaw et al., 2021).

Further work on legacy slabbed pieces and thin sections made by Goldring (1938) of *C. proliferum* in the NYSM by F. Neuweiler (Université Laval) and colleagues has involved optical petrology, cathodoluminescence, fluid inclusion analysis, and U-Pb dating of primary carbonate fabrics and several generations of carbonate (calcite and dolomite) cements. The results (unpublished data) illuminate the burial history and tectonics of Lester Park and eastern New York. As might be predicted (Landing, 2007), hydrothermal dolomite provides U-Pb ages which range through much of the Late Ordovician and reflect the local age of the Taconian orogeny. Surprisingly, vein calcite has early Silurian ages which may be related to late Taconian or the early part of "Salinic" events. Finally, Late Devonian and early Carboniferous (Tournaisian) ages on microcrystalline calcite overlap the end of the Acadian orogeny. At present, no petrographic evidence is known that corresponds to the greatest burial depth of the Appalachian region during the Alleghenian orogeny and Permian.

Watch a fascinating video about this geoheritage site. **https://bit.ly/3Mhxt6H**

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# Connecting with Congress as an Interdisciplinary Geologist

*Robby Goldman, 2023–2024 GSA-USGS Congressional Science Fellow*

*Disclaimer: The views and opinions presented in this article are solely my own.*

Being a successful Earth scientist involves the ability to make connections across disciplines. As geoscientists grapple with more frequent extreme weather events and risks to global water supply, cross-disciplinary collaborations are vital for developing creative new solutions that mitigate the worst impacts of climate change. Moreover, innovative scientific discoveries require the participation of diverse teams of researchers, which in turn necessitates investments supporting individuals historically underrepresented in STEM.

I am an interdisciplinary geoscientist with expertise in volcano geodynamics and the social science of hazard communication. I am also the 2023–2024 GSA-USGS Congressional Science Fellow, working in the office of U.S. Senator Mazie K. Hirono (D-HI) on federal policies related to wildfire hazard mitigation and increasing participation in STEM research, education, and industry. The GSA-USGS Congressional Science Fellowship (CSF) is one of over 30 CSFs provided by the American Association for the Advancement of Science (AAAS) and its partner societies. The overarching goal of the CSF is two-fold: to provide scientists an opportunity to work on Capitol Hill and learn how federal policy is enacted, and for those same scientists to lend their expertise and skill sets toward shaping federal policy.

INNOVATIVE SCIENTIFIC DISCOVERIES REQUIRE THE PARTICIPATION OF DIVERSE TEAMS OF RESEARCHERS, WHICH IN TURN NECESSITATES INVESTMENTS SUPPORTING INDIVIDUALS HISTORICALLY UNDERREPRESENTED IN STEM.

The CSF also provides fellows with plenty of flexibility to shape their congressional experiences, including the process of interviewing with congressional offices and, if offers are provided by multiple offices, choosing which member of Congress or congressional committee to work for. This flexibility grants fellows the freedom to pursue their professional and personal goals during their fellowship year. My decision to work for Sen. Hirono was motivated by my desire to learn firsthand about the processes involved in shaping federal policies that address the needs of Hawai‘i's communities. This desire was shaped by a combination of my Native Hawaiian heritage, the fact that my mother's extended family lives in the State of Hawai‘i , and my Ph.D. research demonstrating the important role that USGS scientists played in providing credible and trustworthy hazard information to communities on the Big Island of Hawai‘i during the 2018 eruption of Kilauea volcano.

This past fellowship year, I applied my doctoral-level knowledge of geologic hazard mitigation and my ability to efficiently analyze technical writing toward a Senate hearing examining two reports published by the Wildland Fire Mitigation and Management Commission. In March 2024, several members of the nonpartisan Commission, established under the 2021 Infrastructure Investment and Jobs Act, testified before the Senate Energy and Natural Resources (ENR) Committee, whose membership includes Sen. Hirono. To prepare the senator for this hearing, I reviewed the contents of the Commission's two reports for policy recommendations, identified the most relevant to the State of Hawai‘i , and drafted preparation materials to inform Sen. Hirono's exchange with the Commission's witnesses. On the day of the hearing, I joined Sen. Hirono's senior policy advisor in environment and natural resources—who is also a former AAAS fellow—to provide Sen. Hirono with in-person preparation leading up to her allotted question time. The process of preparing for and staffing Sen. Hirono at this hearing gave me an improved understanding of how members of Congress incorporate scientific

Robby (left) poses for a photo with Senator Mazie K. Hirono (center) and his auntie, Dr. Tana Burkert (right), following a meeting with The Nature Conservancy of Hawai‘i and Palymra (for which Dr. Burkert is a trustee).

expertise—in this case, the reports and hearing testimony provided by the Commission's members—into current and future legislation.

The CSF has also allowed me to understand the process of drafting and introducing legislation on the Senate floor. As part of Women's History Month in March, Sen. Hirono introduced the Women and Underrepresented Minorities in STEM Booster Act of 2024, legislation that would authorize the National Science Foundation to provide grants supporting the participation of demographic groups historically underrepresented in STEM. Thanks to my experience conducting literature reviews for diversity, equity, and inclusion discussions I led with my Ph.D. research group prior to my fellowship, I was able to provide meaningful updates to the STEM Booster Act to include people with one or more disabilities as defined by the U.S. Census Bureau, and/or individuals identifying as Lesbian, Gay, Bisexual, Transgender, or Queer (LGBTQ). I was also responsible for communicating with the staff of other senators supportive of the bill to ensure that those senators were listed as cosponsors, and formally filing the legislation by delivering a printout of the bill's text to the entrance of the Democratic "cloakroom" outside the Senate chamber.

Dr. Goldman prepares to file Senator Hirono's Women and Underrepresented Minorities in STEM Booster Act of 2024 outside the Senate chamber.

Moreover, the CSF has provided me new opportunities to give back to the earth science community, including two groups I previously participated in as part of my doctoral program: GSA's Geology and Public Policy Committee (GPPC) and the American Geophysical Union's (AGU) Voices for Science program.

During the 2024 winter meeting of the GPPC in Washington, D.C., I provided my colleagues with feedback on the language of two recently updated GSA Position Statements—"The Role of the Geoscientist in Assuring the Safety and Integrity of Infrastructure" and "Integrating Geoscience with Sustainable Land-Use Management"—to ensure they were tailored to members of Congress and their staff. These and other position statements are available for GSA members to use to communicate the Society's perspectives on timely geoscience issues to elected officials, and starting in 2019 they have been formatted to serve as "leave behind" documents that GSA members can provide to congressional staff during their meetings.

THE PROCESS OF PREPARING FOR AND STAFFING SEN. HIRONO AT THIS HEARING GAVE ME AN IMPROVED UNDERSTANDING OF HOW MEMBERS OF CONGRESS INCORPORATE SCIENTIFIC EXPERTISE...INTO CURRENT AND FUTURE LEGISLATION.

In April 2024, I volunteered at the orientation workshop for the 2024 cohort of the AGU Voices for Science program, which provides scientists interested in science communication and/or policy with specialized training over a 12-month period. During the workshop, hosted in AGU's Washington, D.C., headquarters, I led "mock" congressional meetings with several teams of Voices for Science participants to help them prepare for their actual congressional visits the next day. Afterward, I joined one other Congressional Science Fellow—also a former Voices for Science participant—on a panel to answer current Voices for Science participants' questions about each of our congressional fellowship experiences, and to share our wisdom on how Voices for Science participants can most effectively engage with policymakers.

I strongly encourage GSA members interested in connecting their expertise to federal policy, and/or pursuing a career in science policy to contact me at rtgoldman47@gmail.com or my GSA Community inbox! You can also visit www.geosociety.org/policy to learn more.

# Build the Bedrock of GSA's 2025 Section Meetings

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Make your mark and elevate regional scientific discovery by submitting an abstract for one of five stellar Section Meetings! To explore the full range of theme sessions proposed for each Section Meeting, simply visit the Section Meeting webpages. From there, you can easily access the submission portal, which includes comprehensive instructions and handy guidelines to help you prepare your abstract submission online.

When you're ready to submit, just sign in using your GSA account username and password. If you don't have an account yet, don't worry—you can create one quickly by following the "Sign In Help & First Time Users" link on the sign-in page.

**ABSTRACTS DEADLINES**

**South-Central, Southeastern, and Joint Northeastern/North-Central Meetings:** 17 December 2024, 11:59 p.m., Pacific Time

**Cordilleran and Rocky Mountain Meetings:** 28 January 2025, 11:59 p.m., Pacific Time

**NON-REFUNDABLE SUBMISSION FEES (IN U.S. DOLLARS)**

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## South-Central Section Meeting

***59th Annual Meeting of the South-Central Section***
**Dates:** 9–11 March 2025*
**Location:** University of Central Arkansas Conference Center, Conway, Arkansas, USA

Join us in Conway, Arkansas, for the 59th Annual Meeting of the South-Central Section, where we will celebrate the region's rich and diverse geological history. Our technical program will delve into topics such as Proterozoic rifting, the Reelfoot Rift, Ouachita Mountains, and critical mineral resources in the southern midcontinent. This meeting offers an opportunity to explore energy sources, sustainability, water management, and geohazards, all within the context of Arkansas's unique geology. We invite geologists of all backgrounds to engage in stimulating discussions and to strengthen our vibrant geologic community.

***Welcome Reception:** 9 March 2025; **Technical Program:** Starts 10 March 2025*

**LOCAL COMMITTEE CONTACTS**

**Co-Chairs:** Scott Ausbrooks (Scott.ausbrooks@arkansas.gov), Angela Chandler (angela.chandler@arkansas.gov)
**Technical Program Chair:** Laura Ruhl (lruhl-whittle@usgs.gov)
**Field Trip Co-Chairs:** Richard Hutto (Richard.hutto@arkansas.gov), Thomas Liner (Thomas.liner@arkansas.gov)
**Sponsorship Coordinator:** Jason Patton (jpatton@atu.edu)
**Exhibits Coordinators:** Jay Hansen (Jay.hansen@aogc.state.ar.us), Camille Gernhart (Camille.gernhart@arkansas.gov)
**Student Volunteer Coordinators:** Dave Mayo (David.mayo@uafs.edu), René Shroat-Lewis (rashroatlew@ualr.edu)
**Workshop Chair:** Kathy Knierem (kknierim@usgs.gov)

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## Southeastern Section Meeting

*74th Annual Meeting of the Southeastern Section*

**Dates:** 19–21 March 2025*
**Location:** Hotel Madison & Shenandoah Valley Conference Center, Harrisonburg, Virginia, USA

We are excited to host the 74th Annual Meeting of the Southeastern Section in Harrisonburg, Virginia, nestled in the picturesque Shenandoah Valley. This meeting will highlight the spectacular geology of the Central Appalachians, with easy access to the Blue Ridge, Piedmont, and Allegheny Plateau. Participants can look forward to a dynamic technical program and opportunities to explore the historic Bluestone area of James Madison University and the cultural attractions of downtown Harrisonburg. We invite everyone to come together in this geologically rich setting for an inspiring exchange of ideas.

****Welcome Reception:** 19 March 2025; **Technical Program:** Starts 20 March 2025*

**www.geosociety.org/se-mtg**

### LOCAL COMMITTEE CONTACTS

**General Co-Chairs:** Stephen Leslie (lesliesa@jmu.edu), Steven Whitmeyer (whitmesj@jmu.edu)
**Technical Program Co-Chairs:** William Lukens (lukenswe@jmu.edu), Dhanuska Wijesinghe (wijesidb@jmu.edu)
**Field Trip Co-Chairs:** Yonathan Admassu (admassyx@jmu.edu), Ángel Garcia (garci4aa@jmu.edu)
**Exhibits Sponsorship & Events Co-Chairs:** Chiara Elmi (elmicx@jmu.edu), Scott Eaton (eatonls@jmu.edu), Matthew Heller (matt.heller@energy.virginia.gov)
**Volunteers Coordinator:** Shelley Whitmeyer (whitm2sj@jmu.edu)
**Short Courses & Workshops:** Eric Pyle (pyleej@jmu.edu)
**Committee Member At-Large:** Steve Beadke (baedkesj@jmu.edu)
**Treasurer:** Katie Luciano (lucianok@dnr.sc.gov)

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## Joint Northeastern and North-Central Section Meeting

*60th Annual Meeting of the Northeastern Section*
*59th Annual Meeting of the North-Central Section*

**Dates:** 27–30 March 2025*
**Location:** Bayfront Convention Center, Erie, Pennsylvania, USA

Experience the combined power of the Northeastern and North-Central Sections at the 2025 Joint Meeting in Erie, Pennsylvania. Set against the stunning backdrop of Presque Isle State Park, this meeting will explore the geological wonders of the Lake Erie region, from glaciations to captivating paleontology. The Bayfront Convention Center, with its waterfront views and proximity to vibrant local eateries, will serve as our hub for technical sessions, field trips, and networking events. Don't miss this chance to engage with fellow geologists in a setting rich with natural beauty and historical significance.

****Welcome Reception:** 27 March 2025; **Technical Program:** Starts 28 March 2025*

### LOCAL COMMITTEE CONTACTS

**Co-Chairs:** Patrick Burkhart (patrick.burkhart@sru.edu), Eung Seok Lee (leee1@ohio.edu)
**Vice Chair:** Keith Milam (milamk@ohio.edu)
**Sponsorship Chair:** Patrick Burkhart (patrick.burkhart@sru.edu)
**Exhibits Chair:** Daniel Harris (harris_d@pennwest.edu)
**Technical Program Co-Chairs:** Wendell Barner (wendell.barner@gmail.com), Peg Yacobucci (mmyacob@bgsu.edu)
**Field Trip Co-Chairs:** Eric Straffin (estraffin@pennwest.edu); Joe Hannibal (jhannibal@uakron.edu)
**Student Presentation Judging Chair:** Katherine Fornash (kffornash@ohio.edu)
**Student Volunteers Chair:** Arindam Mukherjee (amukherjee@ohio.edu)

**www.geosociety.org/ne-mtg**

# Cordilleran Section Meeting

*121st Annual Meeting of the Cordilleran Section*

**Dates:** 1–4 April 2025*
**Location:** Holiday Inn Sacramento, Sacramento, California, USA

The 121st Annual Meeting of the Cordilleran Section will be held in Sacramento, California, located on the land of the Nisenan people, a city rich in history and geologic significance. Sacramento, the state capital and "City of Trees," lies at the confluence of diverse geological features, from the Sierra Nevada to the Coast Range. This meeting will provide a forum for discussions on managing geologic and hydrological resources, with a focus on the region's unique geology and its implications for society. We welcome geoscientists from all sectors, especially students from community college through graduate school, to join us for a meaningful exchange of knowledge in this historically significant city.

***Welcome Reception:** 1 April 2025*
***Technical Program:** Starts 2 April 2025*

### LOCAL COMMITTEE CONTACTS

**Meeting General Chair:** David Shimabukuro (dhs@csus.edu)
**Technical Program Co-Chairs:** Steve Skinner (steven.skinner@csus.edu), Sarah Roeske (smroeske@ucdavis.edu)
**Field Trip Co-Chairs:** Kurt Burmeister (k.burmeister@csus.edu), John Wakabayashi (jwakabayashi@csufresno.edu)
**Student Volunteer and Education Chair:** Theron Sowers (theron.sowers@csus.edu)
**Exhibits/Sponsorship Chair:** Julie Griffin (griffin@csus.edu)

**www.geosociety.org/cd-mtg**

# Rocky Mountain Section Meeting

*75th Annual Meeting of the Rocky Mountain Section*

**Dates:** 18–20 May 2025*
**Location:** Utah Valley Convention Center, Provo, Utah, USA

Join us for the 75th Annual Meeting of the Rocky Mountain Section in Provo, Utah, a city surrounded by some of the most geologically diverse landscapes in the United States. The Utah Valley Convention Center will host our sessions, just minutes from the Wasatch Fault and within easy reach of a variety of geologic features, from Precambrian rocks to Pleistocene shorelines. Provo's vibrant downtown and its proximity to the Salt Lake International Airport make it an ideal location for geoscientists to come together for this landmark meeting. We look forward to your participation in this dynamic and engaging event.

***Welcome Reception:** 18 May 2025; **Technical Program:** Starts 19 May 2025*

### LOCAL COMMITTEE CONTACTS

**Meeting Chair:** Daniel Horns (hornsda@uvu.edu)
**Technical Program Co-Chairs:** Nathan Toké (Nathan.Toke@uvu.edu), Matt Olson (Matt.Olson@uvu.edu)
**Field Trip Co-Chairs:** Patricia Garcia (pgarcia@uvu.edu), Daren Nelson (nelsond@byui@edu)
**Exhibits & Sponsors Chair:** David M. Pearson (peardavi@isu.edu)

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Honor those who have made remarkable contributions in the geosciences by nominating a colleague for a medal, award, or recognition.

For more details and specific requirements for each award, visit **https://bit.ly/4cBcerd.**

*GSA selects individuals based on track record and commitment to integrity and promise to continue living up to the ethical standards embodied in GSA's Code of Ethics & Professional Conduct, in addition to their many accomplishments.*

**The deadline for receipt of all medal, award, and recognition nominations is 15 February 2025.**

## HOW TO NOMINATE

To ensure thorough consideration by the respective committees, please follow these nomination instructions carefully; additional information supplied will not enhance the nomination.

1. **Nomination Form:** Complete the online form at **https://bit.ly/3XkfzXl** for all awards.
2. **Supporting Documents:** Submit via email to awards@geosociety.org unless specified otherwise. Required documents include:
   - Curriculum vitae
   - Letter of nomination (300 words or less)
   - Additional supporting documents as listed for each award below.

Questions: awards@geosociety.org

## PENROSE MEDAL

The Penrose Medal was established in 1927 by R.A.F. Penrose Jr. to be awarded in recognition of eminent research in pure geology, for outstanding original contributions, or for achievements that mark a major advance in the science of geology. This award is made only at the discretion of the GSA Council, and nominees may or may not be members of the Society. Penrose's sole objective was to encourage original work in purely scientific geology, which is interpreted as applying to all scientific disciplines represented by GSA. Scientific achievements should be considered rather than contributions in teaching, administration, or service. Mid-career scientists who have already made exceptional contributions should be given full consideration for the award.

**Additional Supporting Documents**
- Selected bibliography of no more than 20 titles.
- Letters of support from each of five GSA Fellows or Members ***in addition*** to the person making the nomination.

## ARTHUR L. DAY MEDAL

The Day Medal was established in 1948 through a donation by Arthur L. Day, founding director of the Geophysical Laboratory of the Carnegie Institution of Washington. It is awarded annually, or less frequently at the discretion of the Council, to recognize outstanding distinction in the application of physics and chemistry to the solution of geologic problems, with no restriction to the particular field of geologic research. It was Dr. Day's wish to provide an award to recognize outstanding achievement in research and to inspire further effort, rather than to reward a distinguished career, and so it has been the longstanding practice of the Society to award this medal to geoscientists actively pursuing a research career.

**Additional Supporting Documents**
- Selected bibliography of no more than 20 titles.
- Letters from five scientists with at least three of those being from GSA Fellows.

## YOUNG SCIENTIST AWARD (DONATH MEDAL)

The Young Scientist Award was established in 1988 to be awarded to a young scientist (35 years or younger throughout the year in which the award is to be presented—*for 2025, only those candidates born* ***on or after 1 January 1990*** *are eligible*) for outstanding achievement in contributing to geologic knowledge through original research that marks a major advance in the earth sciences. The award consists of a gold medal (the Donath Medal) and an honorarium.

**Additional Supporting Documents**
- Selected bibliography of at least 10 titles.
- Letters of support from each of five GSA Fellows or Members ***in addition*** to the person making the nomination.

## GSA FLORENCE BASCOM GEOLOGIC MAPPING AWARD

The Florence Bascom Geologic Mapping Award was approved by GSA Council in October 2013 and the first award was presented in 2015. This award acknowledges contributions in published high-quality geologic mapping that led the recipient to publish significant new scientific discoveries, to bring about greater understanding of fundamental geologic processes and concepts, and to contribute to the application of new knowledge to societal needs and opportunities in such areas as mineral resources, water resources, and the environment.

The recipient will have authored high-quality geologic maps, cross sections, and summary reports that have received scientific acclaim and are available to both peers and the public, through Federal or State agencies or major scientific societies. In evaluating the merits of nominees for this award, scientific achievements should be considered rather than contributions in teaching, administration, or service. Nominees may or may not be members of the Society, and they may be from any nation.

The selection criteria employed by the Geologic Mapping Award Committee are as follows: (A) excellence of the nominee's published geologic maps; (B) clear record of greater understanding of fundamental geologic processes and/or concepts, and high-quality publication of same, emerging directly from the meritorious quality of the geologic mapping; and (C) peer acclaim of the practical usefulness of the geologic mapping and the new discoveries that emerged from the mapping.

**Additional Supporting Documents**

- Selected bibliography of geologic maps (20 titles or less).
- Selected bibliography of peer-reviewed publications (20 titles or less).
- PDFs or website links to several key geologic maps authored by the nominee.
- Letters of support from three (3) GSA Fellows or Members in addition to the nominator letter. Diverse supporters (i.e., including individuals who are not currently/recently associated with the nominee's institution) are strongly encouraged.

## RANDOLPH W. "BILL" AND CECILE T. BROMERY AWARD

The Bromery Award for Minorities should be given to any minority, preferably African Americans, who qualify under at least one of these two categories:

1. Nominee has made significant contributions to research in the geological sciences, as exemplified by one or more of the following:
   - Publications which have had a measurable impact on the geosciences
   - Outstanding original contributions or achievements that mark a major advance in the geosciences
   - Outstanding lifetime career which demonstrates leadership in geoscience research
2. Nominee has been instrumental in opening the geoscience field to other minorities, as exemplified by one or more of the following:
   - Demonstrable contributions in teaching or mentoring which have enhanced the professional growth of minority geoscientists
   - Outstanding lifetime career service in a role which has highlighted the contributions of minorities in advancing the geosciences
   - Authorship of educational materials of high scientific quality that have enjoyed widespread use and acclaim among educators or the general public

**Additional Supporting Documents**

- Letters of support from three (3) scientists with at least two (2) from GSA Fellows or Members and one (1) from a member of another professional geoscience organization.
- Optional selected bibliography of no more than 10 titles.

"PEOPLE THAT WORK HARD AND HONESTLY, PURSUE THEIR CRAFT AND THEIR GOALS, THEY DESERVE RECOGNITION."
—LOUIS JACOBS, NOMINATOR FOR 2023 BROMERY AWARD

## DORIS M. CURTIS OUTSTANDING WOMAN IN SCIENCE AWARD

The Doris M. Curtis Outstanding Woman in Science Award recognizes a woman who has had a major impact on the field of the geosciences based on her Ph.D. research. The generous support of the Doris M. Curtis Memorial Fund makes this award possible. GSA's 103rd president, Doris Curtis, pioneered many new directions for geology, not the least of which was her tenure as GSA president after an unbroken chain of 102 men. Causes dear to her were women, public awareness, minorities, and education. Women are eligible for this award the first five years following their Ph.D. degree.

**Supporting Documents**

- Curriculum vitae including dissertation title and abstract.
- Letter of nomination that clearly states how the Ph.D. research has impacted the geosciences in a major way. DEI promotion activities are to be included in the submitted letter of nomination.

- Letters of support from three (3) scientists with at least two (2) from GSA Fellows or Members and one (1) from a member of another professional geoscience organization. DEI promotion activities are to be included in the submitted letters of support.
- Additionally, Nominators and Support Letter Writers are requested to address the continued impact of the nominee and their Ph.D. research to the scientific community by including the following:
  - Relevance of the work to the specialty field and more broadly to the geosciences and society.
  - Discussion of the impact of the PhD work via altered ways of thinking, new techniques, new citation data of resulting publications, etc.
  - Efforts by the nominee to impact the geosciences through activities such as mentoring, teaching, and initiatives promoting diversity in the field.
- Selected bibliography of no more than 10 titles.

"I FOUND IMMENSE SATISFACTION IN NOMINATING A WORTHY COLLEAGUE FOR A GSA AWARD, AS IT HIGHLIGHTED THE EXCEPTIONAL SCIENTIFIC CREATIVITY OF AN INDIVIDUAL WHOM I DEEPLY RESPECT."
—KURT KONHAUSER, NOMINATOR FOR 2022 DAY MEDAL

## GSA DISTINGUISHED SERVICE AWARD

GSA Council established the GSA Distinguished Service Award in 1988 to recognize individuals for their exceptional service to the Society. GSA members, Fellows, associates, and employees may be nominated for consideration, and any GSA member or employee may submit a nomination for the award. GSA's Executive Committee will select awardees, and GSA Council must ratify all selections. Awards may be made annually, or less frequently, at the discretion of Council.

**Additional Supporting Documents**

- Brief biographical sketch that clearly demonstrates the applicability of the selection criteria.
- Optional selected bibliography of no more than 10 titles.

## GSA PUBLIC SERVICE AWARD

GSA Council established the GSA Public Service Award in 1998 in honor of Eugene and Carolyn Shoemaker. This annual award recognizes contributions that have materially enhanced the public's understanding of the earth sciences or have significantly served decision makers in the application of scientific and technical information to public affairs and earth science–related public policy. This may be accomplished by individual achievement in:

- Authorship of education materials of high scientific quality that have enjoyed widespread use and acclaim among educators or the general public;
- Acclaimed presentations (books and other publications, mass and electronic media, or public presentations, including lectures) that have expanded public awareness of the earth sciences;
- Authorship of technical publications that have significantly advanced scientific concepts or techniques applicable to the resolution of earth-resource or environmental issues of public concern; and/or
- Other individual accomplishments that have advanced the earth sciences in the public interest

The award will normally go to a GSA member of any nation, with exceptions approved by Council, and may be presented posthumously to a descendant of the awardee.

**Additional Supporting Documents**

- Brief biographical sketch that clearly demonstrates the applicability of the selection criteria.
- Selected bibliography of no more than 10 titles.

## GSA MICHEL T. HALBOUTY DISTINGUISHED LECTURER AWARD

The GSA Foundation is pleased to have established the Michel T. Halbouty Distinguished Lecturer Fund. The intent of the fund is to provide an honorarium for a Halbouty Distinguished Lecturer at GSA annual meetings. The fund was established to select a top lecturer on a topic of relevance to natural resources (i.e., water, land, energy, and minerals). Selection of the lecturer will be on the basis of career accomplishments and reputation, as well as the topic of the lecture.

The Halbouty Lecture topic of natural resources encompasses a broad swath of geology. Nominations of scholars across this range of topics are encouraged. The list of former lecture topics provides specific examples of potential breadth.

Nomination topics APC takes into account when selecting a lecturer:

- finite limits on worldwide availability;
- regional overviews (U.S.) of availability, quality, quantity, and use;
- environmental damage from extraction or exploitation;
- geologic aspects of environmental remediation;
- overarching government policies concerning natural resources;
- regional exploration; and
- new exploration tools.

## INTERNATIONAL HONORARY FELLOW AWARD

Established by the GSA Council in 1909, Honorary Fellowship may be bestowed on individuals who have made outstanding and internationally recognized contributions to geoscience, or in rare circumstances, provided notable service to the Society. In practice, nearly all candidates are non–North Americans who live and work outside of North America. The most noteworthy exceptions were astronauts. The awardee does not have to be a member of the Society to receive the award. Honorary Fellows will be recognized during the GSA Annual Meeting and will receive complimentary lifetime membership to the Society.

**Additional Supporting Documents**

- Letters of support from three (3) scientists with at least two (2) from GSA Fellows and one (1) from a GSA Fellow or a person of equivalent international stature.
- Selected bibliography of no more than 20 titles.

## INTERNATIONAL DISTINGUISHED CAREER AWARD

The Distinguished Career Award will be given to a GSA member who has made numerous, distinguished, and significant contributions that have clearly advanced the international geological sciences through both scientific investigations and service. The award will consist of a plaque inscribed with the name of the recipient, the name of the award, the name of the nominee's Section, and the emblem of The Geological Society of America. The award will be presented to the awardee at the national GSA meeting. International encourages the membership to submit names of qualified candidates for this honor.

**Additional Supporting Documents**

- Optional letters of support.
- Selected bibliography of no more than 20 titles.

## JOHN C. FRYE ENVIRONMENTAL GEOLOGY AWARD

In cooperation with the Association of American State Geologists (AASG), GSA makes an annual award for the best paper on environmental geology published either by GSA or by one of the state geological surveys.

Anyone can nominate a paper as long as it is selected from a GSA or state geological survey publication and published during the preceding three full calendar years. The nomination letter must include a paragraph stating the importance of the paper. Up to three (3) letters from users of the publication can be included to support the nomination.

Each nominated paper will be judged on its uniqueness or significance as a model of its type of work and its overall worthiness for the award. The paper must (1) establish an environmental problem or need; (2) provide substantive information on the basic geology or geologic process pertinent to the problem; (3) relate the geology to the problem or need; (4) suggest solutions or provide appropriate land-use recommendations based on the geology; (5) present the information in a manner that is understandable and directly usable by geologists; and (6) address the environmental need or resolve the problem. It is preferred that the paper be directly applicable to informed laypersons (e.g., planners, engineers).

Please send your nominations to GSA Grants and Awards, P.O. Box 9140, Boulder, Colorado 80301-9140, USA. For more information, please visit https://www.geosociety.org/GSA/About/awards/GSA/Awards/Frye.aspx.

## AGI MEDAL IN MEMORY OF IAN CAMPBELL

The AGI Medal in Memory of Ian Campbell recognizes singular performance in and contribution to the profession of geology. Candidates are measured against the distinguished career of Ian Campbell, whose service to the profession touched virtually every facet of the geosciences. Campbell was a most uncommon man of remarkable accomplishment and widespread influence, and in his career as a geologist, educator, administrator, and public servant, he was noted for his candor and integrity. To submit a nomination, go to https://www.americangeosciences.org/awards/iancampbell.

## AGI MARCUS MILLING LEGENDARY GEOSCIENTIST MEDAL

The 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. Prior to 2007, it had been called the AGI Legendary Geoscientist Award. To submit a nomination, go to https://www.americangeosciences.org/awards/legendarygeoscientist.

# The Federal Budget: How Scientists Can Inform the Appropriations Process on Capitol Hill

By reaching out to legislative offices, scientists can provide important perspectives on both the personal importance of their science and how federal funding for science bolsters communities.

*Joshua Martin, GSA Science Policy Fellow*

The arrival of October brings with it the start of a new fiscal year here in Washington, D.C. From the President's budget request to the eventual implementation of authorized programs by federal agencies, understanding the federal budget process is an important avenue for effective engagement in scientific advocacy and policymaking. The process involves several stages, including congressional review, the development and passing of 12 separate appropriations bills, and their final approval by the President. By familiarizing themselves with the budget requests of key agencies and staying informed about appropriations bills, GSA members can play a vital role in supporting innovation and discovery in the geosciences.

### WHAT IS AN APPROPRIATIONS BILL?

An appropriations bill, also known as a supply or spending bill, is a legislative proposal that authorizes the allocation of government funds to specific federal agencies, programs, or activities for a fiscal year. It is essential for funding the operations and initiatives of the government and must be passed by Congress and signed by the President to become law.

### HOW TO GET INVOLVED

Scientific engagement in the appropriations process brings visibility to important scientific issues, which helps protect funding for science and foster innovation and discovery. **The easiest way to engage in this process is to contact members of Congress and ask them to prioritize funding for the geosciences!** GSA's Policy Toolkit (www.geosociety.org/policy-toolkit) has many useful videos and articles that can assist with this process, including information on finding and contacting your members of Congress, following up afterward, and engaging with policymakers in and out of D.C.

- **Familiarize yourself with the budget requests of relevant agencies,** including the U.S. Geological Survey (USGS), the National Science Foundation (NSF), the National Oceanic and Atmospheric Administration (NOAA), the National Aeronautics and Space Administration (NASA), the Environmental Protection Agency (EPA), and more. The President's Budget Request, found through the Office of Management and Budget (OMB), will outline the administration's priorities for these agencies.
- **Check if the appropriations committees in either chamber of Congress have released their appropriations bills.** The Interior, Environment, and Related Agencies Appropriations Act and the Commerce, Justice, Science, and Related Agencies Act will set the budget for many agencies relevant to the geosciences, including the USGS, NSF, NOAA, NASA, and the EPA.
- **Read Letters of Testimony.** Often, organizations with an interest in specific areas of the budget (like GSA) submit "Outside Written Testimony," making funding requests for specific agencies or even specific projects.
- **Develop specific requests for funding when contacting your members of Congress.** Ultimately, you will make the most impact with a clear, concise message.

If you would like to get involved but you're not sure where to begin, you can find resources at www.geosociety.org/policy or reach out to GSA's policy office at sciencepolicy@geosociety.org.

### HOW THE FEDERAL BUDGET IS SET

**STEP 1**
President submits budget request, outlining the funding priorities for federal agencies in the upcoming fiscal year.

**STEP 2**
Each chamber of Congress reviews the President's proposal.

**STEP 3**
Congress holds hearings to evaluate the needs of the various agencies.

**STEP 4**
The chamber committees divide the total spending amounts covering different areas of government spending.

**STEP 5**
Both chambers of Congress must agree on the final versions of the appropriations bills, which are then sent to the President for approval.

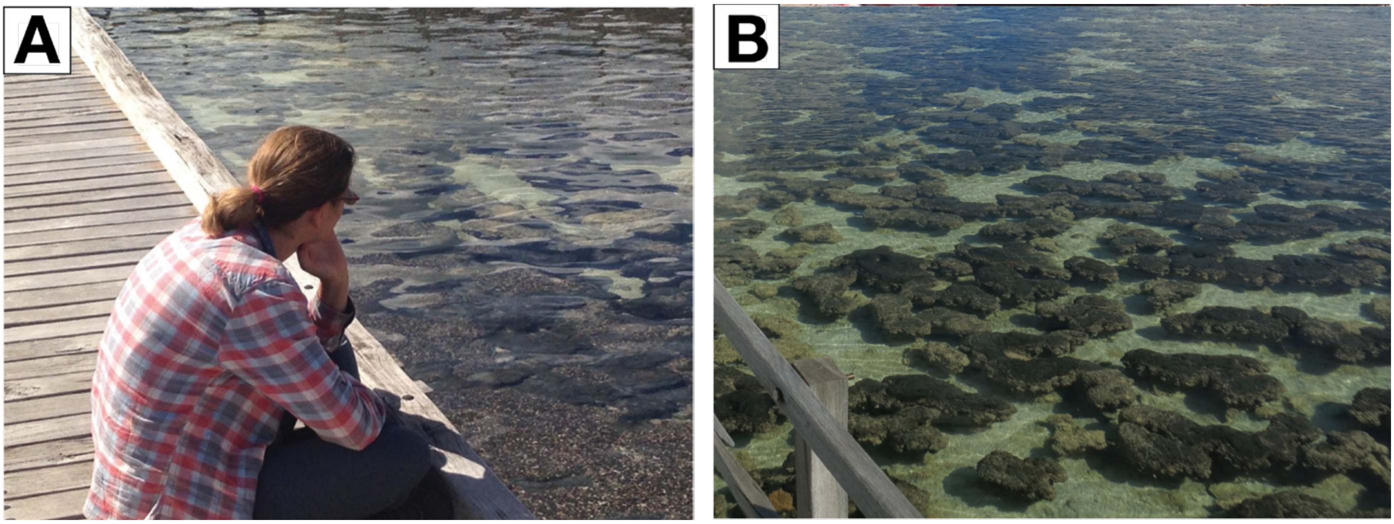


Figure 1. (A) A geologist contemplates living stromatolites at Shark Bay, Australia. Photo by T. Shipley. (B) A close-up of living stromatolites in Shark Bay, Australia.

# Shark Bay, Australia, and the Centrality of Analogical Thinking

**Basil Tikoff [*,1] and Thomas F. Shipley[2]**

**Geology logline:** *The stromatolites preserved in the ca. 3.4 Ga rocks of the Pilbara craton of Western Australia are understood, in part, by analogy to living microbial mats in Shark Bay, Australia.*

**Cognitive logline:** *Analogies are the foundation of reasoning about the past where alignment of two related concepts allows inferences about less-well-understood concepts from well-understood concepts.*

> *out on the islands … you can watch the time of the world go by, from minute to minute, hour to hour, from day to day, season to season.*
>
> —Robert McCloskey, *Time of Wonder* (1957)

Shark Bay, Australia, is the home of some of the best-known present-day stromatolites (Fig. 1). Stromatolites are accretionary structures made by microbial mats, which are biofilms containing symbiotic colonies of bacteria and algae that occur in shallow marine settings. They are common in the fossil record from the Archean until the middle of the Paleozoic. Their relative scarcity since the Devonian is a result of being eaten by a variety of marine animals. The stromatolites of Shark Bay are thought to flourish because of the extreme salinity of the water in the bay, which limits the presence of predators.

Shark Bay is on many geologists' bucket lists. Tim visited in 2015 with a group of geologists. These geologists took time away from fieldwork—their only break—to make the 2600+ km roundtrip visit to Shark Bay. What brings scientists to see these unassuming black lumps? Geologists traveling great distances to visit a place is hardly notable; for psychologists, however, this is far outside the realm of familiar practice. Tim observed that geologists visiting those stromatolites in Shark Bay, Australia, registered the sense of wonder parents see in their young children, as captured by Robert McCloskey in *Time of Wonder* (Fig. 1A). What the geologists saw was more than irregular dark lumps. It was like seeing a relative's name on a passenger arrival list at Ellis Island: A place to go where one might viscerally experience the travels of a relative at a different time. What they saw embodied their profession in the way that no historical artifact does.

Historical artifacts are valuable, as they mean something to those who know the temporal and spatial connections, but the connections have no physical necessity, and their meaning comes from community knowledge. For example,

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Freud lived at Berggasse 19 in Vienna's 9th district, but it could have been a different address and his ideas still would have been important. Nothing intrinsically links Freud to that space. In contrast, the meaning of stromatolites is intrinsic. For a geologist, time is not an abstract unidimensional construct that occurs in isolation. Geologic time is revealed by events that leave their traces on the objects that participate in them. The stromatolites of Shark Bay have the ability to embody a different time on Earth. This essay explores how that occurs.

The geologists had been working in—and returned to—the Pilbara craton of Western Australia. The sedimentary rocks there and in the Barberton belt of South Africa contain some of the oldest stromatolites in the rock record. The stromatolites from the Dresser Formation of the Pilbara craton, which have an estimated age of 3.43 Ga, are one of the earliest visible signs of life in the fossil record (Fig. 2; Noffke et al., 2013). The living Shark Bay stromatolites are only a thousand kilometers from exposures of some of the oldest stromatolites in the Pilbara craton.

Consider how geologists think about stromatolites, past and present. Aligning the traces of past events to traces of present-day events permits reasoning about an event that can no longer be directly observed. As Charles Lyell (1830) succinctly put it, "The present is the key to the past." To understand the past from the present, geologists must reason by *analogy.* The black lumps in Shark Bay are *analogous* to lumps preserved in sedimentary rocks in the Pilbara craton that are 3.43 billion years old. The analogy is based on the mechanical properties of biofilms interacting with sediments, and the physics of such interactions would not have changed over the years. Thus, the similarities of three-dimensional structure between the Pilbara fossils and the Shark Bay stromatolites suggests an analogy.

Figure 2. Archean stromatolites from the Archean Dresser Formation, Pilbara craton, Australia. Photo by N.M. Roberts.

TO UNDERSTAND THE PAST FROM THE PRESENT, GEOLOGISTS MUST REASON BY *ANALOGY.*

Formally, an analogy maps the relationships in one system onto the relationships in another system. In English, analogies are often marked by "is like," and can range from concrete perceptual similarity to more abstract relationships. Metaphors are also analogies where the mapped relationships have no perceptual similarity (Lakoff and Johnson, 1980). Analogies are not substituting one object for another, but rather aligning properties of one thing with properties of another. In this way analogies are not arbitrary but reflect relationships in the world. Gestures, which geologists use a lot, are often analogies. When a geologist communicates a subducting plate by sliding one hand under a horizontal palm, the spatial mapping to plate movement is direct. Many geological gestures are analogies where the meaning comes not from convention but through spatial mapping. The point is that if gestures are analogies, then it indicates that meaning of analogies comes directly from the world—via spatial mapping—rather than through language or social convention.

What we know about the properties of objects in the world is collected together, in our minds, as a set of relationships. These structured memories allow humans to employ analogical reasoning to use what they know to guide decisions when encountering something new (see suggested reading of Gentner et al., 2001). An analogy allows one to use known relationships to project aspects of a well-known category onto a lesser-understood category. We begin with a biological example where rich evolutionary knowledge allows strong analogies from taxonomic structures. To say that "a *Tasmanian devil* is like a *dog*" is to say that the various properties of dog, such as the relationship "dogs have fur," can be mapped onto those of the Tasmanian devil (each has fur, as well as teeth, eats meat, walks on four legs on the ground, weighs more than 2 kg and less than 30 kg, is taller than 10 cm and shorter than 1.5 m, etc.). Knowledge structured in this way allows humans to take what they know about dogs and use it to infer aspects of Tasmanian devils. Introductory geology textbooks are full of analogies so that students can learn about the unfamiliar from the familiar (e.g., the structure of the Earth is like a peach with concentric layers). We will return to analogies in future essays on mental models where we discuss experts' use of analogies.

Discovering a strong analogy requires identifying two categories of phenomena where the structure of relationships is similar. Comparison makes the common structure stand out more clearly. Once you notice the relationships that are shared by the dog and the Tasmanian devil, you are likely to consider possible inferences about unknown aspects of the Tasmanian devil. By mapping the relationships within a dog (dogs have canine teeth, dogs have live young) onto relationships of Tasmanian devils (devils have canine teeth, devils have live young) you may reason that other known relationships, such as dog suckles its young, are also applicable to a Tasmanian devil. Such inferences are hypotheses about the nature of the less familiar category. It is the relationship between relationships (e.g., the relationship between the relationships within the "dog" category and the relationships within the "Tasmanian devil" category) that is the key to this hypothesis generation. Without making the analogy/comparison between dogs and Tasmanian devils, it might never occur to you to think about how a female Tasmanian devil feeds her offspring. But the hypotheses about the nature of the less familiar category follow naturally once the analogy is made. Here is the main point: ***Analogies are a cognitive engine for hypothesis generation.***

THE ANALOGY CONTINUES TO SERVE SCIENCE AS A STIMULUS . . . TO MENTALLY TRAVEL BACK TO THE ARCHEAN TO ASK QUESTIONS FOR WHICH WE DO NOT YET HAVE SETTLED ANSWERS.

In geology, analogies are critical to discovering new understandings of the past. The known properties of present-day stromatolites are the key to the fossil stromatolites. What we know about modern stromatolites—how they function as systems with the intricate interrelations among species and the geometric forms they construct—allows scientists to construct hypotheses about what was occurring in the shallow pools that covered the Pilbara craton billions of years ago, and how those early environmental conditions controlled the development of life (Allwood et al., 2007). This scientific reasoning reveals the mind formally projecting the relationships from a well-understood system (modern stromatolites) onto an unfamiliar system (Archean stromatolites) to create an understanding of the relationships in the unfamiliar system. It took a while for consensus to develop. Scientists first constructed the analogy in the 1980s and offered it to others as a hypothesis (Walter et al., 1980). Further learning occurred as the various relationships in the analogy were considered (e.g., is the form a solid basis for function? Are there alternative, nonbiological, explanations for the structures?). For over 20 years debate ensued, in part due to structural, spatial, or diagenic uncertainty in key outcrops (Allwood et al., 2007). Discovery of unaltered outcrops allowed more certain observations. Eventually, consensus coalesced around a strong analogy, which became a theory. The analogy continues to serve science as a stimulus (a word that literally translates as "goad") to mentally travel back to the Archean to ask questions for which we do not yet have settled answers. For instance, where did the complex molecules come from to form these microbes that could organize into mats?

Analogies create knowledge. Learning through analogy can yield errors of omission and commission. A Tasmanian devil is not a dog; although both are mammals, the former is a marsupial and the latter is a placental mammal. Knowing that distinction explains a lot about the Tasmanian devil, including its biogeography as living in former parts of Gondwana. An analogy that is based on a sparse mapping may result in inferences that are akin to over-interpretations. One such example is to attribute features of placental mammals, such as long pregnancies where young are fed by a placenta, to marsupial mammals, such as a Tasmanian devil. For a more geological example of an analogy with drawbacks, consider the analogy sometimes made when teaching about convective overturn in the mantle: It is like the convection of cream in tea or convection cells in miso soup. Students typically assume that the mantle is liquid because the analogical object (convecting tea or soup) is liquid (Francek, 2013). The mantle, however, convects as a solid over very long times, a situation for which there is no strong analogy in typical human experience.

These challenges of analogical thinking have implications for both research and teaching. For research, it is possible that a "rigidity of thinking" may result from an assumption implicit in an analogy that may not be correct in reality. For teaching with analogy, there is benefit to providing guidance when initially mapping, which includes a clear statement of limits. For example, saying "an aquifer is like a sponge" helps students understand how water could be stored underground without it being a lake, but the pores' spaces and connectivity should not be inferred from kitchen sponge pores. Furthermore, having a community-vetted set of analogies to draw from when teaching would be a useful tool to avoid common student misconceptions.

Ilyse Resnick and colleagues (2017) have found that students encountering unfamiliar scales, such as billions of years, for the first time may have difficulty grasping analogies across the scales of geologic time (Cheek, 2012). Prior to a geology class, many students think of the entire range of geologic time as one big category of "a long time ago." Instructors make use of space-for-time analogies (e.g., Moore, 2014) in classrooms by mapping paper rolls and sports fields onto the 4.6 billion years of Earth history. Unfortunately, a single analogical mapping does little to differentiate within the too-large category of long ago. Multiple analogies that connect to familiar magnitudes can help. As scales of time move outside of the familiar scale of human recorded history, one encounters geological events far in the human past, such as the last ice age. The maximum ice extent of the last glacial stage (Wisconsin) was ~20,000 years ago. While 20,000 years is long ago in human time (~800 generations), from the broader perspective of geologic time, it is remarkably recent. Resnick and others suggest that students be given the opportunity to construct and align spatial analogies for time (e.g., where the events of human history are on a 1-m scale) for successive orders of magnitudes of geologic time (e.g., where the events of ice ages are on a 1-m scale), specifically including the entire previous scale (e.g., human history). Using this approach of nested scales, students begin to develop a sense of the time duration of stromatolites on Earth that goes beyond "well that's a big number ago," to understand the relative scale of geological events.

Just as the student learns by analogy in classroom and textbook, so too do experts learn new ideas by analogy. These analogies are shared at meetings, over meals, and on field trips. The learning may progress in fits and starts, but it is no less learning. Much of that learning is powered by analogies. Weaker analogies, where there is a flaw in the mapping, can derail learning and promote misconceptions for novice and expert alike. But strong analogies lead to new, testable hypotheses.

To finish, we return to Shark Bay, stromatolites, and the power of analogies. Stromatolites left a clear and lasting impression on Earth. They originally occurred on an Earth with little to no free oxygen in the atmosphere. By their mere existence, they helped transform Earth by oxygenating small pockets of their world. How do we know that stromatolites were oxygenating Earth? We are not certain, but one theory uses the present-day stromatolites, which produce oxygen, as an analog for past stromatolites. While the stromatolites are at least as old as ca. 3.4 Ga, they became widespread around 2.8 Ga. That timing is consistent with a fundamental change in our atmosphere—changing the relative balance of $CO_2$ and $O_2$ in Earth's atmosphere—known as the Great Oxygenation Event (see review by Ligrone, 2019). That event occurred over a prolonged period centered around ca. 2.5 billion years ago and made the way for almost all life on the planet; it was caused by both inorganic chemical reactions and stromatolites living (and dying). All that time understood by carefully aligning a lumpy bit of algae and bacteria with a rock!


## ACKNOWLEDGMENTS

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GEOLOGY THROUGH THE LENS

# Ripples in Time

Glaciotectonically tilted current ripples in a proglacial delta. Port Huron Phase (Wisconsin Episode) sediments exposed in a bluff overlooking Lake Michigan just south of Ludington, Michigan.

Kevin Kincare just retired from a combined 40-year career as a Research Geologist mapping glacial geology around the Great Lakes for the Michigan Geological Survey and the U.S. Geological Survey.

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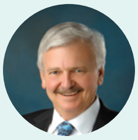
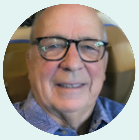
**Lydia Fox** is currently an associate professor of Geological & Environmental Sciences at the University of the Pacific. Lydia earned a B.S.E. from Princeton University and a Ph.D. from the University of California, Santa Barbara. A passionate teacher, former department chair, and current Director of Undergraduate Research for the university, Lydia previously worked for Schlumberger Well Services, the U.S. Geological Survey, and California State University, Northridge. Lydia is also a GSA Fellow.



**Stephen Wells** is the former president of New Mexico Institute of Mining and Technology. Steve earned a B.S. from Indiana University, and an M.S. and Ph.D. from the University of Cincinnati. An award-winning scientist, enthusiastic administrator, teacher, and mentor, Steve has also been a professor, department chair, president of the Desert Research Institute, and board member of numerous scientific organizations. He is a former GSA president and also a GSA Fellow.

**David Szymanski** is a professor at Bentley University in Waltham, Massachusetts. Dave earned a B.S. from the University of St. Thomas, and an M.S. and Ph.D. from Michigan State University. His current research foci as a forensic scientist are the cycling of elements in Earth systems and transdisciplinary problems of sustainability. Dave was a GSA/USGS Congressional Science Fellow, where he worked in the U.S. Senate. He has also served in leadership roles on numerous key GSA committees.



**George Davis** is the former provost of the University of Arizona and former president of the University of Vermont. George earned a B.S. from The College of Wooster, an M.A. from the University of Texas at Austin, and a Ph.D. from the University of Michigan. He has held numerous academic leadership positions and has received awards for his groundbreaking research in structural geology, teaching, and distinguished service. He is a former GSA president and is also a GSA Fellow.

**Katy Sementelli** is a petroleum geoscientist with Woodside Energy. She previously worked for ExxonMobil, Apache, Hess, and BHP. Katy earned a B.S. from Edinboro University and an M.S. from the University of North Carolina at Chapel Hill. Her expertise in sequence stratigraphy, clastic sedimentology, and clastic reservoir characterization has led to her work in onshore and offshore basins in North America, South America, and Africa. Katy is also passionate about inclusion and diversity in the petroleum industry and geosciences.