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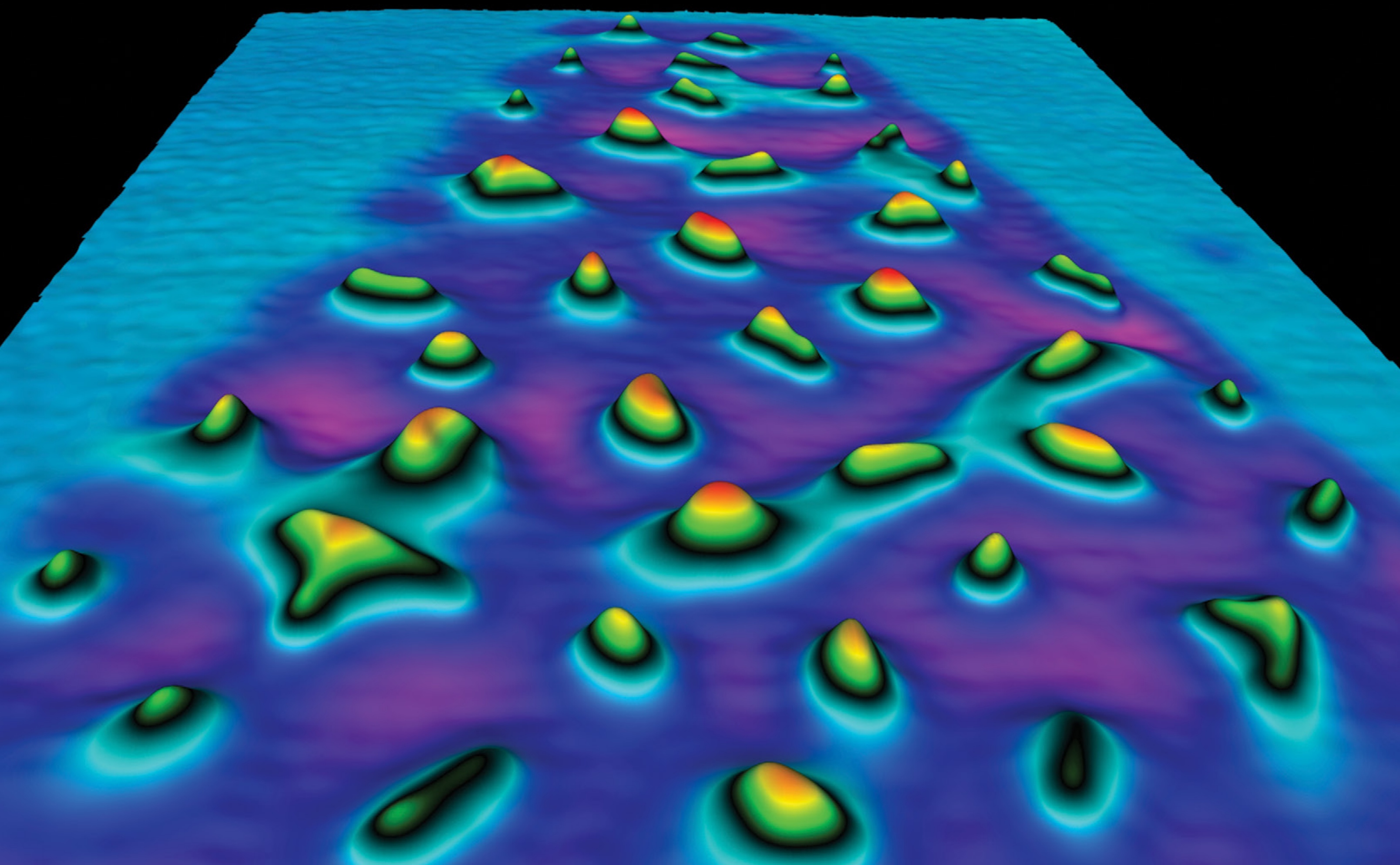
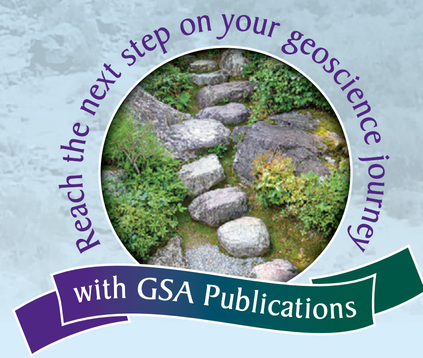
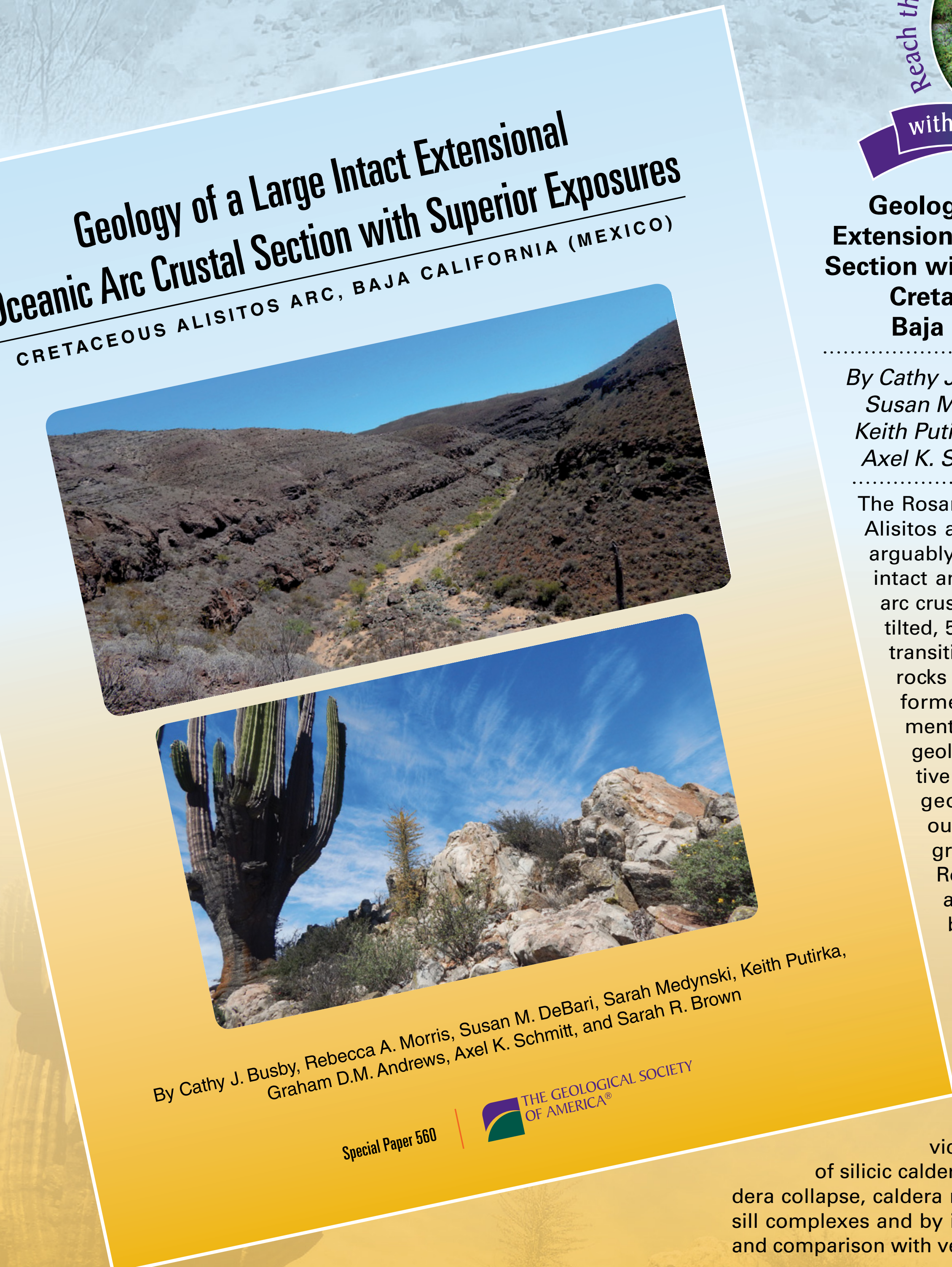
Halokinetic Induced Topographic Controls on Sediment Routing in Salt-Bearing Basins: A Combined Physical and Numerical Modeling Approach







Geology of a Large Intact Extensional Oceanic Arc Crustal Section with Superior Exposures: Cretaceous Alisitos Arc, Baja California (Mexico)

By Cathy J. Busby, Rebecca A. Morris, Susan M. DeBari, Sarah Medynski, Keith Putirka, Graham D.M. Andrews, Axel K. Schmitt, and Sarah R. Brown

The Rosario segment of the Cretaceous Alisitos arc (Baja California, Mexico) is arguably the best-exposed structurally intact and unmetamorphosed oceanic arc crustal section on Earth. The gently tilted, 50-km-long section exposes the transition from upper-crustal volcanic rocks to mid-crustal plutonic rocks, formed in an extensional environment. This book presents a detailed geologic map, based on an exhaustive data set including geochemistry, geochronology, and annotated outcrop photos and photomicrographs. Subsegments within the Rosario segment include a subaerial edifice, a volcano-bounded basin, and a fault-bounded basin, each underpinned by separate plutons. The entire data set is integrated across these subsegments in a time slice reconstruction of arc evolution and the relationships between plutonism and volcanism. The data set provides constraints on the evolution of silicic calderas and tectonic triggers for caldera collapse, caldera resurgence by emplacement of sill complexes and by incremental growth of plutons, and comparison with velocity profiles in modern arcs.

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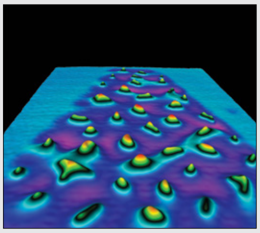

Cover: Perspective view of topography developed in a physical model of a salt-bearing basin. Salt diapirs form highs within the basin (black, green and red colors) and are surrounded by withdrawal basins (minibasins; dark blue to purple). Some of the rising diapirs form interconnected networks of salt-cored highs. Image by Tim Dooley, Applied Geodynamics Laboratory. See related article, p. 4–9.

GSA CONNECTS 2023

GSA NEWS

Halokinetic Induced Topographic Controls on Sediment Routing in Salt-Bearing Basins: A Combined Physical and Numerical Modeling Approach

Jinyu Zhang*, Lorena Moscardelli[#], Tim P. Dooley, and Nur Schuba, *Bureau of Economic Geology, Jackson School of Geosciences, The University of Texas at Austin, Austin, Texas 78712, USA*

ABSTRACT

Allogenic controls are frequently cited as key factors influencing basin evolution; however, fewer studies perform paleo-topographic reconstructions to examine the impact of topography in the development of stratigraphic sequences. Disentangling how allogenic versus autogenic controls affect the stratigraphic succession within a basin affected by salt tectonics is particularly challenging because decoupling the stratigraphic signature of lithospheric induced uplift and subsidence from salt tectonics is not a trivial exercise. We tackle this problem by integrating physical modeling results with a landscape numerical model and compare results with a case scenario from the subsurface. The physical model provides surface displacement data that are then used as inputs into the landscape numerical model to simulate the surface and stratigraphic evolution of a salt tectonic basin during a 25-m.y. timespan and within the context of a continental-scale source-to-sink (S2S) system. Results show that the evolution of salt structures impact the development and diversion of sedimentary routing systems within salt basins, thus influencing the character of the stratigraphic record independently of allogenic factors such as lithospheric induced uplift. Modeling results highlight the importance of reconstructing the paleo-topography of ancient depositional systems affected by salt tectonics to truly understand the nature of the final stratigraphic record.

INTRODUCTION

Basin-scale sediment distribution and its resulting stratigraphy are widely believed to be controlled by allogenic controls including changes in sediment supply, eustasy, and tectonics (e.g., Jervey, 1988; Heller et al., 1993). Changes in stratigraphy are often linked to variations associated with one or a combination of these allogenic controls; however, fewer studies have considered the effects that local topographic development can have in the imprinting of the stratigraphic record. In basins affected by salt tectonics, allogenic signatures within the stratigraphic record are overprinted by the influence of salt movement, and, as a consequence, decoupling the effects of sediment supply, eustasy, conventional tectonism, and salt tectonics becomes difficult. We believe that illustrating these relationships is important because salt basins are common in many regions of the world, including the Gulf Coast region of the United States and the deep-water Gulf of Mexico. Surprisingly, most geoscientists working outside the realms of industry or applied research have little exposure to knowledge associated with the complexities that salt basins pose when trying to untangle basin evolution and fundamental sedimentological, stratigraphic, and tectonic processes. By discussing some aspects of these complexities, using physical and numerical models coupled with observations from a real case study, we hope to bring attention to the importance of studying salt tectonic process and sediment interactions within salt basins as an important and often overlooked component of Earth's evolution.

In this study we present a novel methodology integrating inputs derived from physical modeling with landscape numerical modeling. The integrated model simulates the surface and stratigraphic evolution of salt-controlled basins within the context of a continental-scale source-to-sink (S2S) system covering the entire sedimentary profile from the upstream sediment source in the continental realm to the sediment sink in the marine realm. Such an approach benefits from using surfaces derived from a physical model that simulates the evolution of a salt basin containing numerous salt diapirs. Time steps of vertical movements derived from the physical model are the input for the numerical models. The input parameters from the physical model responded to well-known laboratory conditions constraining the evolution of the salt-tectonic topography (e.g., Dooley et al., 2013, and Supplemental Material[1]) and guiding the numerical approach. We use the numerical modeling approach to understand: (1) the level of influence that salt tectonics can insert in the development of sediment routing systems within the sink domain, and (2) how the evolution of local topography within salt basins influences the vertical development of stratigraphic patterns. Our study emphasizes the importance of reconstructing the

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[1]Supplemental Material. Explanations of seismic data acquisition, processing, and interpretation. Time-thickness map and seismic cross-sections of Lower Cretaceous Mississippi Salt Basin. Methodology of salt tectonics physical models, landscape, and stratigraphic numerical models. Table with input parameters for landscape and stratigraphic numerical model. Figure illustrating uplift and subsidence rates of the sink domain. Explanations for animations. Go to https://doi.org/10.1130/GSAT.S.22391062 to access the supplemental material; contact editing@geosociety.org with any questions.

paleo-topography of ancient depositional systems to better understand the imprinting of the stratigraphic section while taking into consideration the impact of an S2S configuration. Finally, we used learnings derived from this integration between physical and numerical models to establish parallels with observations from the Lower Cretaceous Mississippi Salt Basin (Fig. 1) to demonstrate the validity of the analogy between the modeling effort and a real case scenario.

METHODOLOGY

We integrated the results from a physical model and an S2S numerical model to better understand the sediment routing in salt-bearing basins. The physical model was designed to explore salt-tectonic processes within a salt-bearing basin punctuated by numerous salt structures similar to the ones observed in the Campeche Basin of the southern Gulf of Mexico (e.g., Davison, 2021, and references therein). It is important to highlight that results from physical models (aka. sandbox models) are agnostic, meaning that observations can be applied to other settings where particular processes form similar structures. Moreover, physical models of salt tectonics are not meant to exactly duplicate characteristics observed in a particular basin; instead, they are primarily designed to help understand processes associated with the formation of certain geological features (e.g., Dooley et al., 2012; Ge et al., 1997; Rowan and Vendeville, 2006).

It should be stressed that this first iteration of our numerical model doesn't take into consideration flexural subsidence as a response to sediment loading, taking only into consideration input from the physical model. This approach was adopted by design, given that we wanted our numerical models to start from a simpler baseline to progressively increase levels of complexity at later stages. We will incorporate sediment loading in our next iteration of numerical models, and we will compare results from different runs to weigh the influence of sediment loading versus pre-set geometric configurations exclusively derived from the physical model.

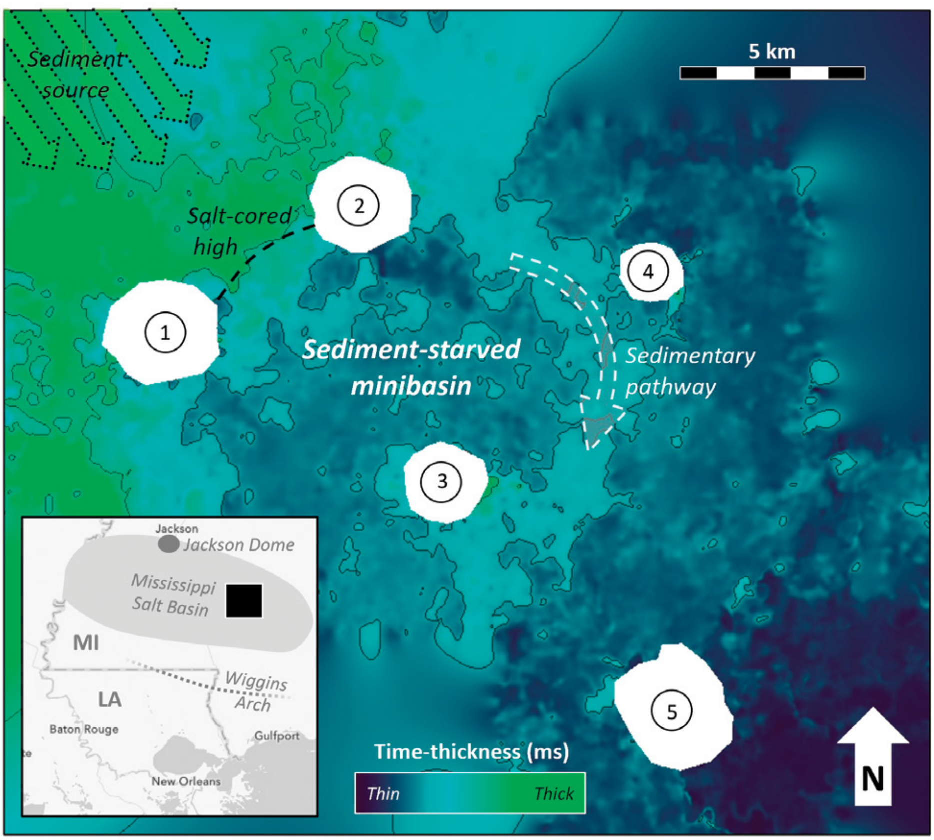

Figure 1. Time-thickness map from a Lower Cretaceous unit in the Mississippi Salt Basin (Thieling and Moody, 1997; Johnson et al., 2006). Regional sediment source is from the northwest. Numbers 1 to 5 in white areas denote locations of salt domes. Domes 1 and 2 acted as a salt-cored high blocking sedimentary input. A clockwise oriented sedimentary pathway developed around Dome 2. Contour interval is 50 ms. Map derived from seismic data courtesy of CGG. MI—Mississippi; LA—Louisiana.

The physical model utilized well-documented modeling materials, with a silicone polymer acting as our salt analog, and a mixture of silica sands and spherical cenospheres to simulate the siliciclastic overburden (e.g., Reber et al., 2020, and references therein). Salt diapirs and pillows with varying geometries were seeded by differential loading, as is typical for this style of physical modeling (e.g., Rowan and Vendeville, 2006; Dooley et al., 2013), and gradually grew upward as a series of diapirs, resulting in the localized drawdown of the autochthonous salt layer to feed these growing salt structures, leading to the formation of numerous salt-withdrawal basins (minibasins; Fig. 2A). As the diapirs grew, some linked as composite structures, forming salt-cored highs with the greatest structural relief above the crests of the original diapirs (Fig. 2A). The S2S numerical model uses height-change data through time from the physical model (i.e., the rates of subsidence and uplift, Fig. 2A) to constrain the evolution of the salt-related topography. The original parameters extracted from the physical model are upscaled to fit a continental-scale S2S system (Figs. 2A–2B). The pyBadlands software package is employed to simulate the evolution of topography and stratigraphy (Salles et al., 2018). The detailed description of the model parameters and governing equations of the landscape numerical modeling can be found in the supplemental material (see footnote 1). Even though the integrated physical and numerical modeling method proposed in this study is novel, the employed workflows of physical modeling of salt tectonics and S2S numerical modeling are well practiced in recent studies (e.g., Dooley et al., 2020; Duffy et al., 2021; Reber et al., 2020; Zhang et al., 2020; Ding et al., 2019).

The simulation time of the S2S numerical modeling is 25 m.y. The length and width of the entire numerical model from S2S are 1200 km and 500 km, respectively. The source domain is 250 km long with an initial 200-m-high topography and a constant uplift rate at 40 m/m.y. (Fig. 3). The source domain supplies sediments into the basin through a 250-km-long transfer zone that connects with a 700-km-long sink domain. The time duration, dimensions, and uplift rates used in the numerical model were defined based on analogies between the physical model and observations from the Campeche Basin (e.g., Davison, 2021).

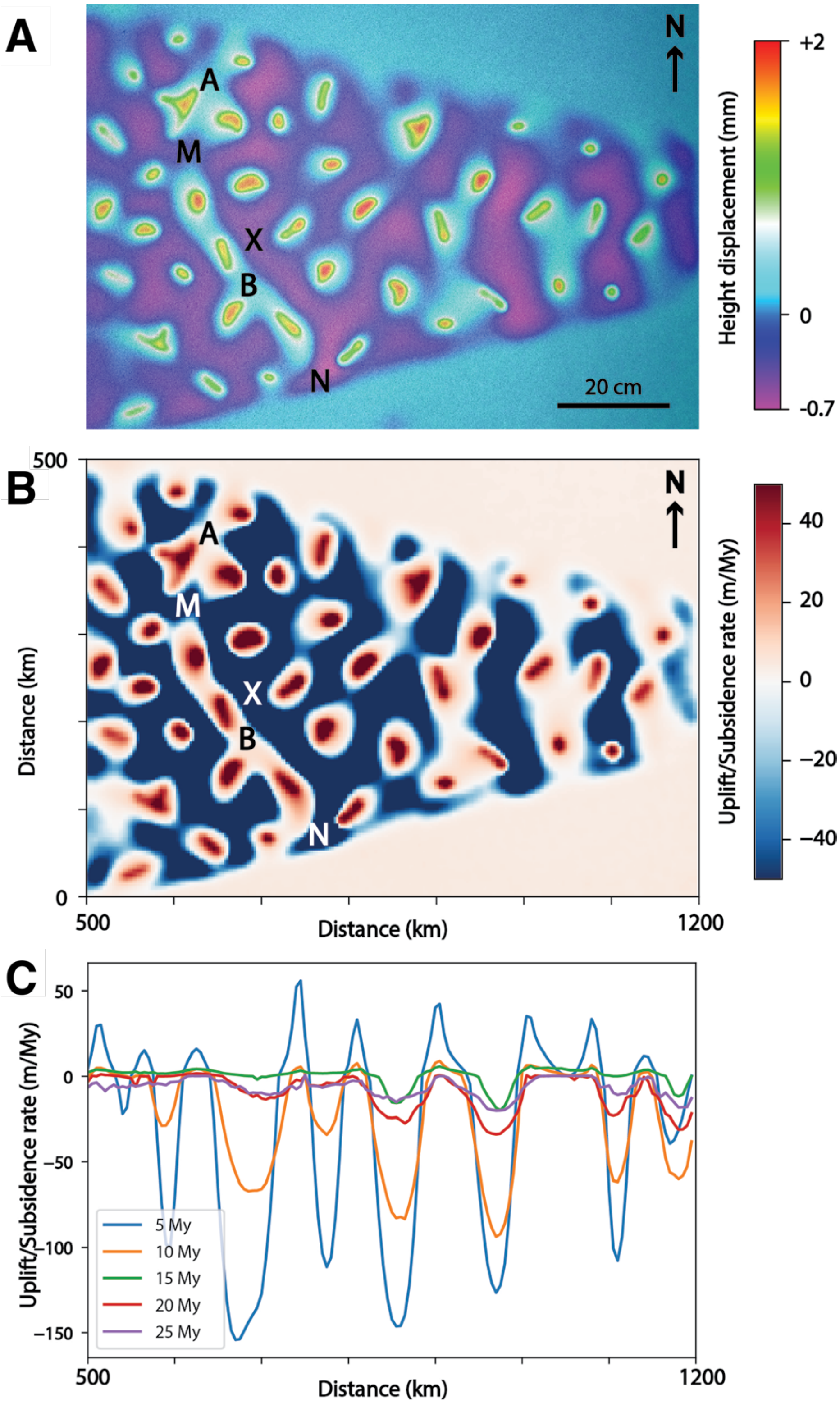

Figure 2. (A) Height displacements of our physical model from time-lapse stereo surface recordings and digital image correlation software. (B) Three-dimensional distribution of uplift/subsidence rates at 5 m.y. (upscaled from the data presented in Fig. 3A). (C) Cross section at basin axis showing the rates of uplift and subsidence at 5, 10, 15, 20, and 25 m.y. The cross section captures the high subsidence/uplift rates typically associated with the initial remobilization of in situ salt (blue and yellow lines for 5 and 10 m.y., respectively) versus later phases of evolution when most of the salt has already been remobilized (green, red, and purple for 15, 20, and 25 m.y., respectively). These trends are observed both in physical models and real case studies in the subsurface including the Mississippi Basin example that is presented in this work (see Fig. 1). Salt-cored highs are indicated by letters A and B in the map views, sedimentary pathways are indicated by letters M and N, and X represents location of starved minibasins.

The salt-tectonic movement within the sink domain in the numerical model is constrained by topographic inputs from the physical model by means of time-lapse stereo surface recordings and associated DIC (digital image correlation) software that captured incremental surface height changes (Fig. 2).

Finally, after obtaining results from our numerical model, we compare observations to a real subsurface case study in the Mississippi Salt Basin. The location of the 3-D seismic reflection survey that sourced the interpretations is shown in Figure 1. The prestack time-migrated seismic volume is situated over the east-central portion of the basin, has an area of ~533 km^2, and spans over five salt domes. Information on data acquisition, processing, and interpretation can be found in the supplemental material (see footnote 1).

RESULTS

Numerical Model

The numerical simulations showcased an S2S configuration that was active through 25 m.y. with the following characteristics: (1) sediment supply derived from the uplifting source domain, (2) a sediment transfer domain that bypassed sediments into the basin, and (3) a distal basin with local topography controlled by the effects of salt tectonics (Fig. 3 and Animation 2 in the supplemental material). The results reported herein focus on the description and interpretation of observations made within the sink domain. We use the terms sink and basin interchangeably.

The topography of the sink domain is defined by two stages of basin evolution. Stage 1 (0–15 m.y.) is influenced by the rapid rise of salt diapirs and high subsidence rates within proximal parts of the basin, while Stage 2 (15–25 m.y.) is characterized by a decrease in subsidence and the triggering of sediment bypass toward distal parts of the basin (Fig. 3). During Stage 1, the subsidence rate was 150 m/m.y.; this generated high accommodation in the proximal parts of the basin where extrabasinal sediments gradually infilled subsiding minibasins (Figs. 2 and 3). During Stage 2, subsidence rates fluctuated between 10–50 m/m.y., the proximal minibasins were already infilled, and sediments bypassed toward the east. Sediments infilled proximal minibasins during Stage 1 via line-sourced transport from fluvial systems that transited the transfer zone. Two salt-cored topographic highs (A and B in Fig. 3) partly blocked sediment transport within the sink domain during

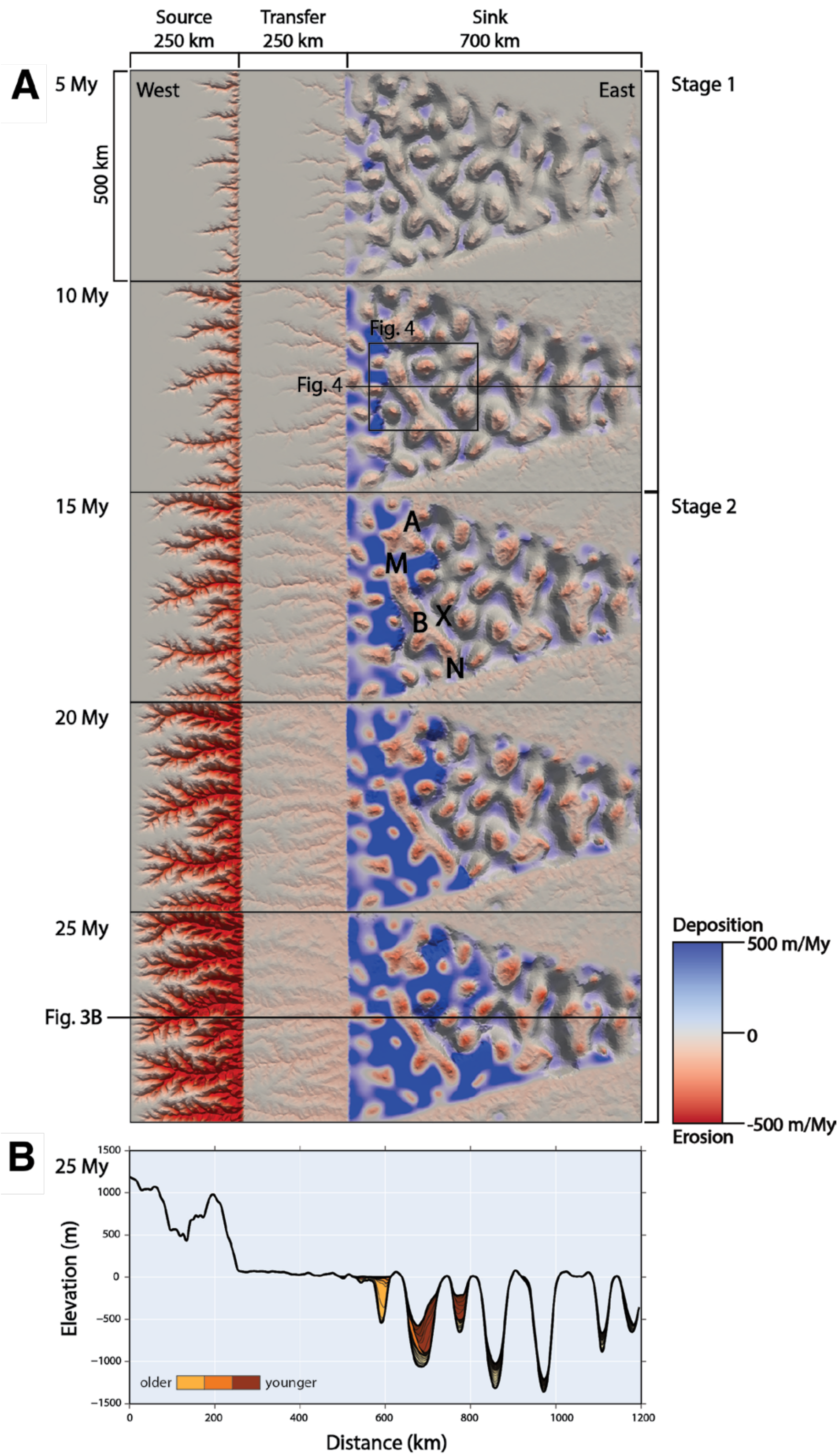

Figure 3. (A) Erosion/deposition maps of the source, transfer, and sink domains at 5, 10, 15, 20, and 25 m.y. Stage 1 (0–15 m.y.), active salt deformation controls basin accommodation and sediments infill the proximal minibasins. Stage 2 (15–25 m.y.) sedimentary pathways (M and N) bypass sediments around salt-cored highs A and B. Parts of minibasin X remain sediment starved. (B) Cross section along northern end of minibasin X showcasing modified stratigraphic patterns (see Fig. 4).

Stage 2 while proximal minibasins were completely infilled with sediments. During this time, the sediment dispersal system became point sourced with the development of two sedimentary pathways that delivered sediments into the central and distal portions of the basin (sediment pathways M and N in Fig. 3). In contrast, the minibasin located to the east of salt-cored high B (minibasin X, see Figs. 3 and 4) remains sediment starved during Stage 2 as salt-cored topographic highs block the free flow of sediments. Cross sections of basin stratigraphy in Figure 4 showcase how the minibasins are gradually filled from proximal to distal (see also Animation 2 in the supplemental material [see footnote 1]). In Stage 1, the depositional dip of strata infilling the minibasins is to the east, suggesting sediment supply from west to east; however, during Stage 2 the depositional dip reverses to the west within the central parts of the sink domain (minibasin X), implying an east to west sediment supply direction (Fig. 4).

Mississippi Salt Basin Case Study

In the Lower Cretaceous interval of the Mississippi Salt Basin, there is a clear heterogeneity of minibasin infills, with initial regional sediment supply as line-sourced from the northwest (Fig. 1). In this example, the salt-cored highs of domes 1 and 2 acted as barriers to sediment routing, generating a local sediment starved minibasin immediately to the southeast. As a consequence, a clockwise sedimentary pathway developed around dome 2 to feed downstream minibasins in an oblique pattern that is divergent from the initial line-sourced sedimentary input from the northwest (Fig. 1). The diversion of sedimentary sources and pathways as shown in the Lower Cretaceous Mississippi case study are common in basins affected by salt tectonics and are believed to be controlled by autogenic effects associated with salt deformation (e.g., Duffy et al., 2020). Despite the known influence of salt tectonics on the development of stratigraphic patterns, few studies have convincingly illustrated how these local topographic controls modify sedimentary pathways and how this impacts the rock record.

DISCUSSION

Tectonic and Local Topographic Controls on Sediment Distribution

Based on the dominant controls, basin evolution was divided into two stages: Stage

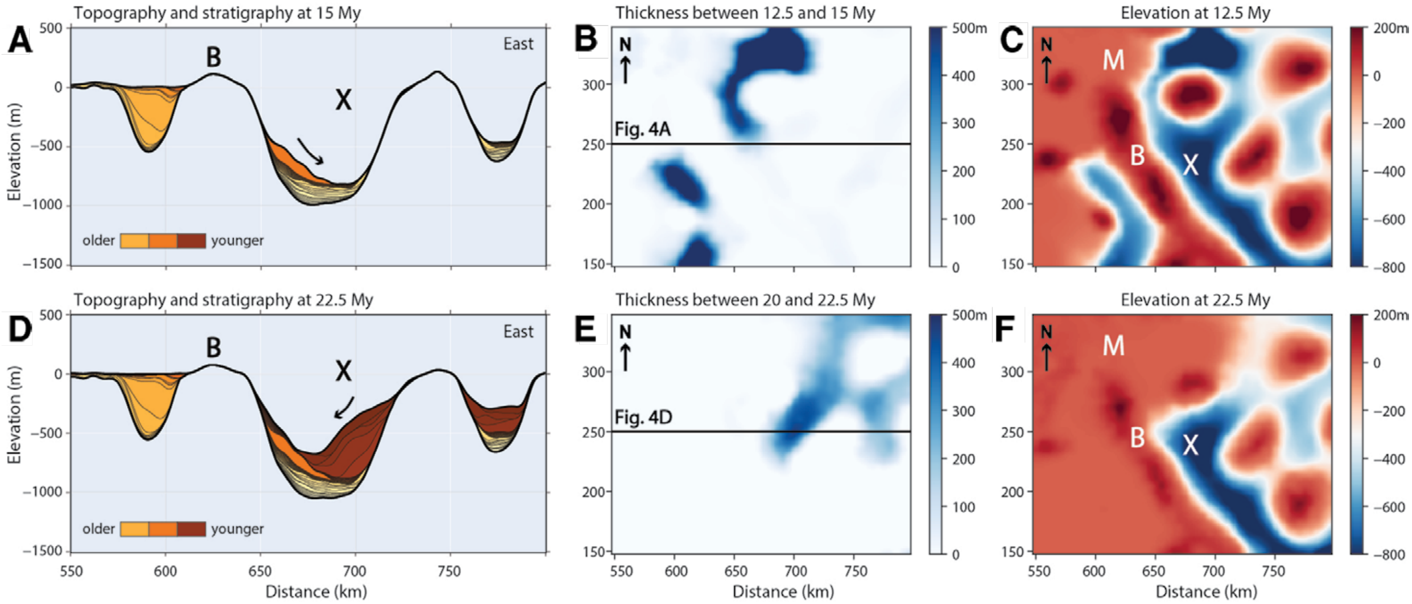

Figure 4. (A)–(C) Cross section, thickness map, and elevation map of a representative interval of Stage 1. B indicates location of salt-cored high, X location of minibasin, and M location of sedimentary pathway. The proximal minibasin to the west is completely infilled by this time; minibasin X is underfilled but stratigraphic bedding is predominantly dipping toward the east, indicating sediment supply from west to east if the cross section is taken as the only reference point for the interpretation. (D)–(E) Cross section, thickness map, and elevation map of representative interval of Stage 2. Minibasin X continues to be underfilled, but there is a change on the dip of stratigraphic beds toward the west, suggesting sediment supply from east to west if the cross section is taken as the only reference point for the interpretation. The thickness and elevation maps illustrate how sediment pathways (M) navigate salt-cored highs (B) to infill the northern portions of minibasin X from the north-northwest during Stage 1 and from the northeast during Stage 2.

1 (0–15 m.y.), which is controlled by active surface deformation associated with major salt movements; and Stage 2 (15–25 m.y.), which is controlled by the resultant local topography and sediment bypass toward the east. The rapid rise of salt-cored highs during Stage 1 (0–15 m.y.), including diapirs and irregularly shaped salt walls, is responsible for the overall basin configuration through time. During this early stage of basin evolution, the development of tortuous sedimentary pathways controlled sediment distribution within the proximal minibasins (Fig. 3A). During Stage 2, the basin relief evolved into a mature minibasin province flanked by salt-cored highs. Sediment dispersal patterns changed from line-sourced to point-sourced as the main depocenters moved basinward and were impacted by the local topography. The numerical model clearly illustrates how stratigraphic architectures varied from proximal to distal portions of the sink domain through time (Fig. 4). Figure 4 records the development of the stratigraphic infilling at different time steps in the model; the display clearly showcases how stratigraphic dips vary notably from east-dipping at 15 m.y. to west-dipping within the margins of minibasin X at 22.5 m.y. These drastic variations in depositional dip could be wrongly described as implying multidirectional sedimentary sources in real case scenarios where only seismic data is used to perform interpretations. However, our numerical model demonstrates that it is possible to explain these changes as due to readjustments of the sedimentary routing system as a response to the evolving mobile-substrate architecture (Fig. 4).

Using A/S Ratio to Predict Stratigraphic Patterns?

The balance or imbalance status between sediment supply (S) and accommodation (A), referred to as the A/S ratio, is widely used to predict stratigraphic patterns and serves as a conceptual basis for most sequence stratigraphic models. The increase of sediment supply or decrease of accommodation promotes regressive successions and basin fills. However, this theory does not hold when we look at the detailed evolution of composite minibasin X in the model (Fig. 4). Our results demonstrate that the stratigraphic patterns of minibasin X are mostly influenced by local, salt-controlled topography, rather than by allogenic changes on sediment supply or accommodation. The concept is rather simple once the numerical model is interrogated; however, in real case scenarios, where subsurface data is low quality or scarce and paleo-topographic reconstructions are not possible, these stratigraphic architectures could be easily misinterpreted. We plan to increase the complexity of the numerical model in future runs by adding flexural subsidence as a response to sediment loading; however, the current results demonstrate that paleo-topographic heterogeneities alone can significantly influence sedimentary pathways and resulting stratigraphic architectures that are preserved in the rock record.

Physical and Numerical Models as Analogs for Real Case Studies

In terms of basin evolution, in our numerical model Stage 1 can be defined as an underfilled and out of equilibrium phase while Stage 2 is trending toward equilibrium with proximal minibasins being infilled with sediments and sedimentary pathways actively developing toward the distal parts of the basin. Minibasin segmentation and sediment underfilling is still dominant in the distal basin during Stage 2 of our model. In the Mississippi Salt Basin, reactive and active diapirism took place from the Early–Late Jurassic to the Early Cretaceous (Johnson et al., 2006). This phase is analogous to Stage 1 in our model, a time period dominated by strong salt movement and uplift that helped define minibasin placement. A second phase of passive diapirism took place in the Mississippi Salt Basin from the Early to Late Cretaceous

(Johnson et al., 2006), and our analysis of subsurface data clearly showcases how during this time sedimentary pathways bypassed salt-cored highs following a trend that diverted from the original line-sourced pattern observed to the northwest (Fig. 1). Processes operating during the Early to Late Cretaceous in the Mississippi Salt Basin are analogous to Stage 2 of our model where proximal parts of the system are infilled by sediments while new sedimentary influx is rerouted around diapirs or salt-cored highs toward the distal basin (Figs. 1 and 3).

CONCLUSIONS

Our modeling results suggest that: (1) salt tectonics plays a key role in setting up the basin configuration and determining the sediment routing within the sink domain, (2) the evolution of local salt-related topography strongly controls the stratigraphic patterns within individual minibasins, and (3) it is possible to use physical and numerical models as analogs for real case subsurface case studies. The dramatic changes of stratigraphic patterns within a minibasin don't need to be linked to allogenic controls and can simply reflect a local response to salt tectonics. Our study emphasizes the importance of reconstructing paleotopography to understand sediment routing systems, especially in basins that developed above mobile substrates such as salt. Our methodology of integrating physical tectonic modeling and S2S numerical modeling provides new ideas on how to quantitatively predict the stratigraphic patterns preserved within salt-bearing basins. It is our intention to continue increasing the complexity of the numerical model by incorporating flexural subsidence as a response to sediment loading in our next batch of models. Salt tectonics, and the geological processes that operate within salt-bearing basins, have been predominantly the subject of study of geoscientists working in industry and applied research given the economic relevance that these basins have for oil and gas exploration. The overemphasis on proprietary resource assessment within these basins has left a gap in the understanding of some of the fundamental processes operating in salt-bearing basins that impacted Earth's evolution and therefore there is a need to pursue additional fundamental research using a more academic approach.

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THE GEOLOGICAL SOCIETY OF AMERICA®
CONNECTS 2023
15–18 October
Pittsburgh, Pennsylvania, USA

Important Dates

Now Open: Abstracts submissions open 1 May

Now Open: Non-technical event space/event listing system

June: Housing opens

Early June: Registration and Travel Grant applications open

6 June: Meeting room request deadline (fees increase after this date)

25 July: Abstracts submission deadline

August: Student volunteer program opens

13 September: Early registration deadline

13 September: GSA Sections Travel Grants deadline

20 September: Registration and student volunteer cancelation deadline

20 September: Housing deadline for discounted hotel rates

David L. Lawrence Convention Center / © 2015 JP Diroll.

OFFICIAL GSA LOCATIONS

David L. Lawrence Convention Center (DLCC)
1000 Fort Duquesne Blvd. | Pittsburgh, PA 15222, USA

The Westin Pittsburgh at DLCC
1000 Penn Ave. | Pittsburgh, PA 15222, USA

Omni William Penn Hotel
530 William Penn Place | Pittsburgh, PA 15219, USA

Keep Our Meeting Respectful and Inclusive

GSA strives for a professional, respectful, and inclusive environment at all our events, including meetings, field trips, short courses, and other GSA-sponsored programs. Creating a positive environment enables full participation and a sense of belonging, which in turn foster open dialogue, networking, and the productive exchange of scientific ideas.

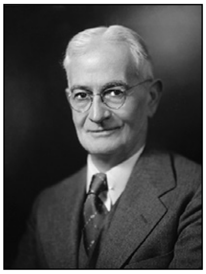
EVENTS CODE OF CONDUCT

GSA's Events Code of Conduct (Events Code) lists "dos and don'ts" for all events, including a strict prohibition against discrimination, harassment, and bullying. The Events Code applies to all participants, including registrants, guests, volunteers, exhibitors, staff, and service providers. Meeting attendees are required to read and sign the Events Code as part of the registration process. For additional information, go to the ethics homepage at **www.geosociety.org/ethics.**

RESPECTFUL INCLUSIVE SCIENTIFIC EVENTS (RISE)

GSA established RISE in 2016 as a visible way to bring our Events Code to life. Conspicuous posters remind participants of our conduct standards and how to report concerns. GSA takes all concerns seriously and has robust procedures to ensure that appropriate follow up occurs, including ample resources to field complaints. These include staffing a RISE office at our annual meeting and making sure that dozens of trained RISE Liaisons are on hand to respond if they receive a complaint or see a potential violation. In 2023, GSA is rolling out a new hotline, hosted by a third party, which enables event participants to speak up anonymously. Additional details can be found at **http://geosociety.ethicspoint.com/.**

Pardee Keynote Symposia



Joseph Thomas Pardee

P1. **Land of Our Ancestors Submerged by a Lake of Betrayal**

Convenors: Patrick Burkhart; Joe Stahlman; Renee M. Clary; Stephen Boss; William Andrews; Christina DeVera

We propose to show two documentaries conveying a broader discussion than the simplistic focus upon flood control. First viewing: *Land of Ancestors* (1991), followed with discussion on experience of the Seneca. Second viewing: *Lake of Deception* (2016), followed with reactions, concerns, discussion of lessons, and envisioning the future.

P2. **Spotlight on Positive and Diverse Female Role Models**

Endorsements: *Association for Women Geoscientists; GSA Continental Scientific Drilling Division; GSA Energy Geology Division; GSA Environmental and Engineering Geology Division; GSA Geoarchaeology Division; GSA Geobiology and Geomicrobiology Division; GSA Geochronology Division; GSA Geoinformatics and Data Science Division; GSA Geology and Society Division; GSA Geophysics and Geodynamics Division; GSA Hydrogeology Division; GSA Karst Division; GSA Limnogeology Division; GSA Marine and Coastal Geoscience Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Planetary Geology Division; GSA Quaternary Geology and Geomorphology Division; GSA Soils and Soil Processes Division*

Convenors: Abigail Burt; Jennifer Nocerino; Karen Fryer

This session spotlights diverse women who succeeded on their own terms, took risks, and dared to fail. These diverse speakers will come from a broad range of career interests, employment types, and backgrounds. There will be invited speakers, an animated story map, and short video clips of voices from around the globe. These amazing mentors and role models will challenge assumptions, share their stories, and demonstrate that there are women who look like you in a wide range of geoscience careers. The session will be followed by the popular Women in Geology Mentor Program.

P3. **Addressing Society's Urgent Need for Critical Minerals; From Policy to Practice**

Endorsements: *GSA Geology and Society Division; GSA Energy Geology Division; GSA Environmental and Engineering Geology Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Geology and Public Policy Committee; Securing America's Future Energy (SAFE) Center for Critical Minerals Strategy; International Association for Promoting Geoethics*

Disciplines: Geoscience and Public Policy, Energy Geology, Economic Geology

Convenors: Lily Jackson; Erin Phillips; Franciszek Hasiuk; Danielle N. Woodring; James Heller

This symposium will highlight the multidimensional topics facing society pertaining to critical minerals. Expert speakers will address current circumstances surrounding critical minerals and policy, geopolitics and national security, roadblocks to new mining ventures, permitting processes and NEPA, and social and environmental justice. Audience members will be engaged throughout the session via interactive polling. Following talks from invited speakers, join us for a moderated panel discussion in this interactive symposium.

P4. **Encouraging Positive Mental Health in the Geosciences**

Endorsements: *International Association for Geoscience Diversity; U.S. National Committee for Geological Sciences; U.S. National Committee for Psychological Sciences; U.S. National Committee for Soil Sciences; U.S. National Committee for Quaternary Research; U.S. National Committee for Geodesy and Geophysics; GSA Continental Scientific Drilling Division; GSA Environmental and Engineering Geology Division; GSA Geoarchaeology Division; GSA Geochronology Division; GSA Geoinformatics and Data Science Division; GSA Geology and Health Division; GSA Geology and Society Division; GSA Geophysics and Geodynamics Division; GSA Geoscience Education Division; GSA Hydrogeology Division; GSA Limnogeology Division; GSA Marine and Coastal Geoscience Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Planetary Geology Division; GSA Quaternary Geology and Geomorphology Division*

Convenors: Jennifer Nocerino; Ester Sztein; Marjorie A. Chan; Jennifer Lansford

Geoscientists are frequently isolated in the field, the laboratory, and in learning environments. COVID, virtual lessons, and meetings have increased these feelings of exclusion and/or isolation. Discrimination due to gender, race, and/or disability, along with hidden disabilities such as chronic illness and mental health issues have increased dramatically, taking a toll on our community. This session intends to raise awareness of the challenges experienced by many geoscientists; explores the signs seen in those that are struggling; and gives examples of what universities, companies, and colleagues can do to create a safe working environment conducive to good mental health.

P5. **Past, Present, and Future of Waste Management**

Endorsements: *GSA Environmental and Engineering Geology Division; GSA Energy Geology Division; GSA Geology and Health Division; GSA Geology and Society Division; GSA History and Philosophy of Geology Division; GSA Hydrogeology Division; GSA Soils and Soil Processes Division*

Advocate: Syed Hasan

Environmentally safe management of waste has become a global issue. The complex stream of societal waste that includes municipal solid waste, hazardous, medical, electronic, and radioactive wastes whose safe management has been presenting scientific, economic, and political challenges to all countries. This session will bring national and international experts to discuss the issues and offer potential solution.

Call for Papers

Abstracts deadline: 25 July

SUBMITTING AN ABSTRACT

- **Abstracts form opens:** Monday, 1 May
- **Submission deadline:** Tuesday, 25 July
- **Abstract non-refundable submission fee:** GSA MEMBERS: professionals: US$60; students: US$25. NON-MEMBERS: professionals: US$80; students: US$50.
- To begin your submission, go to **community.geosociety.org/gsa2023/program/technical**
- For detailed guidelines on preparing your submission, please view "preparing an online submission" at **https://gsa.confex.com/gsa/2023AM/categorypreparation.cgi.**

TWO-ABSTRACT RULE

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

POSTER PRESENTERS

- You will be provided with one horizontal, free-standing 8-ft-wide by 4-ft-high display board and Velcro for hanging your display at no charge.
- AM Session: Posters will be displayed 9 a.m.–1 p.m., with presenters present 11 a.m.–1 p.m.
- PM Session: Posters will be displayed 2–6 p.m., with presenters present 4–6 p.m.

ORAL PRESENTERS

The normal length of an oral presentation is 12 minutes plus three minutes for questions and answers. You *must* visit the Speaker Ready Room at least 24 hours before your scheduled presentation. All technical session rooms will be equipped with a PC Windows 10/MS Office 2021. Presentations should be prepared using a 16:9 screen ratio.

IN-PERSON ONLY

Technical sessions (poster and oral) will be in-person only at GSA Connects 2023; however, all topical sessions, discipline sessions, Pardee Keynote Symposia, Noontime Lectures, and the Presidential Address will be recorded and available for on-demand viewing after the meeting.

ABSTRACTS SUBMISSION: EXPECTED BEHAVIOR

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

Special Lectures

Sunday, 15 Oct., noon–1:30 p.m.

GSA Presidential Address:
Christopher (Chuck) Bailey,
"*Geoscience at the Confluence*"

Tuesday, 17 Oct., 12:15–1:15 p.m.

Susan L. Brantley, 2023 Michel T. Halbouty Distinguished Lecture:
"*How Fracking Affects Our Water*"

Register Today for Best Pricing

Deadline: 11:59 p.m. MDT on 13 Sept.
Cancelation deadline: 11:59 p.m. MDT on 20 Sept.
community.geosociety.org/gsa2023/registration

EVENTS REQUIRING TICKETS/ADVANCE REGISTRATION

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

TRAVEL GRANTS

You still have time to apply for grants. Various groups are offering grants to help defray your costs for registration, field trips, travel, etc., for GSA Connects 2023. Check the website at **community.geosociety.org/gsa2023/travel-grants** for application and deadline information. Note: Eligibility criteria and deadline dates may vary by grant. The deadline to apply for the GSA Student Travel Grant is 13 Sept.

CONTINUING EDUCATION UNITS

GSA offers continuing education units (CEUs) valid toward continuing education requirements for employer, K–12 school, or professional organizations. Please check the meeting website after the meeting to download your CEU certificate.

STUDENT VOLUNTEERS

The Student Volunteer Program will open in August. Earn complimentary registration when you volunteer to work for at least 10 hours, plus get an insider's view of the meeting.

Please sign up as a volunteer before you register for the meeting, unless you want to reserve a space in a field trip or short course. Detailed information can be found at **community.geosociety.org/gsa2023/registration/volunteers.**

CHILDCARE

GSA will not be providing childcare services within the Convention Center in Pittsburgh; however, we have teamed up with a local childcare service that offers individual reservations based on your needs. The cost is the responsibility of the attendee. For more information, please visit jovie.com. To speak with the owner specifically, please use this link to schedule a meeting: https://calendly.com/nrimer, Nikki Rimer, Owner. 412-837-2353 nrimer@jovie.com.

MEDIA REGISTRATION

Complimentary meeting registration is available to journalists and public information officers (PIOs) from geoscience-related organizations. Media registration provides access to all scientific sessions, the Resource and Innovation Center, and the newsroom. Get information about eligibility and request media credentials at **community.geosociety.org/gsa2023/connect/press/registration.**

Meet With Us on Social Media

twitter.com/geosociety
instagram.com/geosociety
https://www.linkedin.com/company/geological-society-of-america
facebook.com/GSA.1888
community.geosociety.org

Follow hashtag #GSA2023


Special Paper 555
THE GEOLOGICAL SOCIETY OF AMERICA®
Tectonic Evolution of the Sevier-Laramide Hinterland, Thrust Belt, and Foreland, and Postorogenic Slab Rollback (180–20 Ma)
Edited by John P. Craddock, David H. Malone, Brady Z. Foreman, and Alexandros Konstantinou

Hotels

GSA has selected several hotels within close proximity of the Pittsburgh Convention Center (DLCC). Rates are in U.S. dollars and do not include the current applicable tax of 14% per room per, per night.

Hotel	Rate	Distance to DLCC	Parking
The Westin Hotel (HQ Hotel)	$245	0.2 mi	Self: $ hourly, $28 daily Valet: $41
Omni William Penn Hotel	$239	0.5 mi	Self: $20 daily Valet: $38
Kimpton Hotel Monaco	$239	0.3 mi	Valet: $38
Embassy Suites by Hilton	$199	0.5 mi	Valet: $38
Drury Plaza Hotel	$209	0.4 mi	Valet: $37

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

Pittsburgh Hotel Map

1. **DRURY PLAZA HOTEL PITTSBURGH DOWNTOWN**
2. **EMBASSY SUITES BY HILTON PITTSBURGH DOWNTOWN**
3. **KIMPTON HOTEL MONACO PITTSBURGH**
4. **OMNI WILLIAM PENN HOTEL**
5. **THE WESTIN PITTSBURGH**

GeoCareers: Your Guide to Career Success

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

GEOCAREERS DAY

(Sunday)

Direct access to company representatives

- Career Workshop
- Company Information Booths
- Mentoring Roundtables
- Panel Luncheon

GEOCAREERS CORNER

(Sunday–Wednesday)

Career guidance and information

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

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

Visit website **community.geosociety.org/gsa2023/geocareers** for event details, dates, and times.

Be a Mentor, Share Your Experience

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

Drop-in Mentor: This one-on-one mentoring activity takes place in the GeoCareers Corner. Students have 30 minutes to ask questions and seek advice from a mentor. Approximately 28 mentors are needed.

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

On To the Future Mentor: On To the Future (OTF) mentors are paired with a student who is a part of the OTF program, which supports students from diverse groups. Mentors will meet with their mentee each day of the meeting, introduce the mentee to five contacts, and share their professional experiences in the geosciences. Matching will be completed using an online platform. Approximately 75 mentors are needed.

Résumé or CV Mentor: Résumé mentors are matched with a student on-site to review the student's résumé or curriculum vitae (CV). Consultations take place for 30 minutes in the GeoCareers Corner in a one-on-one setting. Approximately 28 mentors are needed.

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

Complete the Mentor Interest Form to become a mentor at: **https://forms.gle/jgw9x3bGhbaiV2cP7.**

Transportation and Travel

There are many ways to get around Pittsburgh... car, bus, taxi, bike, pedicab, boat, or your own two feet! Check out all the ways to travel around the city at **www.visitpittsburgh.com/plan-your-trip/transportation.**

Flying? You're going to love Pittsburgh International Airport. PIT, in airport parlance, is a growing world-class facility that serves more than 8 million passengers annually and offers flights to more than 50 nonstop destinations on multiple carriers. Learn more at **www.flypittsburgh.com.**

Non-Technical Event Requests

Deadline for first consideration: **6 June**

Please let us know about your non-technical events via our online event space & event-listing database at **community.geosociety.org/gsa2023/plan-event.** Space is reserved on a first-come, first-served basis; in order to avoid increased fees, you must submit your request by Tuesday, 6 June. Event space/event listing submissions should be used for business meetings, luncheons, receptions, town halls, etc.

1. For events held at the David L. Lawrence Convention Center (DLCC) or The Westin Pittsburgh at DLCC (HQ Hotel) or Omni William Penn Hotel (Monday evening only).
2. For off-site events (events that are being held at another location in Pittsburgh that you have arranged on your own).
   Meeting room assignments will be sent out in July.

Scientific Field Trips

Descriptions and leader bios are online at **community.geosociety.org/gsa2023/field.**
ECP—early-career professional.

401. **Underground Treasures: Exploring the Stunning Caves of Tennessee and Kentucky.** Thurs.–Sat., 12–14 Oct. US$957. Cosponsor: *Edmunds Central School District*. Leader: Spencer Cody, Edmunds Central School District, Spencer.Cody@k12.sd.us.

Join us on an exciting three-day adventure in discovering some of America's most remarkable underground geological wonders as we experience the caves of Tennessee and Kentucky. Day one will begin in Atlanta, where we will load our 15 passenger van. Our first stop will take us deep into Lookout Mountain above Chattanooga, Tennessee, to see the tallest and deepest underground waterfall in the United States, Ruby Falls. We will continue into the foothills of the Smoky Mountains to explore the Craighead Caverns cave system and see The Lost Sea, America's largest underground lake. Our final stop will take us to Tuckaleechee Caverns below Smoky Mountains National Park with its remarkable stadium-size "Big Room" of formations. We'll spend the night in Knoxville. Day two will take us up into Kentucky to Bowling Green's Lost River Cave through chert and limestone formations traversing the underground river via boat. Additionally, Lost River Cave has a remarkable blue hole formation that sinks into a deeper underground river. Next, we will head up to Cave City to tour Crystal Onyx Cave. We will then head into Mammoth National Park to explore the remarkable formations of Great Onyx Cave on a lantern tour with lodging in Cave City. On day three, we will conclude our caving adventure in grand fashion with the Grand Historic Tour of Mammoth Cave to learn about the cave's amazing geological features and interesting history. After the tour, we will head up to Pittsburgh to drop off field trip attendees at the convention center.

402. **Examining Late Paleozoic Paleosol Records across Outcrop to Nanoscales for Climatic and Environmental Signals.** Fri.–Sat., 13–14 Oct. US$503. Cosponsor: *Sedimentary Geology Division*. Leader: Amy Weislogel, West Virginia University, amy.weislogel@mail.wvu.edu.

This is a hybrid field trip/workshop aimed at advancing the application of automated mineralogy to paleosol characterization. During day 1, we will visit approximately four to five Upper Pennsylvanian–lowermost Permian outcrops in southwestern Pennsylvania (mainly Dunkard Group) that display a range of paleosols records (Vertisols, Oxisols, Spodosols, and Histosols) of late Paleozoic ice age environmental change. During day 2, participants will be provided with a compositional assessment of the paleosols we visited, including bulk-rock mineralogy/geochemistry and automated mineralogy, to discuss data analysis and interpretation. If time permits en route back to Pittsburgh, we will visit additional outcrops to continue this discussion. During day 1, for each outcrop, we will examine macroscale features augmented with smaller-scale observations from optical microscopy. We will discuss sampling strategy/protocols for spatially nested observations from outcrop- to nanoscale. During day 2, we will evaluate traditional bulk-rock geochemistry versus automated mineralogy and consider potential future avenues of research that can leverage a "big data" approach to environmental reconstruction from paleosols using automated mineralogy, including assessment of environmental indices. This trip will appeal to sedimentologists interested in the application of cutting-edge automated mineralogy to paleosol characterization, as well as to sedimentary geologists more broadly interested in late Paleozoic ice age climate dynamics, terrestrial/critical zone deposits, and terrestrial paleobiology. Additionally, some paleosols in the region, particularly those associated with coal horizons, have been shown to host high concentrations of critical elements that are potential feedstock for batteries in the transition to green-energy or low-to-no carbon energy systems.

403. **Hydrology and Geology of the Fernow Experimental Forest.** Fri.–Sat., 13–14 Oct. US$755. Leaders: Jill Riddell, West Virginia University, jlriddell@mix.wvu.edu; Benjamin Rau; Christopher Russoniello.

The Fernow Experimental Forest (FEF), in Parsons, West Virginia, was set aside in 1934 as a research forest within the Monongahela National Forest. In 1950, small head watersheds in the western portion of FEF were delineated and subjected to different silvicultural treatments. Temperature, discharge, and water chemistry have been monitored in these watersheds for approximately 60 years. The bedrock geology dips to the east with layered sandstone and limestones exposed in the west and east, respectively, of NNE-flowing Elk Lick Run. Small-gauged head watersheds discharge into Elk Lick Run, which discharges into the Cheat River. New research in the FEF seeks to monitor stream temperature in the small head watersheds throughout the FEF and in Elk Lick Run to evaluate the effects of watershed morphology and bedrock geology on stream temperature. This field trip will consist of stops at established watersheds in the FEF to

INDUSTRY TRACKS

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

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

demonstrate the effectiveness of robust long-term data collection; road cuts and outcrops of the bedrock geology to observe the underlying units in the FEF; the confluence of the Cheat River to observe the scale of the hydrology of the region; and the Timber and Watershed Laboratory in Parsons, West Virginia, to showcase the historical and modern significance of research forests to the scientific community. We invite all persons with an interest in hydrology, geomorphology, geochemistry, or sedimentary geology to join us to explore and discuss the complex relationships between surface hydrology and bedrock geology. This trip is accessible to persons able to ride in a car.

404. **Geologic Setting and Organic Architecture of Fallingwater, Frank Lloyd Wright's Masterpiece.** Fri., 13 Oct. US$127 professionals and early-career professionals; US$20 students. Cosponsor: *Earth Science Excursions, LLC*. Leader: Fred Zelt, fbzelt@aol.com.

We will tour the interior and grounds of Fallingwater, a cantilevered residence that was built atop Pennsylvanian Pottsville Sandstone and a waterfall on Bear Run in the scenic Laurel Highlands east of Pittsburgh. Fallingwater is a United Nations Educational, Scientific and Cultural Organization (UNESCO) World Heritage Site, has received many architectural honors, and is regarded by many as Frank Lloyd Wright's architectural masterpiece. The house and grounds represent exemplary blending of the natural environment with a structure that fulfilled the requirements of the original owners. In addition to being built on a sandstone outcrop, local sandstone was built into the exterior and interior of Fallingwater. For example, the living room was designed so that natural sandstone crops out from the floor in a focal point near the fireplace. This field trip is an opportunity to explore one of the most famous structures in the world in October when deciduous trees on the grounds and in the Laurel Highlands should be showing autumn colors.

We encourage student member participation with a reduced registration fee for this trip. Anyone is welcome regardless of ability. The trip offers students an opportunity to meet with their peers, expand their network, as well as interacting with a group of professionals with diverse viewpoints. They will have an opportunity to learn in the field with an expert who will highlight local geology. We'll end the day with the option of dinner together and further discussion.

405. **Central Pennsylvania Springs and Karst in Honor of William B. White.** Sat., 14 Oct. US$168. Cosponsors: *Laura Toran; Ellen Herman*. Leader: Laura Toran, Temple University, ltoran@temple.edu.

Attendees will visit classic Pennsylvania karst features where some of the foundational karst work in the United States was conducted by Will White and his colleagues and students. We will examine some of the springs described by Shuster and White in their 1971 publication and compare the results of that study, which relied on biweekly sampling, to more recent high-frequency sampling. Data loggers and stormwater sampling used to characterize springs more recently will be demonstrated. We will also visit caves, sinkholes, and a large and well-known road cut through the karst-forming Ordovician carbonates of the folded Valley and Ridge physiographic province.

406. **Drake Well: Understanding the Birthplace of the Oil Age and its Historical Human and Environmental Impacts.** Sat., 14 Oct. US$144. Cosponsors: *History of Earth Sciences Society; GSA History and Philosophy of Geology Division*. Leaders: Renee Clary, Mississippi State University, rclary@geosci.msstate.edu; Stephen Boss; William R. Brice; Christy Hyman.

Edwin Drake's first commercially drilled oil well in the United States ushered in an "Oil Age" that impacted the trajectory of geology and humankind. Renowned historian of petroleum geology, Dr. William "Bill" Brice, leads the field excursion to the Drake Well Museum and Park in Titusville, Pennsylvania, for a day-long exploration of the immediate impact of oil production in Pennsylvania and the long-term legacy of the Oil Age for humanity. The state park includes multiple exhibits detailing the geology and technology of the Drake Well—including some of the historic indigenous oil-seep sites, a full-scale replica of Drake's original drilling shack and derrick, plus several other original outdoor equipment exhibits. We will examine local stratigraphy and learn why there would have been no Drake Well discovery if Drake sited his well ~100 m in any direction from where it is. Other excursion stops include William Andrew "Uncle Billy" Smith's gravesite (the 1859 driller of the Drake Well), the Edwin Drake grave and memorial, and Pithole, the remnants of an oil boom town that grew into a major population center and the third largest Pennsylvania post office in a few quick years. Dr. Christy Hyman (Mississippi State University) interweaves petroleum's legacy—both positive and negative—to address the landscape, human impacts, and environmental justice issues of the petroleum industry.

407. **Overview of Environmental and Engineering Geology and Geohazards with a Virtual Field Trip to Landslides Near Pittsburgh.** Sat., 14 Oct. US$205. Cosponsors: *Pittsburgh Geological Society; GSA Environmental and Engineering Geology Division*. Leader: James Hamel, jvhamel3918@gmail.com.

In an effort to expose GSA's On To the Future students and young professionals to career possibilities in the applied geosciences, the Association of Environmental and Engineering Geologists (AEG) is hosting this applied geosciences career discussion and virtual field trip (VFT) to the Interstate Route 79 and Toms Run Nature Reserve Landslide Areas, 9 miles (14 km) northwest of Pittsburgh. This career presentation and VFT are endorsed by the Pittsburgh Geological Society (PGS) and the GSA Environmental and Engineering Geology Division. AEG members will present a brief overview of applied geoscience careers in environmental and engineering geology, geohazards, and landsliding in southwestern Pennsylvania. The field trip leader will lead participants through the VFT, with questions and discussion at the end of each trip segment. This Google Earth–based VFT was prepared in lieu of an in-person field trip planned as part of the 75th anniversary celebration of the PGS in March 2020, which was canceled due to COVID-19. The in-person field trip was run in April 2022, and its guidebook is available on the PGS website: https://pittsburghgeologicalsociety.org/uploads/pubs/Interstate_Route_79_and_Toms_Run_Nature_Reserve_Landslide_Areas_North_of_the_Ohio_River_and_Northwest_of_Pittsburgh_March_2022.pdf. Participants will be provided electronic access to the PGS VFT and guidebook along with 1–2 page handouts on environmental and engineering geology, geohazards, and landsliding in southwestern Pennsylvania. There will be no formal GSA guidebook. Participants should bring a laptop computer and provide a Gmail address (for access to the PGS VFT) to the trip leader a minimum of two weeks prior to the event.

408. **Paleoenvironmental and Tectonic Implications of an Upper Devonian Glaciogenic Succession from East-Central West Virginia, USA.** Sat., 14 Oct. US$201. Leaders: Frank Ettensohn, University of Kentucky, fettens@uky.edu; D. Clay Seckinger; David P. Moecher; Cortland F. Eble.

The trip examines a single, long exposure along U.S. Highway 48 near Bismarck in east-central West Virginia that includes upper parts of the Hampshire Formation and overlying parts of the lower Price Formation, all of which are Late Devonian in age. Lower parts of the Price Formation (Rockwell Member) contain a controversial unit with diamictites of likely glaciogenic origin. The mere presence of the diamictites, as well as the age and source of contained clasts and matrix, based on detrital zircon provenance, suggests important implications relative to coeval tectonism and unroofing of the orogen. Moreover, unusual sedimentary facies and soft-sediment deformation in parts of the Rockwell Member may be related to synsedimentary activity on the nearby West Virginia Dome. The sedimentary succession in this exposure is unique and provides opportunities to discuss interpretations related to age, sedimentary facies, eustasy, glaciation, local structural activity, and regional tectonism.

409. **The Cultural Geology of Youngstown: Geological Setting, Building and Decorative Stones, Iron and Steel Heritage, and More.** Sat., 14 Oct. US$203. Leaders: Joseph Hannibal, jhannibal@uakron.edu; Brigitte Petras; Colleen McLean.

This trip will provide an overview of the geological setting of Youngstown, Ohio, along the Mahoning River and the major building and decorative stones used in Youngstown, notably the marble cladding of the Butler Museum of American Art (which has seen some deformation), the Kasota stone (Oneota Dolostone) used for St. Columba Cathedral (which is full of fossil burrows), and stones used in beautiful Oak Hill Cemetery. It will also include visits to the Museum of Industry and Labor, which includes exhibits related to the iron and steel industry of the region, and the Clarence R. Smith Mineralogy Museum. The trip will include discussion of the relationship of Youngstown with Pittsburgh and the canal system that once linked the two steel cities.

410. **The Warren Hamilton Field Trip: Special Geologic Features of Ohiopyle State Park, Pennsylvania.** Sat., 14 Oct. US$160. Cosponsor: *Earth Science Excursions LLC*. Leaders: Fred Zelt, fbzelt@aol.com; Jim Shaulis; Frank Pazzaglia.

With waterfalls and the deepest gorge in Pennsylvania, Ohiopyle State Park provides opportunities to observe a variety of habitats, three-dimensional exposures of the Pennsylvanian sandstone most responsible for shaping Laurel Highlands landscapes, and evidence for the relationship between Pleistocene–Holocene climate cycles, landscape evolution, and knickpoint migration rate in a periglacial highland setting. Ohiopyle is one of the most popular public lands in the region, and the relationships among geology, ancient climates, and the landscape can be observed on an excursion to some of the most scenic natural features of the park: Baughman Rock Overlook, Cucumber Falls, Ohiopyle Falls, Meadow Run Waterslide, and Youghiogheny River Entrance Rapid. We will visit outcrops of fluvial/deltaic sandstones within the Pennsylvania Pottsville Formation and discuss evidence for penecontemporaneous deformation of this part of the Allegheny Plateau during the Alleghenian orogeny. Mapping of Pleistocene river terraces and cosmogenic age dating conducted here in the last few years by Lehigh University geologists have greatly increased current understanding of the evolution of this special landscape. Our hike will include a visit to a 6-m-long *Lepidodendron* fossil. We will walk for as much as 5 km on a sidewalk and hiking paths that have hills, steps, roots, holes, rocks, and uneven ground.

411. **A Land of Ice and Water: An Accessible Introduction to Glacial and Watershed Processes in Western Pennsylvania.** Thurs., 19 Oct. No cost. Cosponsor: *The International Association for Geoscience Diversity (IAGD)*. Leaders: Jennifer Piatek, Central Connecticut State University, piatekjel@ccsu.edu; Anita Marshall; Yesenia Arroyo.

We will explore the geology of western Pennsylvania and the impacts of water on the region's geomorphology in this day trip, which will leverage accessible field trip stops to provide all attendees with an opportunity to interact with the local geology, hydrology, and history. The first part of the trip will explore local and regional geological history visible from Frick Park, located within the Pittsburgh city limits, via landscapes, overlooks, and outcrops along paved trails and park roads. After this introduction to the local geology, we will visit two passive treatment systems, one at the Pittsburgh Botanic Garden and one at Wingfield Pines, which were installed to treat net-acidic and net-alkaline coal mine drainage, respectively. Participants will have an opportunity to learn about passive treatment system design, engage in water sampling and discuss their analysis with local experts to examine the effectiveness of these treatment systems.

This trip is sponsored by the International Association for Geoscience Diversity (theIAGD.org) and is offered at no cost to participants.

Accessibility: All field trip locations will include wheelchair-accessible options: stops in Frick Park will utilize park trails and paths, and will require minimal walking. Restroom facilities will be available at the lunch stop and at the Botanic Gardens.

INDUSTRY TRACKS

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

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

Water-sampling stops are within 250 yards of parking areas and can be accessed on low-slope wide paths that will accommodate mobility devices. Driving time between sites will be approximately 30 minutes.

Accommodations such as ASL interpreters will be provided upon request. Everyone is welcome, but in order to ensure that priority is given to geoscience colleagues with disabilities, an application form is required. Learn more and apply at: https://theiagd.org/2023-accessible-field-trip-land-of-ice-and-water-western-pa/

412. **A Short Tour of the Fluviokarst of Southeastern West Virginia.** Wed.–Fri., 18–20 Oct. US$450. Cosponsor: *West Virginia Geological Survey.* Leaders: John Tudek, hewhocaves@gmail.com; J. Wayne Perkins.

Join us for two and a half days of exploring the exceptional karst of southeastern West Virginia. During this time, we will examine numerous features that make West Virginia southern karst one of the world-class areas for karst exploration. After the close of the conference on the first day, we will travel from Pittsburgh to Lewisburg, West Virginia, passing through and stopping at our newest national park, New River Gorge National Park, and enjoying the view from the overlook at the visitor center. On day two, we will examine some of the many features of the karst in and around the Davis Spring Basin of the Mississippian Period, which is, at ~75 square miles (194 km^2), the largest karst basin in West Virginia. We will visit a few of the passages in the over 100 miles (161 km) of explored caves in the basin and see multiple inlets to the system as well as the primary outlet—Davis Spring. On day three, we will travel back to Pittsburgh through scenic West Virginia, passing through Germany Valley, home to over 60 miles (97 km) of integrated, possibly hypogenic cave development in Cambrian–Ordovician rocks before stopping at Seneca Rocks to see some of West Virginia's most spectacular scenery, where vertical beds of the Tuscarora sandstone rise above the limestone valley below. Following this, we will arrive at Pittsburgh in the early evening.

413. **A Record of the Pleistocene: Periglacial Landforms, Deposits, and Fauna in the Appalachian Highlands of Maryland, West Virginia, and Pennsylvania.** Thurs.–Fri., 19–20 Oct. US$570. Primary leader: Rebecca Kavage Adams, Maryland Geological Survey, rebecca.adams@maryland.gov; coleaders: David K. Brezinski, Maryland Geological Survey, david.brezinski@maryland.gov; Mitzy Schaney, University of Pittsburgh at Johnstown, m.schaney@pitt.edu; Steve Kite, West Virginia University, jkite@wvu.edu.

Pleistocene features will be examined at sites in the Appalachian Plateau region of Maryland, West Virginia, and Pennsylvania. The first day will begin at the Carnegie Museum of Natural History in Pittsburgh, observing Pleistocene fossils collected regionally. While in Pittsburgh, we will view terraces created by glacial Lake Monongahela and then proceed to Morgantown, West Virginia, for a look at fine-grained sediments also deposited by glacial Lake Monongahela. The final stop for the day will be in the Laurel Highlands at Mount Davis in southern Pennsylvania, known for polygonal patterned ground formed in periglacial conditions. The second day will include three stops in the Upper Youghiogheny Basin of West Virginia and Maryland. The first of these will be The Nature Conservancy's Cranesville Swamp. This relict Pleistocene peat bog houses northern flora rare in this region; its pollen record offers a glimpse into climatic changes over the Pleistocene. The second stop will be at the nearby Snaggy Mountain rock maze, the result of frost-heaving in massive Homewood sandstone of the Pottsville Formation. We will view another remnant Pleistocene bog, The Glades, on the way to our fourth and final stop at the Cumberland Bone Cave near Cumberland, Maryland. At this site, a diverse record of Pleistocene fauna was discovered in the early 1900s that is still being studied today.

414. **Coal to Clean Water: Passive and Active Acid Mine Drainage treatment systems in the Pittsburgh Area.** Thurs., 19 Oct. US$113. Leaders: Benjamin Hedin, ben.hedin@hedinenv.com; Rosemary Capo; Robert Hedin.

The Pittsburgh Coal seam has been mined in western Pennsylvania for over 200 years. One consequence of coal mining is the generation of acid mine drainage (AMD) which is responsible for orange and white streams in the Pittsburgh area. The field trip will visit an outcropping of the Pittsburgh coal and three Pittsburgh Coal acid mine drainage (AMD) treatment systems. The trip will highlight different AMD chemistry, due to hydrology, and different treatment technologies. The treatment systems include a passive system treating alkaline AMD with settling ponds and wetlands, a passive system treating acid AMD with limestone, and an active system treating alkaline AMD with hydrogen peroxide.

415. **George Washington's Word Broken: Kinzua Dam and the Seneca Nation.** Thurs.–Fri., 19–20 Oct. US$600. Leader: Patrick Burkhart, Slippery Rock University, patrick.burkhart@sru.edu.

The Treaty of Canandaigua was signed on 11 November 1794, between the United States and the Grand Council of the Six Nations. The 50 signatories included Thomas Pickering, agent for George Washington, and Chief Corn Planter (Seneca, Gaiänt'wakê), as well as others of the Cayuga, Mohawk, Oneida, Onondaga, and Tuscarora Tribes of the Iroquois Confederacy. This agreement secured Indigenous Nation lands, including the Allegheny River Watershed, in addition to promises of perpetual peace and friendship. Kinzua Dam (U.S. Army Corps of Engineers), completed in 1965, displaced 600 Seneca members, condemning 10,000 acres that constituted one third of their land, including valuable farmland and fisheries. The Seneca Nation still holds an annual event to Remember the Removal, after the Treaty of Canandaigua was broken by the JF Kennedy Administration. You will see the story of Kinzua Dam, as it is well told in the impressive new Seneca Iroquois Museum. The Long House accommodations for the overnight are also on that property. Watch this trailer to enhance your understanding: https://www.lakeofbetrayal.com/. The Treaty of Canandaigua, one of the first treaties between the United States and Indigenous Nations, was broken again by the eviction and the emplacement of the dam. This trip will depart Pittsburgh, follow the Allegheny River to Kinzua Dam, and then traverse Allegany State Park, New York. Indigenous people will welcome us at the Seneca Iroquois Museum in Salamanca, the location where tribal members were presented 3 acres (0.012 km^2) apiece in exchange for the condemnation of their lands. An evening will be spent in a local hotel, providing time for meeting all parties, sharing meals, and engaging in cultural exchange likely to include social dancing, storytelling, and viewing collections. The field trip will review the regional geology of the Allegheny Plateau, including the Salamanca Re-entrant of the Laurentide ice sheet. Participants need to expect rustic accommodations, including a plank bunk, so they must bring a sleeping bag, blanket, and pillow.

416. **Fracking in the Oldest Commercial Oil Field: From Legacy Extraction to Environmental Impacts.** Thurs., 19 Oct. US$160. Cosponsor: *Pennsylvania State University*. Leaders: Susan L. Brantley, Pennsylvania State University, sxb7@psu.edu; Tao Wen.

The oldest commercial oil well was in Pennsylvania, leading the state to be the biggest producer of oil in the country. The resulting boom and subsequent development of oil and gas (as well as coal) left hundreds of thousands of operating, abandoned, and orphaned oil and gas wells and coal mines in the state. Most recently, shale-gas companies drill vertical boreholes that are then bent into horizontal orientations to extract gas from source rock (Marcellus Shale and other formations). High-pressure, high-volume hydraulic fracturing ("fracking") is used to release the gas. Development since 2004 has resulted in more than 10,000 shale-gas wells in the state, returning Pennsylvania to the status of a top gas-producing state. Pennsylvania is also one of the top two states for underground gas storage facilities. Shale gas has kept energy costs low, returning money to landowners and the state, and is now replacing some Russian imports in Europe. This has led to acceptance of shale-gas development by some members of the public but push-back on the part of others who note environmental issues and human health impacts thought to be associated with the industry. This trip will emphasize the interplay between extraction and the environment by visiting a subset of these locations (depending upon timing and permissions): a shale-gas well pad; a brine treatment facility; legacy oil and gas wells; and associations between coal mining and gas drilling.

417. **Post-Glacial Tectonism and Bluff Erosion of Northern Erie County, Pennsylvania.** Thurs., 19 Oct. US$229. Cosponsors: *GSA Planetary Geology Division; GSA Structural Geology and Tectonics Division; GSA Quaternary Geology and Geomorphology Division*. Leaders: Nicholas Lang, National Aeronautics and Space Administration, nicholas.p.lang@nasa.gov; Christopher Dolanc.

This will be a one-day field trip that will explore geologic processes that have shaped northern Erie County, Pennsylvania, since glacial retreat in this region. Emphasis will be placed on (1) evidence for postglacial faulting as exposed in strath terraces along local streams, and (2) rates, styles, and causes of bluff erosion along the Lake Erie shoreline.

418. **Special Geologic Features of the Erie Lakeshore in Northwestern Pennsylvania.** Thurs., 19 Oct. US$160. Cosponsor: *Earth Science Excursions LLC*. Leaders: Frederick Zelt, Earth Science Excursions LLC, fbzelt@aol.com; Gary Fleeger.

This trip will examine bluffs and beaches on the shoreline of Lake Erie. We will examine till in lakeshore bluffs and view shoreline sands of Pleistocene Lake Warren, a predecessor of Lake Erie, perched atop till. Shoreline erosion and mass wasting have left till-derived pebbles, cobbles, and boulders on beaches. These clasts have a variety of provenances, including outcrops of Devonian limestone, older Paleozoic carbonates, cross-bedded and burrowed quartz sandstones, and a wide variety of metamorphic and igneous rocks. The crystalline rocks include white marble likely derived from outcrops near Ottawa, augen gneiss, garnet gneiss, gray granite, pink granite, and more. We will see beautifully faceted and striated cobbles and small boulders. Although they are in till from the most recent glaciation, many of these clasts probably were carried by a succession of glaciations, and some may have been eroded from very distant outcrops in Canada. We will also examine Upper Devonian bedrock, which underlies till along the lakeshore. The Upper Devonian strata consist of interbedded shales, siltstones, and fine-grained sandstones that were deposited in offshore environments in the Acadian foreland basin. Tempestite sandstones display abundant sole marks, cross-bedding, and, in places, trace fossils. The tops of some sandstone beds include abundant feeding, locomotion, and resting traces, including traces from *Rusophycus*. It is likely that we will visit a lakeshore exposure that requires walking 3 miles (5 km) in a park through savannah and woodland habitats, with uneven ground and a 60-ft-tall (18-m-tall) hill near the lakeshore.

Short Courses

Learn and explore a new topic. Build your skills.

Early registration deadline: 13 Sept.
Early registration is highly recommended to ensure that courses will run.
Registration after 13 Sept. will cost an additional US$30.
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Can I take a short course if I am not registered for the meeting? YES! You're welcome to—just add the meeting non-registrant fee (US$55) by 13 Sept. to your course enrollment cost. Should you then decide to attend the meeting, your payment will be applied toward meeting registration.

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

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

See **community.geosociety.org/gsa2023/short** or contact Jennifer Nocerino, jnocerino@geosociety.org, for course abstracts and additional information.

ONLINE COURSES

501. **How to Create Your Own 3D Videogame–Style Geologic Field Trip and Host it Online: Accessible, Immersive Data Visualization for Education and Research.** Fri., 6 Oct., 9:30 a.m.–5 p.m. EDT. US$40. Limit: 40. CEU: 0.65. **Instructors:** Mattathias (Max) Needle, University of Washington; Juliet Crider, University of Washington; Jacky Mooc, University of Washington; John Akers, University of Washington. **Course Endorser:** *GSA Structural Geology and Tectonics Division.*

502. **How the Natural Environment Gets Away with Murder: Medical Geology Fundamentals and Applications.** Fri., 6 Oct., 11 a.m.–6 p.m. EDT. US$55 professionals; US$25 students. Limit: 40. CEU: 0.6. **Instructors:** Laura Ruhl, Independent; Robert Finkelman, University of Texas at Dallas; Reto Gieré, University of Pennsylvania; Malcolm Siegel, Water Resources Action Project. **Course Endorsers:** *GSA Geology and Health Division; International Medical Geology Association.*

FRIDAY COURSES

503. **Introduction to ArcGIS Pro for Planetary Geology.** Fri., 13 Oct., 8:30 a.m.–4:30 p.m. US$30. Limit: 40. CEU: 0.7. **Instructor:** Zoe Ponterio, Cornell University.

504. **Understanding Carbonates for Sustainability and the Energy Transition.** Fri., 13 Oct., 8:30 a.m.–4:30 p.m. US$112. Limit: 40. CEU: 0.7. **Instructors:** Jean Hsieh, Sedimentary Geology Consultants; Rob Forkner, BlackDiamond Exploration LLC. **Course Endorsers:** *GSA Sedimentary Geology Division; GSA Energy Geology Division; Society for Sedimentary Geology (SEPM).*

505. **Methods and Geological Applications in Geo-Thermo-Petro-Chronology I.** Fri., 13 Oct., 9 a.m.–5 p.m. US$30. Limit: 50. CEU: 0.7. **Instructors:** George Gehrels, University of Arizona; Michelle Foley, University of Arizona; Kurt Sundell, Idaho State University; Sarah George, University of Oklahoma. Part II of this short course takes place on Saturday (517).

FRIDAY–SATURDAY COURSES

506. **Sequence Stratigraphy for Graduate Students.** Fri.–Sat., 13–14 Oct., 8 a.m.–5 p.m. US$25 (those who complete the course will receive two free GSA ebooks of their choice—a US$25 value). Limit: 40. CEU: 1.6. **Instructors:** Morgan Sullivan, Chevron Energy Technology Company; Bret Dixon, Tall City Exploration; Fabien Laugier, Chevron Energy Technology Company. **Course Endorser:** *Chevron Technology Center.*

SATURDAY COURSES

507. **Introduction to Field Safety Leadership.** Sat., 14 Oct., 8 a.m.–5 p.m. US$95 professionals; US$75 students. Limit: 40. CEU: 0.8. **Instructors:** Kevin Bohacs, KMBohacs GEOconsulting LLC; Kurt Burmeister, Century House Historical Society; Greer Barriault, ExxonMobil Upstream Research Company. **Course Endorser:** *KMBohacs GEOconsulting LLC.*

508. **On To the Future and GSA Associated Societies Expo: Finding Your Pathway to Geosciences Professions.** Sat., 14 Oct., 8 a.m.–5 p.m. By invitation only to On To the Future participants and alumni; workshop fee for invitees will be provided from NSF

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

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

grants #1801569 and #2037271. Limit: 150. CEU: 0.8. **Instructors:** Stephen Boss, University of Arkansas; Kathy Ellins, University of Texas, Austin (retired); Julia Clarke, University of Texas, Austin; Adam Papendieck, University of Texas, Austin; Elizabeth Long, Geological Society of America. **Course Endorser:** *National Science Foundation (Awards #1801569 and #2037271).*

509. **Innovative Tools for Project Management in Academia.** Sat., 14 Oct., 8 a.m.–5 p.m. US$124. Limit: 40. CEU: 0.8. **Instructors:** Amanda Godbold, University of Southern California; Deborah Coyle, incepta inc.

510. **Talking Science: A Communicating Science Workshop.** Sat., 14 Oct., 8 a.m.–5 p.m. US$15. Limit: 40. CEU: 0.8. **Instructor:** Steven Jaret, Kingsborough Community College. **Course Endorsers:** *GSA Planetary Geology Division; National Science Foundation Integrated Earth Science project EAR-1814051.*

511. **Resistivity Surveying: Getting the Best and Making the Most from Electrical Resistivity Tomography and Induced Polarization Data.** Sat., 14 Oct., 8 a.m.–5 p.m. US$120. Limit: 40. CEU: 0.8. **Instructors:** Morgan Sander-Olhoeft, Guideline Geo Americas Inc.; Makayla Shoup, Guideline Geo Americas Inc. **Course Endorser:** *Guideline Geo.*

512. **Quantitative Analysis, Visualization, and Modeling of Detrital Geochronology Data.** Sat., 14 Oct., 8 a.m.–5 p.m. US$100 professionals; US$25 students. Limit: 40. CEU: 0.8. **Instructors:** Joel Saylor, University of British Columbia; Kurt Sundell, Idaho State University; Jack Fekete, University of Arkansas.

513. **Using the StraboSpot and StraboMicro Data Systems for Geology.** Sat., 14 Oct., 8 a.m.–5 p.m. US$20 (those who complete the course will receive two free GSA ebooks of their choice—a US$20 value). Limit: 40. CEU: 0.8. **Instructors:** Doug Walker, University of Kansas; Julie Newman, Texas A&M University. **Course Endorser:** *GSA Structural Geology and Tectonics Division.*

514. **Ground-Penetrating Radar—Principles, Practice, and Processing.** Sat., 14 Oct., 8:30 a.m.–4:30 p.m. US$75. Limit: 40. CEU: 0.7. **Instructor:** Greg Johnston, Sensors & Software Inc. **Course Endorser:** *Sensors & Software Inc.*

515. **How to Build a Digital Crust.** Sat., 14 Oct., 9 a.m.–4:30 p.m. US$100; scholarships available: see https://digitalcrust.org or inquire at daven.quinn@wisc.edu for more info. Limit: 40. CEU: 0.65. **Instructors:** Daven Quinn, University of Wisconsin–Madison; Snir Attia, New Mexico Institute of Mining and Technology; William Gearty, American Museum of Natural History; Benjamin Linzmeier, University of South Alabama; Lucia Profeta, Columbia University; Akshay Mehra, University of Washington. **Course Endorsers:** *GSA Geoinformatics and Data Science Division; GSA Structural Geology and Tectonics Division; GSA Geochronology Division.*

516. **Introduction to OpenTopography for Research and Education.** Sat., 14 Oct., 9 a.m.–5 p.m. US$35. Limit: 40. CEU: 0.7. **Instructors:** Christopher Crosby, EarthScope Consortium; Ramon Arrowsmith, Arizona State University. **Course Endorser:** *OpenTopography.*

517. **Methods and Geological Applications in Geo-Thermo-Petro-Chronology II.** Sat., 14 Oct., 9 a.m.–5 p.m. US$30. Limit: 50. CEU: 0.7. **Instructors:** Mauricio Ibanez-Mejia, University of Arizona; Peter Reiners, University of Arizona; Kendra Murray, Idaho State University; Allen Schaen, University of Arizona. Part I of this short course takes place on Friday (505).

518. **Virtual Reality in Geoscience Education.** Sat., 14 Oct., 9:30 a.m.–5 p.m. US$118. Limit: 30. CEU: 0.65. **Instructors:** Kelly Best Lazar, Clemson University; Stephen Moysey, East Carolina University.

HALF-DAY SATURDAY COURSES

519. **How to Have Productive Conversations with People about Science.** Sat., 14 Oct., 8 a.m.– noon. US$50 professionals; US$35 students. Limit: 40. CEU: 0.4. **Instructors:** Denise Hills, Advanced Resources International Inc.; Beth Bartel, Michigan Technological University; Eliana Perlmutter, Independent; Jansen Smith, Geozentrum Nordbayern. **Course Endorsers:** *GSA Geology and Society Division; GSA Geology and Public Policy Committee; GSA Energy Geology Division; GSA Geoscience Education Division; GSA Geology and Health Division.*

520. **Deep-time.org: The One-Stop Online Research Platform for Geoscientists.** Sat., 14 Oct., 8 a.m.– noon. US$50 professionals; US$30 students. Limit: 40. CEU: 0.4. **Instructors:** Linshu Hu, Zhejiang University; Xinbing Wang, Shanghai Jiao Tong University; Junxuan Fan, Nanjing University; James Ogg, Chengdu University of Technology. **Course Endorser:** *International Union of Geological Sciences (IUGS)'s Deep-Time Digital Earth.*

521. **Open & FAIR Mineral Data: Best Practices for Sharing and Reusing Observations from the Field and Lab.** Sat., 14 Oct., 8 a.m.–12 p.m. (noon). US$50. Limit: 40. CEU: 0.4. **Instructors:** Kerstin Lehnert, Columbia University; Lucia Profeta, Columbia University.

522. **Building Better Broader Impacts (and Evaluation) for NSF Grant Proposals.** Sat., 14 Oct., 1–5 p.m. US$140. Limit: 40. CEU: 0.4. **Instructors:** Amy Myrbo, Amiable Consulting; Shirley Jackson, York College/CUNY; Cheryl Manning, Northern Illinois University.

523. **Voices of Integrating Culture in the Earth Sciences (VOICES).** Sat., 14 Oct., 1–5 p.m. US$109. Limit: 40. CEU: 0.4. **Instructors:** Lisa White, University of California, Museum of Paleontology; Wendy Todd, University of Minnesota Duluth.

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EXHIBITOR MOVE IN & MOVE OUT*

Move In: Sat., 14 Oct., 8 a.m.–5 p.m.
Sun., 15 Oct., 8 a.m.–3 p.m.

Move Out: Wed., 18 Oct., 2–8 p.m.
*Hours subject to change

RESOURCE & INNOVATION CENTER HOURS

Sun., 15 Oct., 5–7 p.m.
Exhibits Opening & Reception begins at 5 p.m.

Mon., 16 Oct., 10 a.m.–6:30 p.m.
Afternoon Reception: 4:30–6:30 p.m.

Tues., 17 Oct., 10 a.m.– 6:30 p.m.
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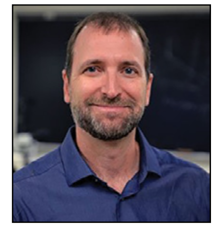

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Council Officers	5	President-Elect	3
		Treasurer	3
		Councilor	4
Diversity in the Geosciences Committee	3	Member-at-Large	3
Education Committee	1	Undergraduate Student Representative	2
Geology and Public Policy Committee	2	Member-at-Large	3
GSA International Committee	4	Member-at-Large	4
		Member-at-Large, outside North America	4
		Member-at-Large, Student	2
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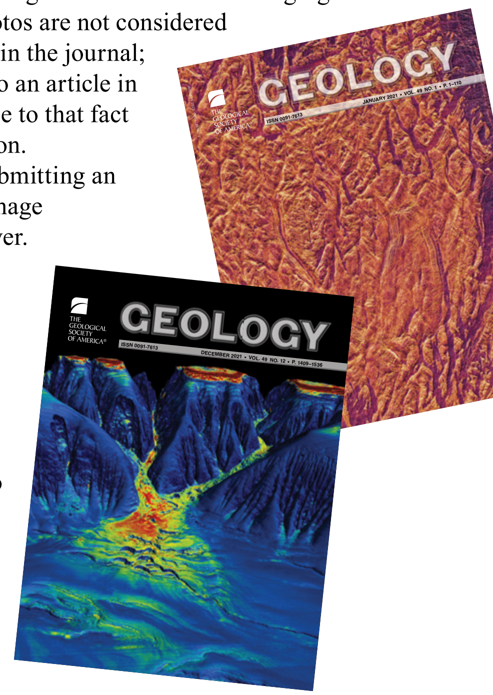

Exploring Science Policy through GSA

Christine Ray, GSA Science Policy Fellow

If you're anything like me, this might be the first time you're learning that science policy exists, let alone that it's something you, a geoscientist, can pursue as a career. I discovered this world through a collision of factors that I never could have predicted when I started down the academic research path, and I hope that, after learning more about my trajectory, the science policy world, and what this fellowship can offer you, you might consider making it a part of your career path, too.

If there is one piece of advice I can leave you with, it is to always follow your instincts, pay attention to what genuinely excites you, and don't be afraid to pursue it, even if it means treading off the beaten path to forge your own, unconventional way forward. As an undergraduate at Rutgers University, I double-majored in animal sciences and astrophysics—the result of starting as a pre-vet hopeful who wasn't introduced to the world of science research (and the tantalizing mysteries that lay just beyond Earth) until I started college. From there, I jumped to graduate school in planetary science at the University of Texas at San Antonio, where I worked with a group of scientists developing a mass spectrometer for the National Aeronautics and Space Administration (NASA) Europa Clipper mission to measure chemical species in the atmosphere of one of Jupiter's moons and determine whether its subsurface ocean might harbor life.

When I started my Ph.D., working on a NASA mission like Europa Clipper felt like a dream come true, but being a graduate student in Texas proved to be a rude awakening to the world outside of my academic bubble: I lived through a pandemic, a winter storm that shut down our state's power grid and left much of the population—myself included—without heat or water for days, and numerous attacks on my state's healthcare and education systems. I watched as our state's policy makers made decision after decision that put the lives and well-being of Texans on the line because they were informed by the will of their largest campaign donors, and not by science. While I did everything I could outside of work hours to try and fight these decisions, volunteering to aid victims and help local political groups promote candidates who would listen to scientists, it wasn't enough to quell my frustration with my state's policy makers and, deeper still, the growing lack of fulfillment I felt from my own career.

This is how I stumbled into the world of science policy, and eventually into GSA's science policy fellowship. Science policy exists to bridge the gap between scientists and policy makers: It aims to better inform scientists about policy and legislators about science. The GSA policy office works on the advocacy side of this world, communicating with legislators about the importance of supporting geoscience research, and creating opportunities for GSA members to engage with their policy makers.

As this year's Science Policy Fellow, I support all of these efforts in a number of different ways. I track geoscience-related legislation as it moves through the U.S. Congress and the Executive Branch, watch Congressional Hearings and briefings from the White House Office of Science and Technology Policy, and communicate key takeaways to GSA members about policy that either draws on geoscience expertise or affects geoscience funding through our social media, our *Speaking of Geoscience* blog, and our monthly *GSA Connection* newsletter. I help to organize Congressional Visits Days for members to meet with their legislators and advocate for geoscience on Capitol Hill, and I develop tools that members can use to prepare themselves for these visits along with other advocacy activities. I also work with other professional societies, universities, and science-minded organizations to coordinate our messaging to Congress about the value of different scientific agencies and programs, assuring that we are all on the same page when we have meetings on the Hill.

If any of this sounds exciting to you, or if you are simply looking for more ways to do something actionable with your science and get your research on important geoscience issues into the hands of those who have the power to do something about them, then I strongly encourage you to consider applying to this fellowship, or to get involved with other policy activities at GSA. Whether you want to move into policy full time or simply make geoscience advocacy a part of your career as a researcher, exploring the science policy world through GSA can provide you with the skills and knowledge you need to be a voice for science in Washington, D.C., and beyond. Visit **www.geosociety.org/policy** or reach out to us at sciencepolicy@geosociety.org to learn more.

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Building the Future: A Next Generation of Geoscientists *and* Supporters

Any guesses as to who is one of the GSA Foundation's most dynamic group of contributors?

Five years ago, we realized just how many GSA students choose to give back to the society to help others like themselves. In the last five years alone, between 1175 and 1500 students have contributed annually. Giving from this group has totaled between $10,000 and $25,000 each year; that's enough to fund five to twelve field camp scholarships, six to sixteen On To the Future recipients, or many GSA meeting travel grants, each year. **GSA student contributors—you are making a difference to those following in your footsteps!**

Tektonikos Building the Future GSA Foundation

As soon as we recognized the extent of student giving through the GSA Foundation, we knew it was important to distinguish this grassroots giving circle that had formed on its own, right under our radar. In 2018, we asked section meeting student attendees to vote on their name. At the end of that year's spring section meetings, hundreds of students had voted, and *Tektonikos: Building the Future* had risen to the top. This logo was created to help the group establish its own identity amidst 7000+ GSA Foundation donors and the society's entire membership.

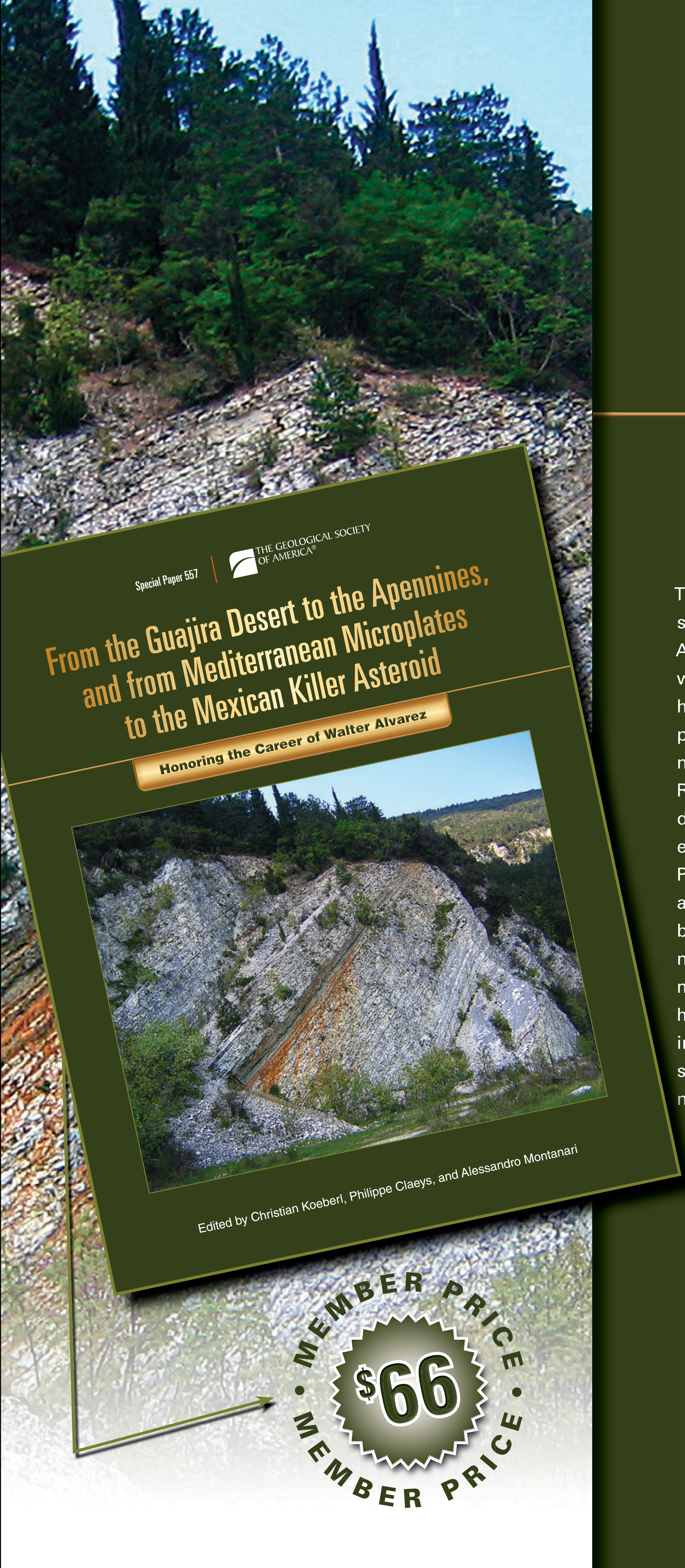
The name *Tektonikos* comes from the Greek root meaning "to build up," which reflects this group's commitment to, and vital role in, the future of GSA and the greater geoscience community.

The GSA Foundation recognizes student gifts at all levels, and we have a substantial base of donors who contribute $50 annually as well as some who opt to give through recurring monthly gifts of just $5, roughly the cost of a cup of coffee from a café. We are proud of GSA student members who are compelled to give back to their society and who recognize how much collective efforts, no matter the size, add up to help students like themselves. The sense of community that is pervasive across GSA—you, the membership—is being passed on to our younger members and to GSA program recipients who are giving back through the GSA Foundation and in other powerful ways: returning as mentors, serving as Student Advisory Council members or chairs, leading GSA's Diversity Committee, and participating in other GSA committees.

Please visit Tektonikos: Building the Future **(https://gsa-foundation.org/tektonikos-student-giving/)** to learn more, or contact A.J. Villa at avilla@geosociety.org or 303-357-1067.

Students showing support at the GSA Foundation booth during GSA's 2023 spring Section Meetings.

www.gsa-foundation.org



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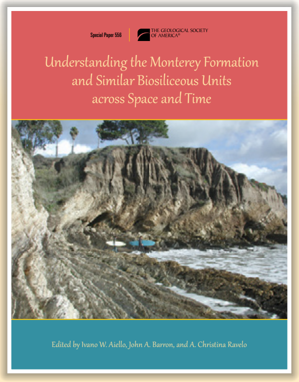

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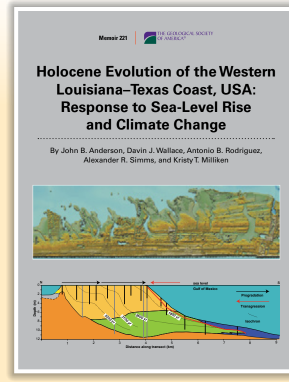

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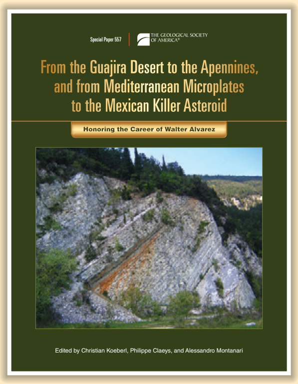

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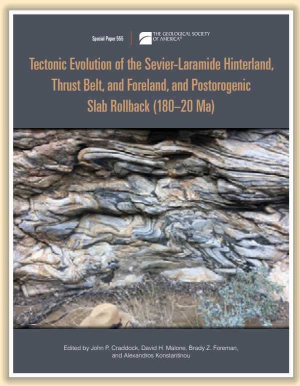

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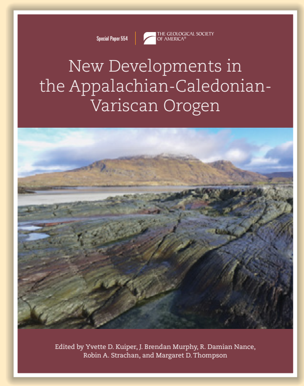

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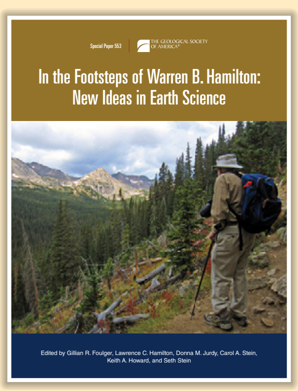

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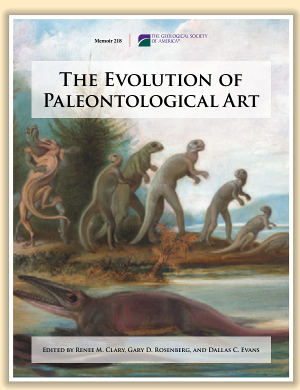

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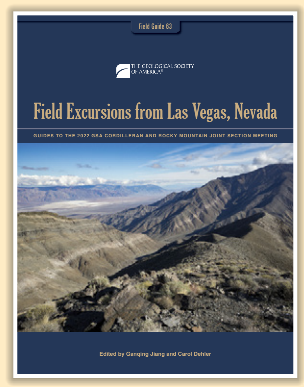

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