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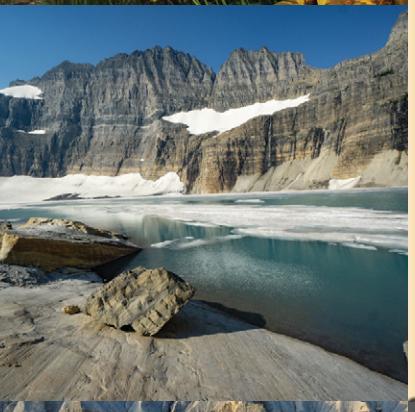

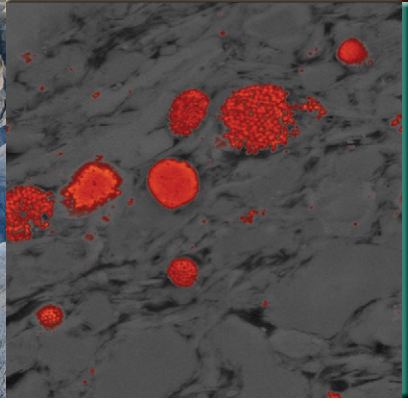

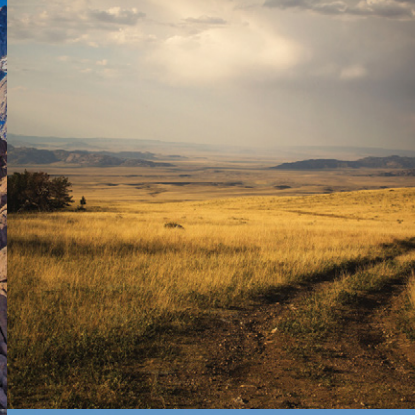

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SCIENCE

Cover: This rock outcrop of the Kinblade Formation chronicles paleoenvironmental change in the early Ordovician of Oklahoma, USA. To study this stratigraphic history, the authors collected a sample from each bed in the sequence and use their new camera setup and workflows to capture multispectral petrographic images to complement field observations and geochemical measurements. Like tiles in a mosaic, these image archives constrain the physical rock properties that record paleoenvironment, influence geochemical interpretations, and ultimately form a snapshot of Earth's history. For the related article, see pages 4–9.

GSA CONNECTS 2022

GSA NEWS

Erratum: In the July 2022 issue, the affiliation for David K. Wright, the recipient of the 2022 Rip Rapp Archaeological Geology Award, was incorrect. The correct affiliation is Dept. of Archaeology Conservation & History, University of Oslo. *GSA Today* regrets this error.

THE GEOLOGICAL SOCIETY OF AMERICA®

A High-Resolution Multispectral Macro-Imager for Geology and Paleontology

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ABSTRACT

Accurately assessing the shape, size, and modality of features in rock samples is a longstanding problem in geology. Recent advances in machine learning have introduced the possibility of performing these tasks through automated image analysis. To leverage these methods for geological and paleontological applications, we first need a way to acquire high-resolution images of polished slabs and thin sections with a field of view large enough to fit samples containing crystals, fossils, bedforms, etc. We describe a new multispectral setup that can acquire images at ~3.76 mm per pixel spatial resolution over a 21 cm^2 field of view, equipped with 8-band (470–940 nm) spectral resolution, plus a band for ultraviolet (365 nm) fluorescence. Additionally, we present a 5-band (470–940 nm) light table with automated rotating polarizers, which allows use of the camera as a high-throughput transmitted light thin section imager. The use of color bands outside the visible spectrum, as well as the registration of multiple cross-polarized rotations, encode rock properties that heighten image contrast and improve the accuracy of machine learning models. Our setup and methods provide an efficient way to (1) build reproducible image archives of rock specimens to complement field observations, (2) classify and segment those images, and (3) quantitatively compare lithofacies and fossil assemblages.

INTRODUCTION

Geologists have developed an eye for the physical rock characteristics that encode Earth's sedimentary, igneous, and metamorphic history. At points on a map or beds in a stratigraphic section, lithofacies observations from field campaigns form the backbone of geologic study. Throughout recent decades, the rise of geochemical techniques has increased the value of samples brought back from the field. For example, many measured sections through carbonate stratigraphies now include bed-by-bed isotope and trace element measurements that give insights into local carbon cycling (Ahm et al., 2021), global marine redox state (Dahl et al., 2019), sediment diagenesis (Ahm et al., 2018), and correlations within (Hay et al., 2019) and between basins (Halverson et al., 2005; Maloof et al., 2010). However, reliable interpretations of these geochemical data benefit from knowledge of the physical properties of the rock samples, such as grain/crystal sizes and modalities (Geyman and Maloof, 2021), primary mineralogy, porosity/permeability, and cross-cutting relationships between fabrics (Bergmann et al., 2011; Hood et al., 2016; Corsetti et al., 2006; Dyer et al., 2017)—data that also serve to refine analyses of sedimentary environment (Geyman et al., 2021). The above examples come from sedimentary geology, but the need to match geochemical data to quantitative lithofacies also applies to interpretations of igneous and metamorphic conditions (Higgins, 2000).

Workers have developed methods to approximate rock contents from samples, often by point counting on the stage of a microscope (Shand, 1916). Although this technique has brought about many geological insights, the uncertainties that stem from incompletely sampling a rock's surface are significant (Solomon, 1963; Neilson and Brockman, 1977), and the small fields of view available in most microscopes limit the scale of features studied to those only a few millimeters in size (Higgins, 2000). To build on previous petrographic findings and contextualize geochemical data, we can develop techniques to quantify lithofacies over a broader range of feature sizes and with more continuous spatial sampling.

New Potential for Petrographic Data through Image Analysis

Geologists could outline, count, and measure all the fossils, grains, or crystals in samples to extract these data, but manual petrographic study is too time-consuming to accompany each of the hundreds or thousands of geochemical measurements and observations made on a single map. We can, however, turn to recent advances in machine learning that have introduced the possibility of training models to recognize rock features (Yesiloglu-Gultekin et al., 2012; Koeshidayatullah et al., 2020). The need for automated feature classification is familiar to many fields, and effective solutions now are being realized in industries such as autonomous vehicles (Tian et al., 2018) and biomedical image processing (Li et al., 2018).

A variety of machine learning models can be trained to perform these tasks, but they all learn to classify image features through repeated practice on example images manually labeled by humans (LeCun et al., 1989), and some of the most effective models for general applications require more than 300,000 traced examples (Lin et al., 2014; He et al., 2017). Prior to training an

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equivalent model to recognize rock features, we first need to think about the properties of the images themselves and how well they capture those features. A potential advantage for automated classification of rock elements is that geological materials are made up of minerals with distinctive reflectance (Bishop et al., 2019) and birefringence (Cesare et al., 2022) characteristics. Capturing these spectral properties with a camera sensitive to more color bands than the human eye can heighten contrast between features in images and reduce the number of training examples needed for accurate classification models (Soomro et al., 2017). Here, we introduce a multispectral camera optimized for petrographic study, which can facilitate image analysis as a laboratory method to complement other geochemical and geophysical measurements.

IMAGING SETUP

The imaging setup presented herein is a modification of the grinding, imaging, and reconstruction instrument (GIRI), housed at Princeton University (Mehra and Maloof, 2018). While GIRI is a specialized solution for either two- or three-dimensional imaging, a similar imaging setup could be realized independent of GIRI with widely available cameras and lights.

Field of View and Spatial Resolution

There is a trade-off between field of view (FOV) and spatial resolution, and so a camera for geological samples must balance these two variables to capture a broad size range of rock features. For many geological applications, pixels on the order of 5 µm are needed to maintain sharp grain boundaries. Most current camera attachments for petrographic or dissecting microscopes achieve this resolution or greater, but only with FOVs smaller than 1 cm^2, which limits feature sizes and can add uncertainty to modality data.

To maintain high spatial resolution while expanding FOV, we design our camera around the continually improving technologies of optical sensors and macro lenses. Our camera sensor is a Phase One IQ4 150-megapixel digital back (Fig. 1D), which measures 4.04 × 5.37 cm with 3.76 µm pixels. We use a 120 mm Schneider Kreuznach apochromatic macro lens, which enables 1:1 photography with an FOV and pixel resolution equal to the dimensions of the digital back. Other lenses can be substituted to increase FOV at the cost of per-pixel resolution. To reduce glare and improve image contrast, we place a broadband polarizer over the lens.

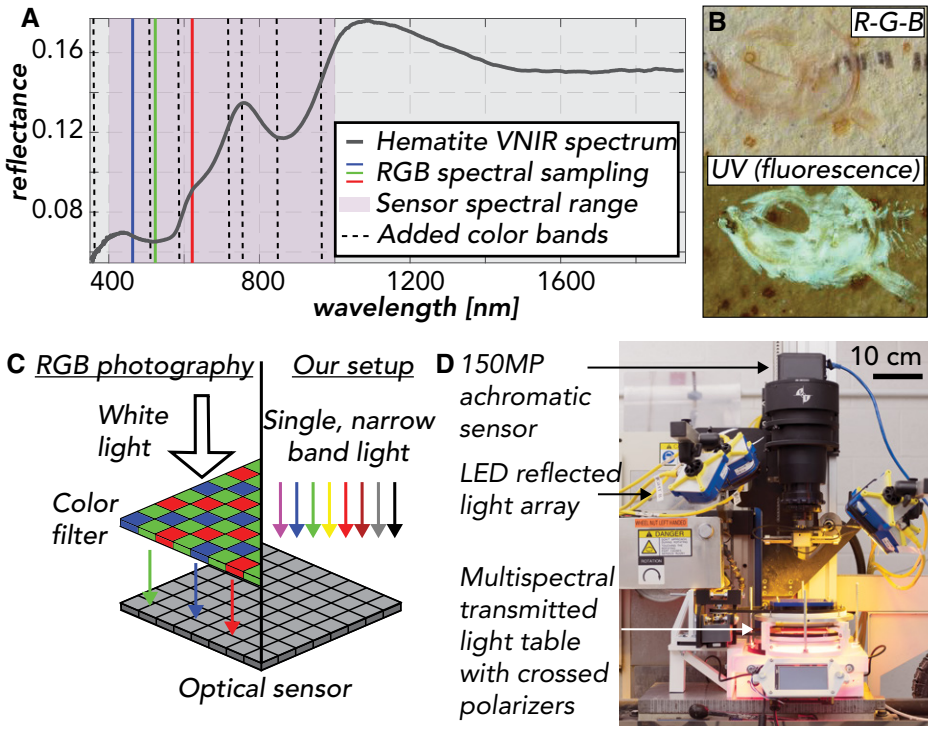

Figure 1. Motivating principles and setups for multispectral petrographic imaging with both reflected and transmitted light. (A) The addition of bands within the sensitivity range of a standard optical sensor allows for the sampling of distinctive spectral characteristics, such as the hematite peak and trough near 750 nm and 850 nm, respectively. (B) Ultraviolet (UV) fluorescence is an informative source of contrast when studying materials responsive to UV light, like the apatitic and organic components of this fish fossil (from Tischlinger and Arratia, 2013). (C) Traditional cameras filter incoming light to just red, green, and blue signals, limiting spectral range and reducing the spatial resolution of each color. We use narrowband lights (one at a time), which allows us to capture signals from the full range of sensitivity, and at the full resolution of the optical sensor. (D) Photograph of our setup. RGB—red-green-blue; VNIR—visible to near-infrared.

Spectral Resolution

One of the key lessons learned from 50 years of satellite-based remote sensing of Earth's surface is the utility of bands outside the traditional red-green-blue (RGB) visible spectrum to take advantage of the unique reflective characteristics of rocks and vegetation (Melesse et al., 2007). The reflective properties of certain geological materials in the visible to near-infrared (VNIR; 300–1100 nm) spectrum still apply at the scale of a hand sample and can be used by a petrographic camera to maximize feature contrast and aid segmentation.

Increasing the range and number of light spectra imaged usually diminishes spatial resolution because increasingly long wavelength (>1000 nm) and/or narrowband light sources are low intensity, meaning cameras designed for hyperspectral imaging must have larger pixels to gather enough photons to form a signal. Thus, we cannot design an imager with continuous spectral coverage throughout the VNIR spectrum and instead choose to optimize for the trade-off between spatial and spectral resolution (Ma et al., 2014). Our optical sensor (sensitive from 300 to 1000 nm) maintains the highest available spatial resolutions while still detecting important spectral properties beyond RGB. In particular, metallic oxides, clay minerals, pyroxenes, and olivines have absorption bands at wavelengths less than 1000 nm that can enhance contrast between geological classes (Bishop et al., 2019; Fig. 1A).

We create color channels by illuminating samples with an array of eight Smart Vision S75 narrowband LEDs (Fig. 1D), which can be chosen from any of the ten wavelengths shown in Figure 1A. We inform our selection of lights through preliminary tests for maximized feature contrast and equip all lights with a polarizing film to reduce glare.

Ultraviolet (UV) Fluorescence

In a dark laboratory setting, fluorescence from minerals like carbonates and phosphates can add contrast when imaged in the visible

spectrum. For example, in carbonate rocks at successive stages of calcite precipitation, diagenesis, and recrystallization, differences in the trace element chemistry of the stages will produce heterogeneities in the strength of fluorescence and thus contrast in the image (Dravis and Yurewicz, 1985). Additionally, organic or apatitic fossil materials often fluoresce, making UV fluorescence photography a valuable tool for creating contrast in paleontological samples (Tischlinger and Arratia, 2013; Fig. 1B). To image fluorescence, we illuminate samples with a 365 nm SmartVision LED. To reduce noise in the images, we place a bandpass filter with a cut-off wavelength of 395 nm over the UV light to remove any visible components of the emitted spectrum and use a 400 nm cut-on UV filter in front of the lens to eliminate any UV light from reaching the camera sensor. Note that when imaging with UV, the camera records the fluorescence of the materials in the VNIR spectrum.

Transmitted Light

Thin section transmitted light imagery offers another opportunity for increased contrast. Anisotropy, cleavage, and twinning create distinctive qualities in grains and crystals within a thin section and delineate grain boundaries (Rogers and Kerr, 1942). Additionally, crossed polarizers in transmitted light setups heighten contrast between features by creating differential extinction and birefringence patterns (Rogers and Kerr, 1942). To image thin sections with transmitted plane-polarized (PPL) and cross-polarized (XPL) light, we have created a light table that can be used with GIRI or any camera stand setup (Fig. 1D). The light source for this table is a dense Ramona Optics LED board with five wavelengths (470, 530, 620, 850, 940 nm), which illuminates the sample through a diffuser and a broadband linear polarizer. To image XPL, we attach a second polarizer over the sample, perpendicular to the lower linear polarizer (Fig. 1D). Unlike traditional petrographic microscopes, this light table holds the sample fixed, while a NEMA 17 stepper motor rotates both polarizers synchronously (Fueten, 1997) with a precision of 2.8×10^{-4} degrees.

Data Processing

In the case of both transmitted and reflected light, all captured image channels are perfectly aligned, allowing the user to view any three channels in a false color image or analyze all captures as a single multichannel image. Our setup, like all cameras, contends with chromatic aberration, whereby each wavelength of light achieves maximal sharpness at a different focal depth due to the wavelength-dependence of light refraction (Jacobson et al., 2013). In the supplemental material[1], we demonstrate how we apply blur modeling and deconvolution to achieve multispectral images that are sharper than a standard RGB camera.

RESULTS

In the following case studies, we illustrate two examples where the added spectral data from our reflected and transmitted light setups enhance our ability to distinguish features within geological samples. To classify pixels, we use a support vector machine (SVM), which is a simple machine learning model, to show the potential for future machine learning efforts when trained on these more informative spectral data.

Case Study 1: Feature Mapping in Reflected Light

A lack of contrast between classes in reflected light imagery commonly stems from all pixel values falling near a brightness line—a 1:1 intensity line where values are well-correlated between channels (Fig. 2B). In Figure 2A, we show an RGB image of an

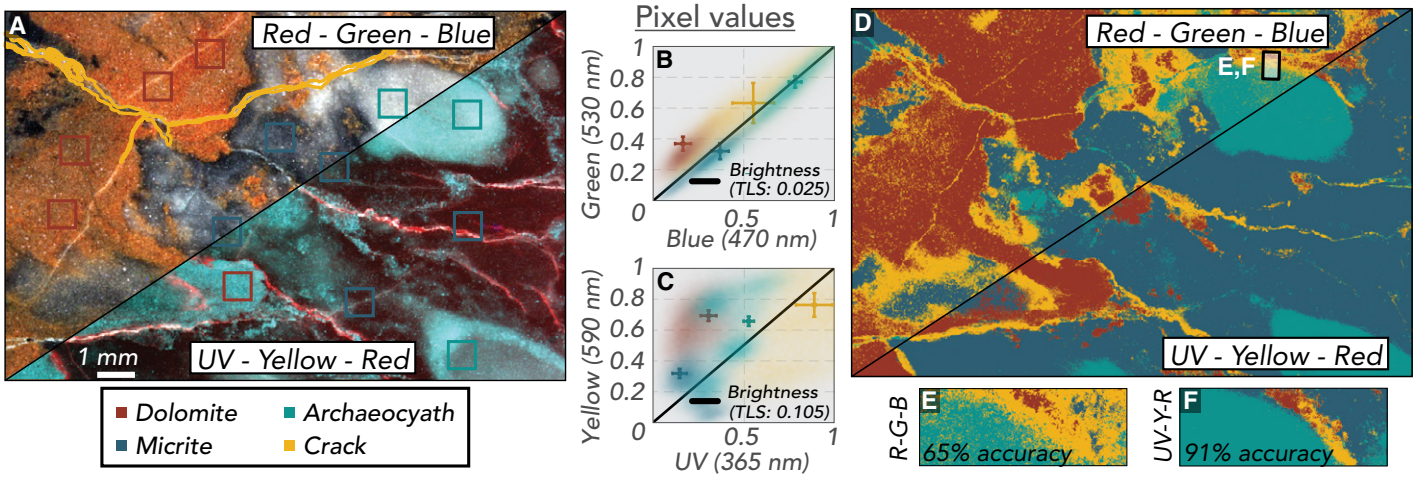

Figure 2. Improved segmentation results with multispectral reflected light imagery. (A) We take the same image of an archaeocyathid boundstone sample in a traditional red-green-blue (RGB) colorspace, as well as a false color ultraviolet (UV)-yellow-red space and sample the same pixels for four feature classes in each (colored boxes). (B) In the RGB image, all classes show covariance between color channels, and most pixels fall around the brightness line. (C) In the UV-yellow-red (UV-Y-R) image, covariance between channels is removed for all classes, as evidenced by the fourfold increase in average distance between each pixel and the brightness line (reported as total least squares, TLS). The movement of all classes away from the brightness line into distinct regions of the color space eases segmentation. (D–F) Using a support vector machine (SVM), an automated classification of the RGB image is 65% accurate and does not give high-resolution borders between classes and regions (D, E). In contrast, an SVM segmentation of the UV-yellow-red image is 91% accurate and gives sharp region and class boundaries more suitable for measurements (D, F).

[1]Supplemental Material. This supplement is intended to show our multispectral setup in more detail and explain how we mitigate chromatic aberration. We include a figure with annotated computer-aided design renderings of our transmitted and reflected light setups, and details for our light emission spectra. The text begins with background on the problem of chromatic aberration, details our experimental setup and blur modeling calculations, and discusses our final results. Go to https://doi.org/10.1130/GSAT.S.19773532 to access the supplemental material; contact editing@geosociety.org with any questions.

archaeocyathid boundstone sample, wherein each of the four classes (dolomite, micritic calcite, archaeocyathid, and calcite-filled crack) shows well-correlated pixel values (Fig. 2B). When segmenting these samples, the class overlap in RGB space hinders pixel-wise classification, leading to uncertain boundaries between classes (Figs. 2D and 2E). The same image in a UV-yellow-red colorspace (Fig. 2A) shows reduced channel covariance for all four classes (Fig. 2C). With the new spectral information available in UV-yellow-red space, an SVM has 30% improved accuracy, and produces resolved regions with distinct boundaries for each class (Figs. 2D and 2F).

Case Study 2: Feature Mapping in Transmitted Light

A primary limitation of performing image analysis on thin sections with existing microscope cameras is the FOV. In this example, we use a granite sample from the Golden Horn Batholith (Eddy et al., 2016) that has crystals with diameters approaching 1 cm. Because these crystals are large relative to a microscope FOV (Fig. 3A), the concentration of minerals in an image will be variable depending on the portion of the thin section placed under the lens. For example, the concentration of plagioclase assessed through classification may range from 29% to 55% when using the 2.5× objective on a petrographic microscope (Fig. 3H). The variation in concentrations increases if magnification increases (reducing FOV) or point counts are used to assess modality as opposed to pixel classifications (Fig. 3H).

This example also illustrates the benefit of building additional image channels from polarizer orientations (as opposed to additional wavelengths of light). With a single RGB image from one orientation of the crossed polarizers, capturing all possible birefringence and extinction properties for a given mineral class in a training set can be difficult and time-consuming, and the end result can be inaccurate classification (Fig. 3F). When multiple rotation XPL images are stacked together in the training set, each pixel takes on a broader range of the color and textural properties that a mineral may exhibit in cross-polarized light, which helps the machine learning model generalize and leads to more accurate classifications with the same number of training samples (Figs. 3C, 3D, and 3G).

DISCUSSION

Because our camera improves outcomes when using machine learning techniques to produce petrographic data, we now are focused on high-throughput methods for complete sample image analyses within stratigraphic sections or geologic maps. Our workflow takes the same samples gathered for geochemical or geophysical laboratory analyses and photographs them as polished slabs and/or thin sections. As an example, we created a bed-by-bed library containing nearly 2,000 images that chronicles paleoenvironmental change through the lower Ordovician Kinblade Formation (Fig. 4). Within a single map or section, systematic image analysis can yield lithofacies

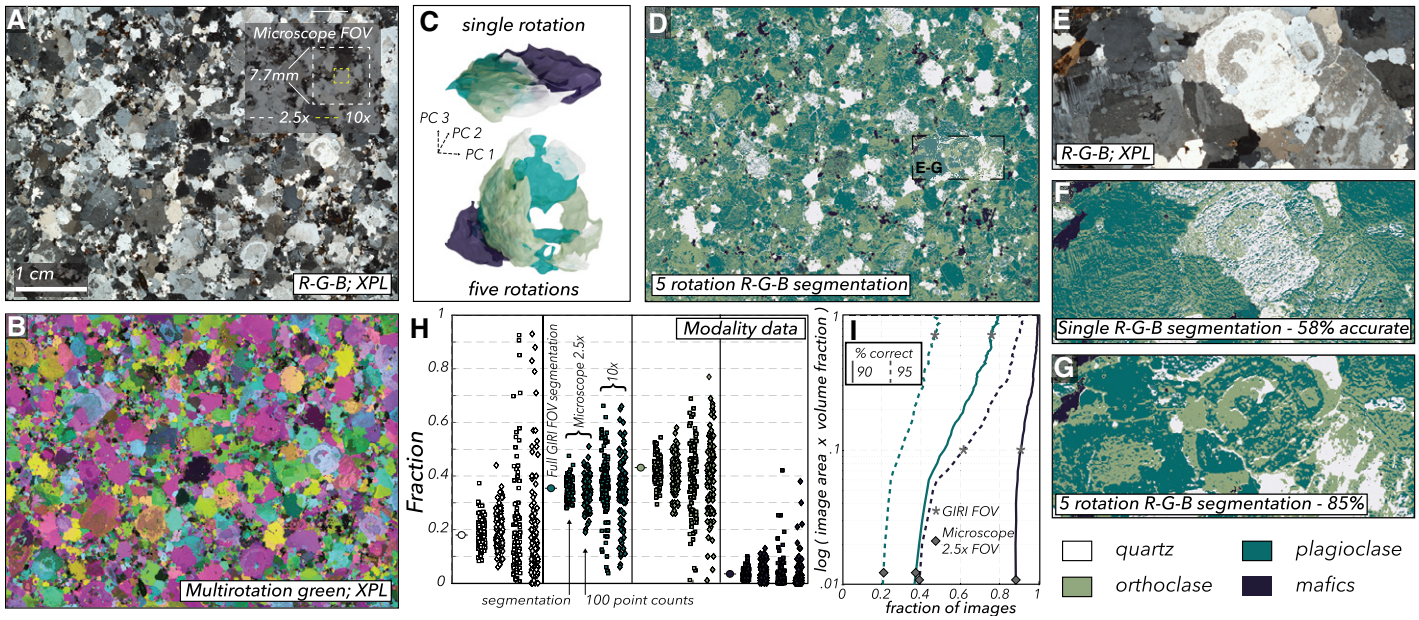

Figure 3. Improved modality data from multiple rotations of crossed polarizers for transmitted light imagery of thin sections. (A) Red-green-blue (RGB), cross-polarized (XPL) image of a granite thin section from the Golden Horn Batholith showing the full field of view (FOV) possible with our setup compared to those obtainable with a microscope camera. (B) False color image obtained using green (530 nm) light at three separate XPL orientations, 18° apart. (C) In principal component (PC) space, the pixel values for the four mineral classes (quartz, plagioclase, orthoclase, and mafics) in a single rotation RGB XPL image mostly overlap in one area of the plot. For an RGB XPL image containing five 18° rotations stacked into a 15-channel image, the pixel values spread out into a cone, where the position on the cone occupied by a given pixel relates to the class of the mineral and the relative orientation of its crystallographic axis. This added separation of the classes in the PC space of the five rotation XPL image improves the accuracy of pixel classifications from machine learning models, like the example given in (D). (E–G) In a zoomed-in portion of the image (E), we see that a support vector machine (SVM) using just a single rotation XPL RGB image (F) is 27% less accurate at classifying pixels compared to an SVM that is given the five-rotation image (G). Even with accurate classifications, analyzing only a relatively small FOV can add uncertainty. We see in (H) that the resulting modality data from the classification in (C) have highly variable values when assessed within the FOV of a traditional petrographic microscope. Each point in the plot represents the modality assessed in a randomly selected area of the segmentation equal to the size of a microscope FOV using either a 2.5× or 10× objective. The variation in these errors between classes stems from the characteristic size and relative abundance of the minerals. (I) To show the effect of crystal size and abundance, we calculate the number of images that correctly estimate the modality of a given mineral in a view size normalized to the mineral abundance (determined using a 4.5 × 5.5 × 4 cm 3D grinding, imaging, and reconstruction instrument [GIRI] reconstruction of the sample). In an experiment randomly drawing thin sections from the full volume of this granite sample, we see that an approximately equal fraction of images estimates the mafic mineral modality within a 90% correctness threshold when comparing GIRI to a 2.5× microscope objective. However, at the 95% threshold, as well as with the larger plagioclase crystals, the GIRI FOV performs nearly twice as well.

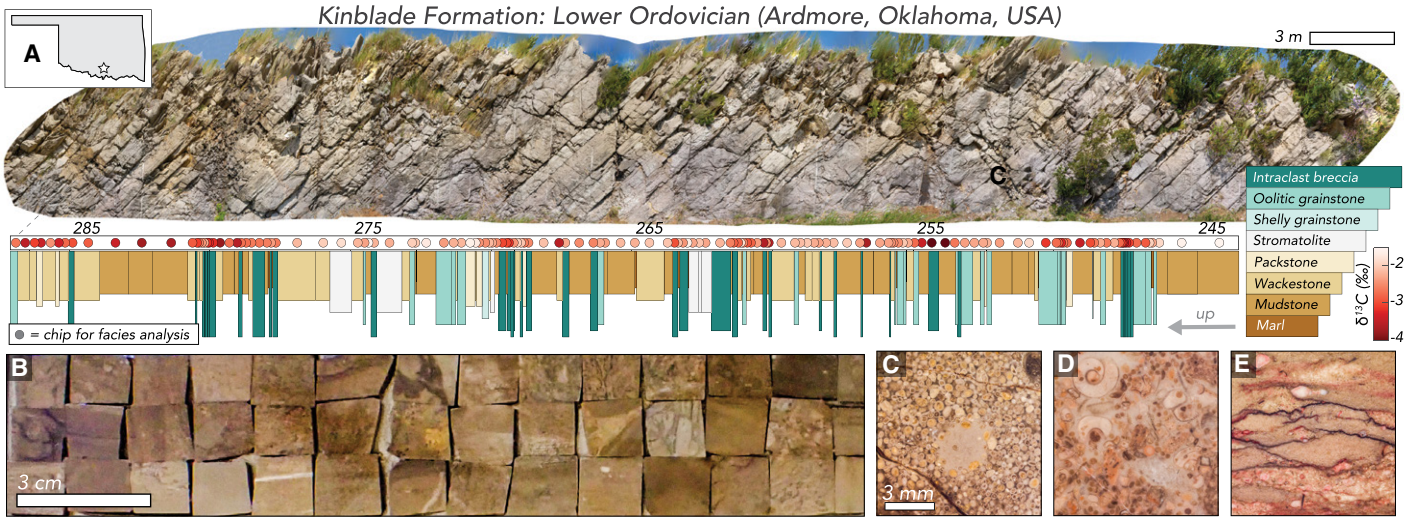

Figure 4. Example of a reproducible, quantitative lithofacies data set. (A) The lower Ordovician Kinblade Formation outcropping in Ardmore Oklahoma (GPS location: 34.372821, –97.145353) is a 791 m succession of carbonate strata containing 1,922 beds. (B) Following bed-by-bed field study, sampling, and geochemical measurement, we epoxy 1 cm² chips from each sample for efficient grinding, polishing, and imaging. The chip size is chosen to best encapsulate the dominant grain, fossil, and bedform sizes in the data set. The resulting ~2,000 images (examples C–E, shown here in red-green-blue space, but all are 8-channel multispectral images) now are a documentation of the lithofacies in the measured section at Ardmore and ready for image analysis, classification, segmentation, and interpretation.

data that quantify spatio-temporal patterns in grain, crystal, and fossil characteristics, while allowing new tests of geochemical interpretations (e.g., Geyman and Maloof, 2021; Ahm et al., 2019).

At the same time, amassing a standardized, multispectral image library with annotated examples (Deng et al., 2009) of geologic features from many localities will help train more general machine learning models for petrography. These collections of slab and thin-section images are a first step toward the goal of automated routines to measure features in rock samples from pictures. Curated image libraries also can serve as a classroom tool for teaching petrography, and student work to classify images can provide training examples for machine learning—a crowdsourcing technique that has seen recent success in several fields (e.g., van den Bergh et al., 2021).

In addition to improving lithofacies data, we see our camera and petrographic images as a vehicle to improve access and reproducibility in geology. Open access to archives like Integrated Ocean Drilling Program (IODP) cores has expanded the number of people producing complementary data sets and provided for deeper, more reproducible studies of Earth's climate and oceans in recent geologic periods (Becker et al., 2019). A similar framework should exist for rock outcrops that span deeper into Earth's history, where, currently, the observations that form geologic maps and stratigraphic sections tend to be documented primarily in field notes or illustrative outcrop/sample photographs. For corroboration or expansion upon previous outcrop-based studies, this system requires workers to visit the locality themselves. Instead, open access to standardized petrographic image collections will allow broader groups of researchers to measure and interpret features in rock formations from around the world, enhancing both reproducibility (Baker, 2016) and diversity, equity, and inclusion (Fernandes et al., 2020) in geology. Although our archives are not continuous records like IODP cores, they benefit from the added spatial context available at rock outcrops and provide a zoomed-in perspective to supplement constantly improving aerial survey techniques (Shah et al., 2021). In concert with satellite, drone-derived, and hand-held imagery, our pipeline for systematic imaging, classification, and measurement of rock samples can form an important layer in multiscale digitization and interpretation of physical rock properties.

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THE GEOLOGICAL SOCIETY OF AMERICA®
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Registration, Housing, and Other Need-to-Know Information

REGISTRATION

Early registration deadline: 7 Sept., noon MDT
Cancelation deadline: 11:59 p.m. MDT on 12 Sept.
Register now at **community.geosociety.org/gsa2022/registration**

STUDENT VOLUNTEERS

GSA student members in good standing: Help us out by volunteering to work at least ten hours at the meeting, and we'll help you out by covering the cost of your registration! See how the meeting works from the inside and fill vital roles that help to make the meeting a success for everyone. Sign up now at **community.geosociety.org/gsa2022/registration/volunteers.**

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 (go to **community.geosociety.org/gsa2022/connect/events** 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.

EVENT SPACE REQUEST

The Group Alumni Reception is back for 2022, and we hope to see many schools return. The first of September is the LAST day to submit a request for event space and event listing at **community.geosociety.org/gsa2022/connect/events/plan.**

ACCOMMODATIONS & SERVICES

GSA strives to create a welcoming, inclusive, and professional experience for every attendee. Let us know in advance of the meeting if you have needs that require further attention. Most dietary considerations can be met without any extra charge. Be sure to provide your request when registering online. GSA will also have a self-care room and nursing room on site.

CRITICAL HOUSING DATES

6 Sept.: Last day to cancel rooms without a penalty
14 Sept.: Room rates are guaranteed as long as there are rooms available in the GSA room block
29 Sept.: All changes, cancelations, and name substitutions must be finalized through Orchid.Events (OE)
After 29 Sept.: You must contact the hotel directly for all changes, cancelations, and new reservations

Once you receive your hotel acknowledgment and have booked your travel, please review your hotel arrival/departure dates for accuracy. If you do not show up on the date of your scheduled arrival, the hotel will release your room and you will be charged for one night's room and tax. If you have travel delays and cannot arrive on your scheduled arrival date, please contact the hotel directly to make the hotel aware of your new arrival date.

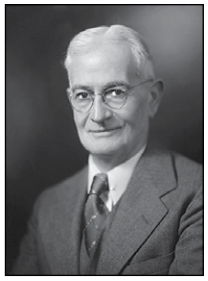
ROOM SHARING/RIDE SHARING

Use the GSA Roommates and Rides board at **community.geosociety.org/gsa2022/travel/rooms-rides** to share housing, airport shuttles, and/or carpool. You can also use this service to meet up with your colleagues at the meeting.

HEALTH AND SAFETY

Learn more about how GSA Connects 2022 is making this meeting happen with health and safety as a top priority at **community.geosociety.org/gsa2022/information/health.**

Pardee Keynote Symposia



Joseph Thomas Pardee

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

P1. **Geoheritage: Connecting Our Stories to Earth's History**

Endorsers: *GSA History and Philosophy of Geology Division; History of Earth Sciences Society; GSA Energy Geology Division; GSA Geoscience Education Division; GSA Karst Division; GSA Hydrogeology Division*

Advocates: Christina DeVera; Renee M. Clary; William Andrews Jr.; Timothy Connors

Geoheritage communicates the story about Earth's geologic history shaping our diverse cultures. Your stories and perspectives ARE important. Join us to share ideas about best practices for collecting information, developing mapping and metadata standards, and disseminating knowledge about how the unique landscapes that we inhabit have impacted our societies. We want to hear your stories about geoheritage projects within your community and how they have increased public awareness and conservation efforts through effective, inclusive, and accessible communication. This session provides inspiration, empowerment, and the foundational elements needed to develop geoheritage efforts in our professional, public, and personal communities.

P2. **Looking to the Future of Environmental and Engineering Geology: EEGD 75th Anniversary**

Endorsers: *GSA Environmental and Engineering Geology Division; GSA Geology and Society Division; GSA Quaternary Geology and Geomorphology Division; GSA Environmental and Engineering Geology Division—Landslide Committee; U.S. Geological Survey Landslide Hazards Program; GSA Geology and Society Division*

Advocates: Matthew Crawford; Ann Youberg; Francis Rengers; William Burns; Stephen Slaughter; Anne Witt

Celebrating the 75th anniversary of the Environmental and Engineering Geology Division, this session will discuss the past, present, and exciting future of many applied geology disciplines. The focus will be cutting-edge research and communication related to geologic hazards, geotechnical engineering, mining geology, remote sensing, geophysics, hydrogeology, and soil and rock mechanics. The session will contribute to a better understanding of these complex topics and processes, support hazard mitigation, improve human health and safety, and help build resilience under changing climatic conditions.

P3. **The Proterozoic-Phanerozoic Transition: Laying the Foundation for the Modern Earth System**

Endorsers: *Paleontological Society; GSA Geobiology and Geomicrobiology Division; GSA Sedimentary Geology Division; SEPM (Society for Sedimentary Geology); Geochemical Society; GSA Continental Scientific Drilling Division; GSA Geochronology Division*

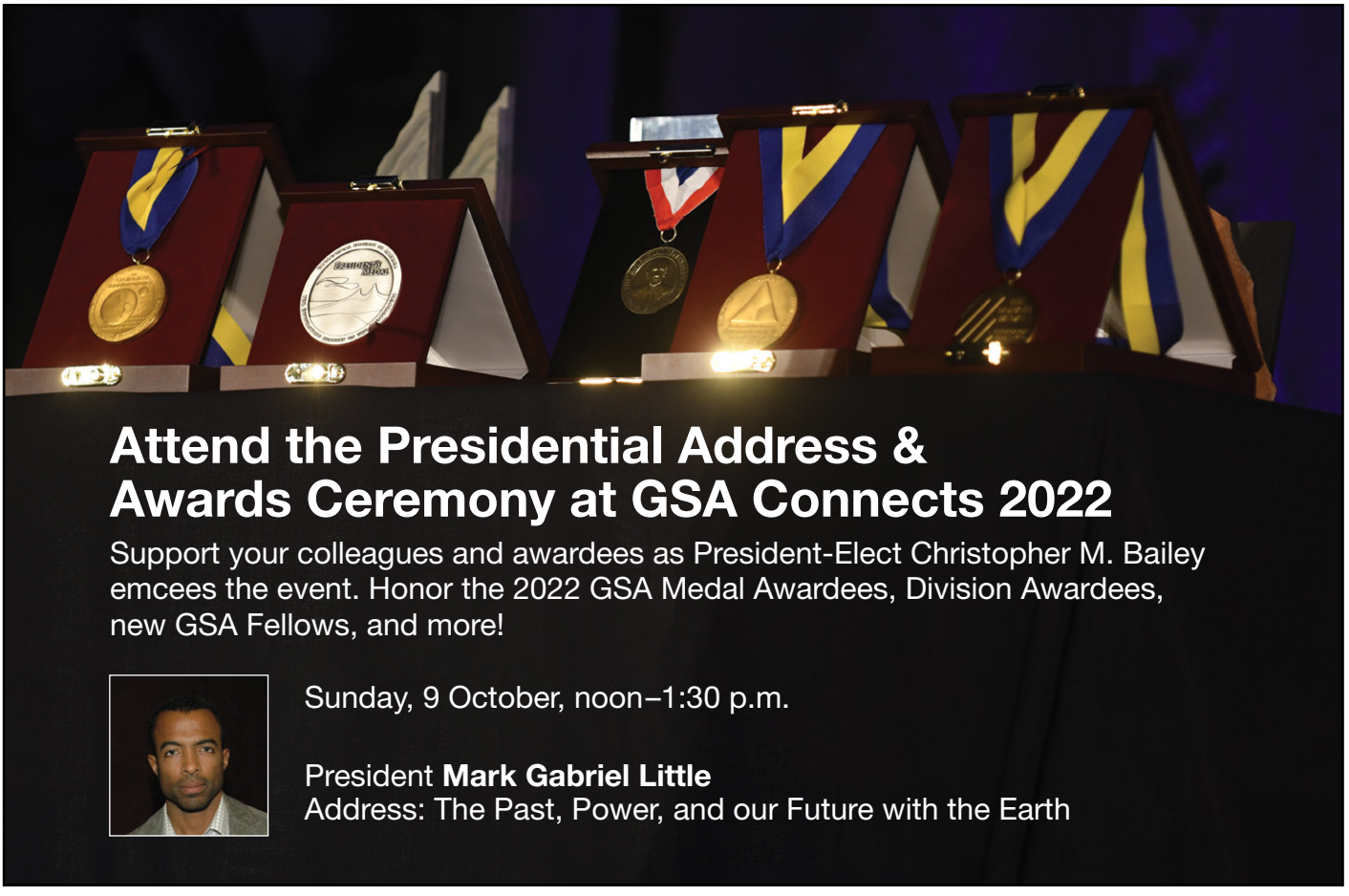
Advocates: Emily F. Smith; David A.D. Evans; C. Brenhin Keller; Kimberly Lau; Alan Rooney; Justin V. Strauss; Shuhai Xiao

The Proterozoic-Phanerozoic transition represents one of the most profound geobiological events in Earth's history, marking the diversification of major animal groups that unmistakably mark the Phanerozoic eon. Key advances have been made in recent years using an integrative and interdisciplinary approach to shed novel insights into biological, environmental, and tectonic changes during this transition. This symposium will showcase some of these advances from sedimentological, stratigraphic, paleontological, geochronological, geochemical, geophysical, and science-communication perspectives. Parallel topical session(s) and a science-communication panel discussion will be arranged.

Noontime Lecture: The Mars 2020 *Perseverance* Rover in Jezero Crater

Katie Stack Morgan
Wed., 12 Oct., 12:15–1:15 p.m.

The Mars 2020 *Perseverance* rover, NASA's newest flagship Mars rover mission, landed in Jezero crater in February 2021. *Perseverance* is seeking signs of ancient life on Mars, and it is the first step of a multi-mission effort to return samples from Mars back to Earth. During the first year of *Perseverance*'s mission, the rover explored a sequence of altered, igneous rocks on the Jezero crater floor, successfully collecting eight rock samples and one atmospheric sample. *Perseverance* then traversed to the ancient delta deposit within the crater and is in the midst of exploring and sampling sedimentary rocks with high biosignature preservation potential. This talk will review highlights from the first year and a half of *Perseverance*'s mission and discuss implications for the Mars sample return effort.



GEOCAREERS DAY

CCC, Mile High Ballroom 1ABC, Mon., 10 a.m.–2 p.m. US$25; includes lunch.

If you are entering the job market or are supporting someone who is and want more information about career pathways in the geosciences, plan to attend one or more of the events below. CCC—Colorado Convention Center.

Geoscience Career Workshop, 10–11 a.m.

Gain an understanding of the job-search process by reviewing workforce data, including salary, employment trends, and projections. Presenters will also review the fundamentals of crafting a winning résumé and how to best utilize the USAJOBS database for applications for federal employment.

Company Connection, 11 a.m.–12:30 p.m.

Visit agency and company booths to ask your career questions. Learn about each unique work culture and types of internships and careers available.

Mentor Roundtables, 11 a.m.–12:30 p.m.

Meet with mentors from industry, government, and academia. The mentors will answer questions, offer advice about career plans, and comment on job opportunities within their fields.

GeoCareers Panel Luncheon, 12:30–2 p.m.

Representatives from government and industry sectors will answer questions and offer advice in preparation for a career in these fields.

GEOCAREERS CORNER

CCC, Room 201/203, Sun.–Tues., 9 a.m.–5 p.m. Free, open to everyone.

Résumé-Review Clinic, Sun.–Tues., 9–11 Oct., 10 a.m.–3 p.m.

Review will be on a first-come, first-served basis. Show up early to secure your 30-minute consultation. Bring two copies of your résumé.

Drop-in Mentoring, Sun.–Tues., 9–11 Oct., 10 a.m.–3 p.m.

Mentoring will be on a first-come, first-served basis. Sign up early to secure your 30-minute consultation.

Early Career Professional Coffee, Sun., 9 Oct., 9–10 a.m.

This informal gathering will include remarks from representatives of several non-profits who have activities of interest to early career professionals. There will be time for networking and sharing ideas on how these organizations can best serve you.

Networking Reception, Sun., 9 Oct., 3:30–5 p.m.

This reception provides an exciting opportunity to network with more than 40 geoscience professionals. The mentors will answer questions, offer advice about career plans, and comment on job opportunities within their fields.

Women in Geology, Sun., 9 Oct., 5:30–7 p.m.

This informal gathering begins with remarks from a few key women speakers who will address issues faced by women in geology. A networking session will follow, providing time for sharing ideas and getting to know other women geoscientists.

Geology Club Meet-Up, Mon., 10 Oct., 2–3 p.m.

Want to see what other geology clubs are up to? Chat with other representatives about their activities, goals, and accomplishments.

Short Courses

Learn and explore a new topic. Build your skills.

Early registration deadline: 7 Sept. at noon MDT. Early registration is highly recommended to ensure that courses will run. **Registration after 7 Sept.** will cost an additional US$30. **Cancelation deadline:** 12 Sept.

Can I take a short course if I am not registered for the meeting? YES! You're welcome to—just add the meeting nonregistrant fee (US$55) by 6 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 nonregistrant 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/gsa2022/program/short** or contact Jennifer Nocerino, jnocerino@geosociety.org, for course abstracts and additional information.

ONLINE COURSES

501. **NSF Graduate Research Fellowship Program (GRFP) Proposal Preparation Course.** Mon., 26 Sept., 8 a.m.–noon MDT. US$20. Limit: 30. CEU: 0.4. **Instructors:** Kristina Butler, University of Texas at Austin; Sarah George, University of Arizona. **Course Endorser:** *GSA Geoscience Education Division*.

502. **Climate Adaptation Planning for Emergency Management.** Tues., 27 Sept., 10 a.m.–2 p.m. MDT *and* Wed., 28 Sept., 10 a.m.–2 p.m. MDT. FREE. Limit: 50. CEU: 0.8. **Instructors:** Jeff Rubin, semi-retired emergency manager; Monica Gowan, independent consultant. **Course Endorsers:** *GSA Geology and Health Division; GSA Geology and Society Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; National Disaster Preparedness Training Center (NDPTC) at the University of Hawai'i; Federal Emergency Management Agency (FEMA).*

503. **Resistivity Surveying: Getting the Best and Making the Most from Electrical Resistivity Tomography and Induced Polarization Data.** Thurs., 29 Sept., 8 a.m.–noon MDT. US$40. Limit: 50. CEU: 0.4. **Instructors:** Morgan Sander-Olhoeft, Guideline Geo Americas Inc.; Harry Higgs, Guideline Geo Americas Inc. **Course Endorser:** *Guideline Geo.*

504. **Introduction to Geostatistical Modeling of Geochemical Data.** Thurs., 29 Sept., 8 a.m.–noon MDT *and* Fri., 30 Sept., 8 a.m.–noon MDT. US$50 professionals; US$25 students. Limit: 50. CEU: 0.8. **Instructors:** Abani Samal, GeoGlobal LLC; Sankar Sasidharan, Harte Research Institute.

505. **How to Create Your Own 3D Videogame-Style Geologic Field Trip and Host it Online: Accessible, Immersive Data Visualization for Education and Research.** Fri., 30 Sept., 9:30 a.m.–5 p.m. MDT. US$40. Limit: 40. CEU: 0.7. **Instructors:** Mattathias (Max) Needle, University of Washington; John Akers, University of Washington; Juliet Crider, University of Washington. **Course Endorser:** *GSA Structural Geology and Tectonics Division.*

FRIDAY COURSES

506. **Geological Modeling and Uncertainties Using Multiple Point Statistics.** Fri., 7 Oct., 8 a.m.–5 p.m. US$115. Limit: 20. CEU: 0.8. **Instructors:** Mats Lundh Gulbrandsen, I-GIS; Tom Martlev Pallesen, I-GIS. **Course Endorser:** *I-GIS.*

507. **Exploring Surface Processes with the CSDMS Workbench: Building Coupled Models.** Fri., 7 Oct., 9 a.m.–5 p.m. US$60. Limit: 40. CEU: 0.8. **Instructors:** Mark Piper, University of Colorado Boulder; Benjamin Campforts, University of Colorado Boulder. **Course Endorser:** CSDMS@HydroShare.

508. **Multiphysics Modeling for the Geosciences.** Fri., 7 Oct., 8 a.m.–5 p.m. US$160. Limit: 30. CEU: 0.8. **Instructors:** Susan Sakimoto, Space Science Institute; Heidi Haviland, NASA Marshall Space Flight Center. **Course Endorsers:** *GSA Planetary Geology Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; COMSOL Inc.*

509. **Methods and Geological Applications in Geo-Thermo-Petro-Chronology I.** Fri., 7 Oct., 9 a.m.–5 p.m. US$40. Limit: 50. CEU: 0.7. **Instructors:** Sarah George, University of Arizona; George Gehrels, University of Arizona; Kurt Sundell, Idaho State

INDUSTRY TRACKS

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

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

University; Mauricio Ibanez, University of Arizona; Kendra Murray, Idaho State University; Allen Schaen, University of Arizona.

FRIDAY–SATURDAY COURSES

510. **Field Safety Leadership.** Fri.–Sat., 7–8 Oct., 8 a.m.–5 p.m. US$45 professionals; US$25 students. Limit: 24. CEU: 1.6. **Instructors:** Kevin Bohacs, ExxonMobil (retired); Kurt Burmeister, California State University, Sacramento; Greer Barriault, ExxonMobil Technology and Engineering Company. **Course Endorser:** *ExxonMobil Technology and Engineering Company.*

511. **Teaching SfM and GNSS Methods to Undergraduates in the Field.** Fri.–Sat., 7–8 Oct., 8 a.m.–5 p.m. US$40. Limit: 30. CEU: 1.6. **Instructors:** Beth Pratt-Sitaula, UNAVCO; Benjamin Crosby, Idaho State University; Bruce Douglas, Indiana University; Christopher Crosby, UNAVCO. **Course Endorsers:** *GEodesy Tools for Societal Issues (GETSI) Field Project; UNAVCO; National Association of Geoscience Teachers (NAGT); OpenTopography.*

512. **Sequence Stratigraphy for Graduate Students.** Fri.–Sat., 7–8 Oct., 8 a.m.–5 p.m. US$25 (those who complete the course will receive three free GSA ebooks of their choice—a US$25 value). Limit: 55. CEU: 1.6. **Instructors:** Morgan Sullivan, Chevron Energy Technology Company; Bret Dixon, Tall City Exploration. **Course Endorser:** *Chevron Energy Technology Company.*

513. **Introduction to the Paleobiology Database.** Fri.–Sat., 7–8 Oct., 8 a.m.–5 p.m. US$100 professionals; free for students. Limit: 100. CEU: 1.6. **Instructor:** Mark D. Uhen, George Mason University. **Course Endorsers:** *Society of Vertebrate Paleontology; Paleontological Society.*

514. **Improve Your Computational Petrology Skills: Designing and Executing a Computational Petrology Research Project and an Introduction to the Magma Chamber Simulator.** Fri., 7 Oct., 1–5 p.m. *and* Sat., 8 Oct., 8 a.m.–5 p.m. US$163. Limit: 40. CEU: 1.2. **Instructors:** Wendy Bohrson, Colorado School of Mines; Frank Spera, University of California Santa Barbara; Valerie Strasser, Colorado School of Mines; Monike Distefano, Colorado School of Mines; Paula Antoshechkina, Caltech. **Course Endorsers:** *GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Planetary Geology Division; GSA Geophysics and Geodynamics Division.*

SATURDAY COURSES

515. **Machine Learning for Small, Uncertain, and Sparse Datasets.** Sat., 8 Oct., 8 a.m.–5 p.m. US$116. Limit: 40. CEU: 0.8. **Instructors:** Velimir Vesselinov, Los Alamos National Laboratory; Bulbul Ahmmed, Los Alamos National Laboratory. **Course Endorsers:** *Computational Earth Science Group; Los Alamos National Laboratory.*

516. **Digital Petrography: Bringing Petrologic Imaging into the Modern Era with Automation, Robotics, Image Analysis, and AI.** Sat., 8 Oct., 8 a.m.–5 p.m. US$60. Limit: 40. CEU: 0.8. **Instructors:** Matthew Andrew, Carl Zeiss X-ray Microscopy; Kitty Milliken, The University of Texas; Brice Lacroix, University of Kansas; Mingyue Yu, University of Illinois. **Course Endorser:** *Carl Zeiss X-ray Microscopy.*

517. **Foundations in the Design and Teaching of Geoscience Courses Using Active Learning Strategies.** Sat., 8 Oct., 8 a.m.–5 p.m. US$25 (Those who complete the course will receive three free GSA ebooks of their choice—a $25 value). Limit: 40. CEU: 0.8. **Instructors:** Leilani Arthurs, University of Colorado Boulder; Chu-Lin Cheng, University of Texas Rio Grande Valley; Ming-Tsan Lu, University of Texas Rio Grande Valley; Patrick Shabram, Front Range Community College.

518. **Introduction to Drones (sUAS) in the Geosciences.** Sat., 8 Oct., 8 a.m.–5 p.m. US$126. Limit: 40. CEU: 0.8. **Instructor:** Gregory Baker, Colorado Mesa University. **Course Endorsers:** *GSA Hydrogeology Division; GSA Geoarchaeology Division; GSA Quaternary Geology and Geomorphology Division; GeoAvatar LLC.*

519. **Three-Dimensional Geological Mapping and Modeling.** Sat., 8 Oct., 8 a.m.–5 p.m. US$106. Limit: 60. CEU: 0.8. **Instructors:** Richard Berg, Illinois State Geological Survey; Harvey Thorleifson, Minnesota Geological Survey; Kelsey MacCormack, Alberta Geological Survey.

520. **On To the Future Professional Development Workshop: Looking Forward to a Career in Geosciences.** Sat., 8 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 #1801569. Limit: 150. CEU: 0.8. **Instructors:** Stephen Boss, University of Arkansas; Kathy Ellins, University of Texas (retired); Susan Eriksson, Eriksson Associates. **Course Endorser:** *National Science Foundation (Award #1801569).*

521. **Talking Science: A Communicating Science Workshop.** Sat., 8 Oct., 8 a.m.–5 p.m. US$30 professionals; US$15 students. Limit: 40. CEU: 0.8. **Instructor:** Steven Jaret, American Museum of Natural History. **Course Endorsers:** *GSA Planetary Geology Division; National Science Foundation Integrated Earth Science project EAR-1814051.*

522. **Ground-Penetrating Radar—Principles, Practice, and Processing.** Sat., 8 Oct., 8 a.m.–5 p.m. US$95 professionals; US$50 students. Limit: 25. CEU: 0.8. **Instructor:** Greg Johnston, Sensors & Software Inc. **Course Endorser:** *Sensors & Software Inc.*

523. **AGeS Geochronology Workshop.** Sat., 8 Oct., 8 a.m.–5 p.m. US$40. Limit: 100. CEU: 0.8. **Instructors:** Rebecca Flowers, University of Colorado Boulder; Ramon Arrowsmith, Arizona State University; James Metcalf, University of Colorado Boulder. **Course Endorser:** *GSA Geochronology Division.*

524. **Hydrogeological Layered Modeling—Use of Data, How to Build, and How to Use Output for Informed Decision Making.** Sat., 8 Oct., 8 a.m.–5 p.m. US$115. Limit: 20. CEU: 0.8. **Instructor:** Tom Martlev Pallesen, I-GIS. **Course Endorser:** *I-GIS.*

525. **Introduction to Planetary Image Analysis with ArcGIS.** Sat., 8 Oct., 8 a.m.–5 p.m. US$40. Limit: 40. CEU: 0.8. **Instructor:** Zoe Learner Ponterio, Cornell University. **Course Endorsers:** *Spacecraft Planetary Image Facility; Cornell University.*

526. **Applying Virtual Microscopy to Geoscience.** Sat., 8 Oct., 8 a.m.–5 p.m. US$100 professionals; US$50 students. Limit: 25. CEU: 0.8. **Instructors:** Christopher Prince, PetroArc International; Suzanne Kairo, Indiana University. **Course Endorser:** *PetroArc International.*

527. **Volcanic Crisis Awareness.** Sat., 8 Oct., 8 a.m.–5 p.m. FREE. Limit: 40. CEU: 0.8. **Instructors:** Jeff Rubin, semi-retired emergency manager; Monica Gowan, independent consultant. **Course Endorsers:** *GSA Geology and Health Division; GSA Geology and Society Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; National Disaster Preparedness Training Center (NDPTC) at the University of Hawai'i; Federal Emergency Management Agency (FEMA).*

528. **Head, Shoulders, Knees, and Toes: Medical Geology Fundamentals.** Sat., 8 Oct., 8 a.m.–5 p.m. US$84. Limit: 40. CEU: 0.8. **Instructors:** Laura Ruhl, University of Arkansas at Little Rock; Robert Finkelman, University of Texas at Dallas; Reto Gieré, University of Pennsylvania; Malcolm Siegel, University of New Mexico. **Course Endorsers:** *GSA Geology and Health Division; International Medical Geology Association.*

529. **Quantitative Analysis, Visualization, and Modeling of Detrital Geochronology Data.** Sat., 8 Oct., 8 a.m.–5 p.m. US$75 professionals; US$50 students. Limit: 40. CEU: 0.8. **Instructors:** Joel Saylor, University of British Columbia; Kurt Sundell, Idaho State University; Glenn Sharman, University of Arkansas.

530. **Cave and Karst Research on Federal Lands.** Sat., 8 Oct., 8 a.m.–5 p.m. US$75. Limit: 40. CEU: 0.8. **Instructors:** Patricia Seiser, National Park Service; Limaris Soto, U.S. Forest Service; Kyle Rybacki, Bureau of Land Management. **Course Endorsers:** *National Cave and Karst Research Institute; National Park Service; U.S. Forest Service; Bureau of Land Management.*

531. **Using the StraboSpot and StraboMicro Data Systems for Geology.** Sat., 8 Oct., 8 a.m.–5 p.m. US$25. Limit: 40. CEU: 0.8. **Instructors:** Doug Walker, University of Kansas; Julie Newman, Texas A&M University. **Course Endorsers:** *GSA Structural Geology and Tectonics Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Geoinformatics and Data Science Division.*

532. **Methods and Geological Applications in Geo-Thermo-Petro-Chronology II.** Sat., 8 Oct., 9 a.m.–5 p.m. US$40. Limit: 50. CEU: 0.7. **Instructors:** Sarah George, University of Arizona; George Gehrels, University of Arizona; Kurt Sundell, Idaho State University; Mauricio Ibanez, University of Arizona; Kendra Murray, Idaho State University; Allen Schaen, University of Arizona.

536. **Advances in Applications of Laser Ablation to the Geosciences.** Sat., 8 Oct., 8 a.m.–5 p.m. US$132. Limit: 40. CEU: 0.8. Instructors: Ian Ridley, U.S. Geological Survey; Michael Pribil, U.S. Geological Survey; Alan Koenig, Newmont Mining Co.; Jay Thompson, U.S. Geological Survey.

HALF-DAY SATURDAY COURSES

533. **Inclusive Educational Outreach with NASA SCoPE.** Sat., 8 Oct., 8 a.m.–noon. US$25. Limit: 40. CEU: 0.4. **Instructors:** Jessica Swann, Arizona State University; David Williams, Arizona State University. **Course Endorsers:** *National Aeronautics and Space Administration; Arizona State University.*

534. **Improv to Improve the Geoscience Community.** Sat., 8 Oct., 1–5 p.m. US$20. Limit: 20. CEU: 0.4. **Instructor:** Erik Haroldson, Austin Peay State University. **Course Endorsers:** *Austin Peay State University College of STEM; National Association of Geoscience Teachers (NAGT); National Association of Geoscience Teachers (NAGT) Teacher Education Division (TED).*

535. **Using Geophysics to Address Societally Relevant, Urban and Environmental Real-World Questions in Introductory-Level Geoscience Courses.** Sat., 8 Oct., 1–5 p.m. US$10. Limit: 40. CEU: 0.4. **Instructors:** John Taber, Incorporated Research Institutions for Seismology (IRIS); Andrew Parsekian, University of Wyoming; Sarah Kruse, University of South Florida; Carol Ormand, Carleton College.

Childcare by KiddieCorp

Location: Colorado Convention Center

Hours: Sun.–Wed., 7 a.m.–6 p.m. daily

Ages: Six months to 12 years

Cost: US$10 per hour per child for children 2 years or older and US$12 per hour per child for children under 2 with a 1-hour minimum per child. At least one parent must be registered for the meeting. This is a discounted rate as GSA subsidizes 85% of the total cost for this service to attendees.

Late pick-up fee: US$5 per child for every five minutes the parent is late.

More info: www.kiddiecorp.com/parents.html

Register securely at https://form.jotform.com/KiddieCorp/gsakids

Reserve Childcare in Advance: To ensure that the center is properly staffed and to facilitate planning of games and other activities for the children, advance registration is required. On-site registration may be possible, at a slightly higher cost, if space is available. The deadline for advance child-care registration is 9 September.

Cancelations: For a full refund, cancelations must be made to KiddieCorp prior to 9 September. Cancelations made after 9 September will incur a 50% fee. No refunds after 23 September.

About: KiddieCorp is a nationally recognized company that provides onsite children's activities for a comfortable, safe, and happy experience for both kids and parents. Childcare services are a contractual agreement between each individual and the childcare company. GSA assumes no responsibility for the services rendered.

Contact: KiddieCorp, +1-858-455-1718, info@kiddiecorp.com

Success in Publishing: Navigating the Process

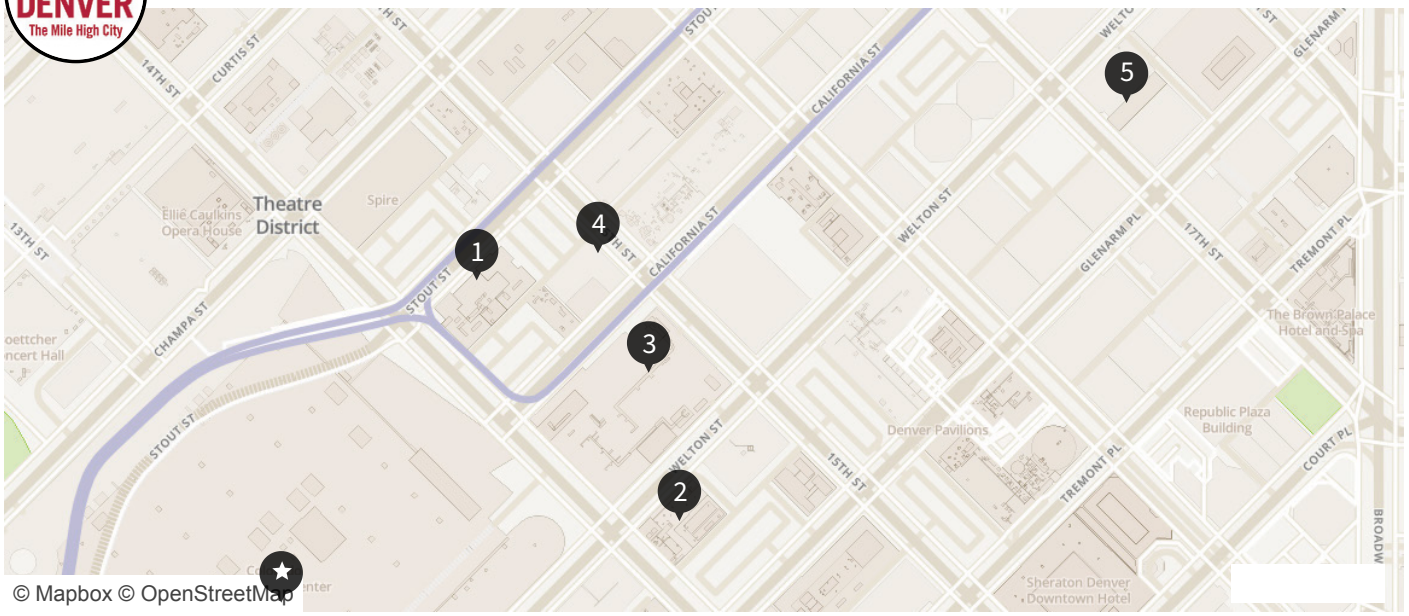
Led by experienced GSA science editors (and GSA Distinguished Service Awardees) Rónadh Cox and Nancy Riggs, this workshop focuses on the bigger creative picture. Learn how to:

- frame and structure your work for publication,
- create well-thought-out figures and tables that communicate your ideas,
- write an attention-getting cover letter,
- choose the right journal for your work,
- and more!

Plus, hear from the experts on what constitutes a good review, how you would benefit from being a reviewer, and how it can advance your career toward an editorship.

This highly successful, free workshop for early career geoscientists on the process of preparing and publishing papers will be held in person for its tenth year during GSA Connects 2022. For more information and to receive email updates, go to **www.geosociety.org/GSA/Publications/GSA/Pubs/WritersResource.aspx.**

Geological Society of America 2022 Hotel Map



★ Colorado Convention Center
700 14th St.
Denver, CO 80202

1 Embassy Suites by Hilton Denver Downtown Convention Center
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1420 Stout St.
Denver, CO 80202
$189 single/double

2 Hilton Garden Inn Denver Downtown
Lodging
1400 Welton St.
Denver, CO 80202
$209 single/double

3 Hyatt Regency Denver at Colorado Convention Center
Lodging
650 15th St.
Denver, CO 80202
HQ Hotel: $249 single/double

4 AC Hotel Denver
Lodging
750 15th St.
Denver, CO 80202
$245 King/$265 Double Queen (single/double)

5 Grand Hyatt Denver
Lodging
1750 Welton St.
Denver, CO 80202
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THRESHOLD 360

Travel & Transportation

A Line train at Denver International Airport. Photo credit: Visit Denver.

DENVER INTERNATIONAL AIRPORT (DEN)

DEN is one of the busiest airports in the world, offering world-class passage to the heart of the Rocky Mountains. Learn more about DEN at **www.flydenver.com/about.**

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Make an Impact—Be a Mentor

Students:
"The interaction was eye-opening and informative."

"One of the most valuable experiences to have right before graduation."

Mentors:
"I appreciated the many student mentorship opportunities and career panels aimed at demonstrating what diverse 'professional geology' career paths look like."

"I enjoyed mentoring and found it interesting to reflect on my career."

Sign up to share your story and meet with students at GSA Connects 2022 at **https://tinyurl.com/2p89ethy.**

- On To the Future Mentor
- Résumé/CV Mentor
- Drop-in Mentor
- GeoCareers Day Table Mentor
- Women in Geology Mentor
- Networking Event Mentor

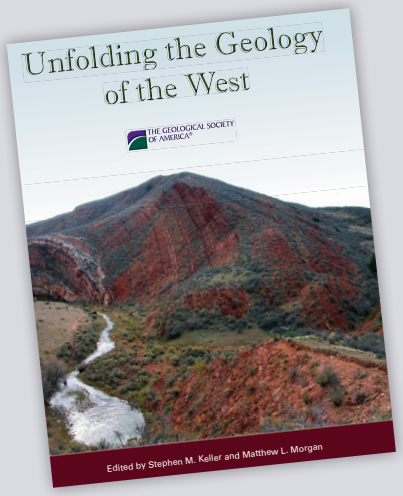
Tour Colorado with This Free GSA Field Guide

From the eastern plains to the western canyons, Colorado offers countless opportunities for geological investigation. To celebrate the return of GSA Connects to Denver, we're offering free digital access to the field guide *Unfolding the Geology of the West*.

Many of the sixteen field guides in this volume cover the same hallowed ground as the early geologic expeditions of the four "Great Surveys" of the late 1800s. Organized into four sections, this volume spans some of the major subdisciplines of geology: (1) stratigraphy, sedimentology, and paleontology; (2) structure and metamorphism; (3) Quaternary landscape evolution; and (4) engineering and environmental geology.

Make the most of your visit—get a free PDF at the GSA Store and get ready to explore Colorado's unique geology. Enter the coupon code UNFOLDING at checkout now through 15 October.

The exploration begins at **https://rock.geosociety.org/store/.**



Resource & Innovation Center

VISIT THE EXHIBIT HALL

Colorado Convention Center Hall A
Sun., 5–7 p.m. (includes the opening reception)
Mon.–Tues., 10 a.m.–6:30 p.m.
Wed., 10 a.m.–2 p.m.

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GSA Karst Division
GSA Limnogeology Division
GSA Marine and Coastal Geoscience Division
GSA Planetary Geology Division
GSA Structural Geology and Tectonics
International Association for Geoscience Diversity
SEPM (Society for Sedimentary Geology)

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Geochemical Society
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National Association of Geoscience Teachers (NAGT)
National Cave and Karst Research Institute
National Park Service
Science is Never Settled
Sigma Gamma Epsilon
Society of Economic Geologists
South Dakota School of Mines and Technology
The Geological Society of London
The Paleontological Society
U.S. Science Support Program, IODP
UNAVCO Inc.
University of Pennsylvania
University of Texas at Dallas
USDA Forest Service
Western Kentucky University

Western Science Center
Yellowstone Bighorn Research Association (YBRA)

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National Park Service/National Cave and Karst Research Institute (NCKRI)—CavSim

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California State University Northridge
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Colorado School of Mines, Dept. Geology & Geology Engineering
East Carolina University
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Missouri State University, Geography, Geology and Planning)
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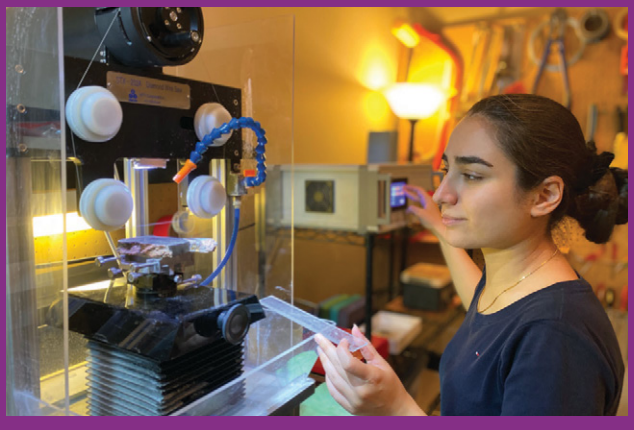

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- Support diversity in and awareness of the geosciences
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Publish, but Skip the "Perish"

Lots of good ideas never get past the "we should…" stage, despite good intentions all around. But sometimes a few determined people do succeed in creating something out of an aspirational notion.

In March 2012, the GSA Publications Committee discussed the question of how GSA could help scientists who are just starting out navigate the challenge of submitting papers for formal publication. The aim was to help advance careers, instill good habits regarding publishing, and encourage good citizen-scientists who give back through reviewing papers and volunteering as editors.

"What's Your Problem; What's Your Point? An Early-Career Workshop on Writing Scholarly Papers" debuted at the GSA 2013 Annual Meeting in Denver, Colorado, USA. Rónadh Cox, John Goodge, and Nancy Riggs volunteered to develop the workshop, and they convened the first one with a boatload of enthusiasm and 51 slides. GSA sprang for the breakfast (and later on, the boxed lunches), and a tradition began. (OK, sometimes the lunches are better than at other times—and the number of slides has been pared down.) The three were joined by Brendan Murphy in 2014 to help with breakout sessions, a feature the attendees valued highly, with its chance to talk one-on-one with experienced editors.

Starting out with a pile of research results and turning that into a concise, interesting paper isn't easy, and every publisher has hoops to jump through with manuscript submission systems. Add to that, responding to reviewer comments can be daunting for a less-experienced geoscientist. The workshop aims to bring it all within reach, with sections on:

- how to focus your thoughts and write about one well-developed idea;
- how to choose the right journal for your research;
- how to prepare files for submitting a paper;
- what to expect in the review process and how to effectively address reviewer comments; and in general,
- what to do and what not to do.

Plus, the attendees benefited from the hard-earned insights of experienced scientist-editors (e.g., "don't write to be understood, write so that you cannot be misunderstood," and "document every change you make").

Rónadh and Nancy continue to lead the workshop; they celebrate their tenth appearance this year. Both brought considerable experience, including as GSA science editors, to the job, and they have added to and adjusted the workshop content over the years. Recently, the workshop has benefited from its location in the GeoCareers Corner, a hub for energetic programs and networking opportunities.

In 2020, the name was updated to "Success in Publishing: Navigating the Process," and like everything else in our world, it was run via webinar rather than in person for a couple of years.

"Success in Publishing" returns to in-person status in 2022, back in its hometown of Denver. And plans are under way to add advice on how early-career scientists from all backgrounds can progress from being authors to being reviewers, associate editors, editorial board members, and science editors, advancing their careers in the process.

Success in Publishing: Navigating the Process
GSA Connects 2022
Sunday, 9 Oct., 11:30 a.m.–1:30 p.m.
GeoCareers Corner, Colorado Convention Center
Room 201/203
Learn more at **www.geosociety.org/GSA/Publications/GSA/Pubs/WritersResource.aspx.**

(If you can't make the meeting in person, the presentations are posted to the GSA website.)

Celebrate *Geology*'s 50th Anniversary Word Scramble Puzzle

Unscramble each word, placing one letter on a line or in a circle to spell 7 geologic terms.

__ __ ◯

REO

__ __ ◯ __

VAAL

__ ◯ __ ◯ __

EHRAS

__ __◯ __ ◯

SESLO

◯ __ ◯ __ __ __

GREESY

__ ◯ __ ◯ __ __ ◯

LEARACD

◯ __ ◯ __ __ __ ◯

OGESUIN

Now unscramble the circled letters above to answer the following question (each circled letter will be used once):

How do geologists say goodbye?

◯◯◯◯ ◯ ◯◯◯◯◯◯ ◯◯◯!

Word Scramble Puzzle Answers: ORE, LAVA, SHEAR, LOESS, GEYSER, CALDERA, IGNEOUS

Question: How do geologists say goodbye? Answer: Have a gneiss day!

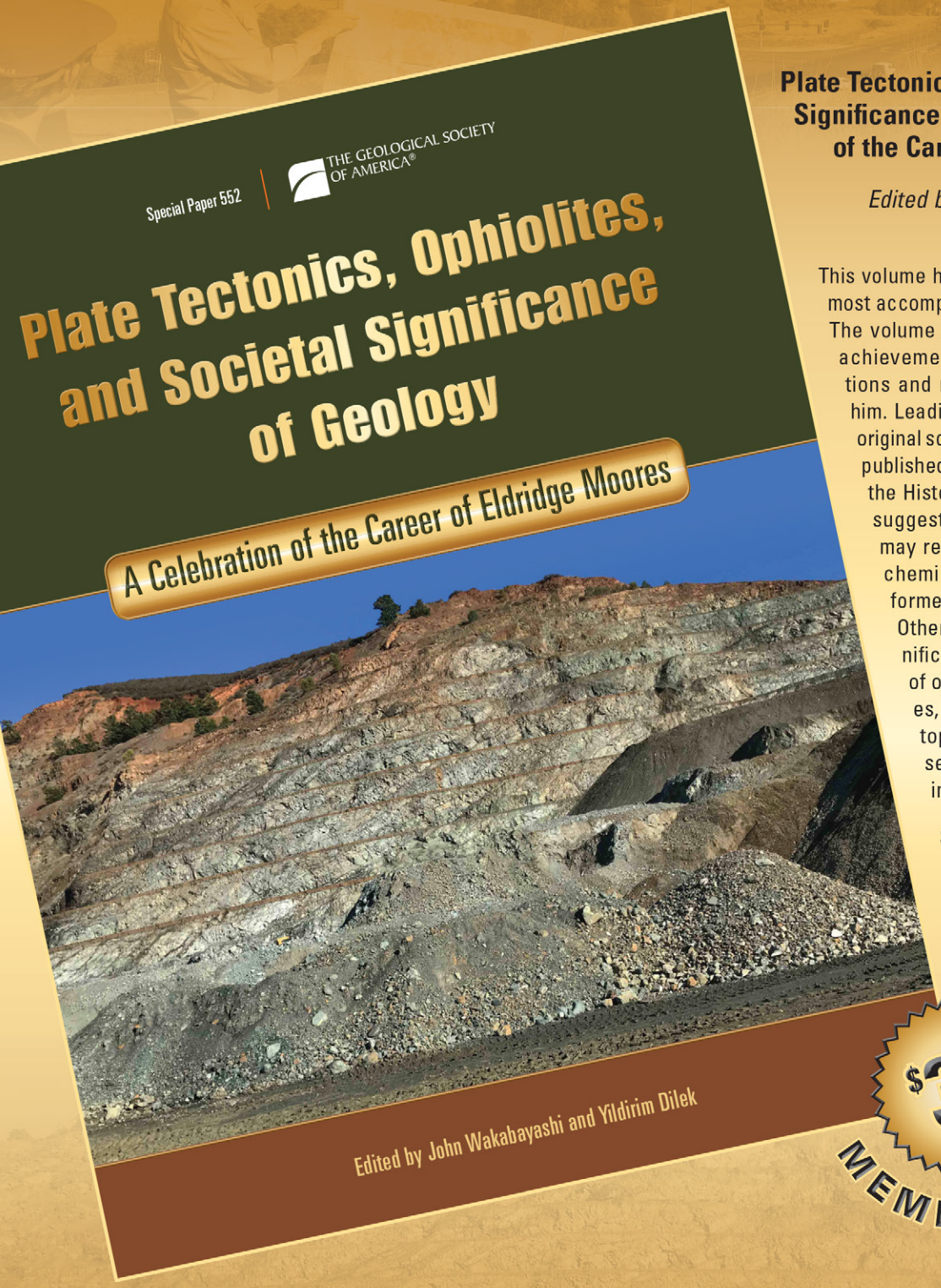

Plate Tectonics, Ophiolites, and Societal Significance of Geology: A Celebration of the Career of Eldridge Moores

Edited by John Wakabayashi and Yildirim Dilek

This volume honors Eldridge Moores, one of the most accomplished geologists of his generation. The volume starts with a summary of Moores' achievements, along with personal dedications and memories from people who knew him. Leading off the volume's 12 chapters of original scientific contributions is Moores' last published paper that presents an example of the Historical Contingency concept, which suggested that earlier subduction history may result in supra-subduction zone geochemical signatures for some magmas formed in non-subduction environments. Other chapters highlight the societal significance of geology, the petrogenesis of ophiolites, subduction zone processes, orogenic belt evolution, and other topics, covering the globe and intersecting with Moores' interests and influences.

SPE552, 296 p.,
ISBN 9780813725529

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www.geosociety.org/sc-mtg

Geosciences at the Crossroads of America

Gypsum formations of Western Oklahoma. Photo by Todd Halihan.

LOCATION

The meeting will take place in Stillwater, Oklahoma, USA, at the Wes Watkins Center of Oklahoma State University (OSU), which is located on the scenic shoreline of the Permian Sea and currently sits at the crossroads of major U.S. highways, U.S. petroleum pipelines, and U.S. ecosystems. OSU has provided an intersection of geologic disciplines since the inception of the Boone Pickens School of Geology, with a history in petroleum, water, and agriculture. The meeting will have a diverse program of workshops, technical sessions, short courses, and field trips that covers a spectrum of geologic disciplines. The meeting is during the spring break for the OSU campus to give some flexibility with facilities. Stillwater is accessible by interstate or air transportation at the Stillwater airport (SWO).

CALL FOR PAPERS

Abstract deadline: 6 Dec.
Submit online at **www.geosociety.org/sc-mtg**
Abstract submission fee: GSA members: professionals: US$30; students: US$18. Non-members: professionals: US$60; students: US$36.

If you cannot submit an abstract online, please contact Heather Clark, hclark@geosociety.org.

TECHNICAL PROGRAM

Please direct questions related to the following sessions to the Technical Program co-chairs, Ahmed Ismail, ahmed.ismail@okstate.edu, and Tracy M. Quan, tracy.quan@okstate.edu.

Theme Sessions

T1. **Discovering Earth through a Multi Geophysical Sensor Approach.** Luel Emishaw, Oklahoma State University, luel.emishaw@okstate.edu; Andrew Katumwehe, Midwestern State University, andrew.katumwehe@msutexas.edu; Zelalem Demissie, Wichita State University, zelalem.demissie@wichita.edu; Mohamed Abdel Salem, Oklahoma State University, mohamed.abdel_salem@okstae.edu; Kevin Mickus, Missouri State University, kevinmickus@missouristate.edu. Oral and Posters.

T2. **Geoscience Education Recruitment and Retention: Adapting Pedagogy for Long-Term Inclusion, Diversity, and Interest in Geoscience.** April Moreno-Ward, Rose State College, mynroux@gmail.com. Oral and Posters.

T3. **Geoscience Education: Advancing Justice, Equity, Diversity, and Inclusion through Research, Curriculum, and Systemic Change.** Wendi J.W. Williams, South Texas College, wwilliam@southtexascollege.edu. Oral and Posters.

T4. **A Sustainable Earth: Exploring the Interactions of Geology and Sustainability.** Michael DeAngelis, University of Arkansas at Little Rock, mtdeangelis@ualr.edu. Oral and Posters.

T5. **Improving Natural Hazard Resilience of Society.** Zelalem Demissie, Wichita State University, zelalem.demissie@wichita.edu; Glyn Rimmington, Wichita State University, glyn.rimmington@gmail.com; Mara Alagic, Wichita State University, mara.alagic@wichita.edu; Atri Dutta, Wichita State University, Atri.Dutta@wichita.edu; Ajita Rattani, Wichita State University, ajita.rattani@wichita.edu. Oral and Posters.

T6. **Geoscience and Hydrology of Your Federal and Other Public Lands: STEM Internships, Research, Science, Mapping, Resource Management, and Education (Posters).** Matt Dawson, GSA, mdawson@geosociety.org. Posters only.

T7. **Hydrogeology and Water Resources: Long-Term Sustainability and Management.** William Andrews, Oklahoma State University, william.andrews@okstate.edu; Robert Mace, Texas State University, robertmace@txstate.edu. Oral and Posters.

T8. **Hydrogeologic Challenges and Roles in Earth Systems.** Kevin M. Befus, University of Arkansas, kmbefus@uark.edu; John G. Richins, University of Arkansas, jgrichin@uark.edu. Oral and Posters.

T9. **Sedimentary Geochemical Characterization of Aquatic Oxygen Dynamics.** Natascha Riedinger, Oklahoma State University, natascha.riedinger@okstate.edu; Tracy M. Quan, Oklahoma State University, tracy.quan@okstate.edu. Oral and Posters.

T10. **Microbial Interactions with Metal, Mineral, and Nutrient Cycling.** Tingying Xu, Oklahoma State University, tingying

.xu@okstate.edu; Sabrina Beckmann, Oklahoma State University, sabrina.beckmann@okstate.edu. Oral and Posters.

T11. **Remediation and Management of Produced Water for Beneficial Uses.** Babu Fathepure, Oklahoma State University, babu.fathepure@okstate.edu; Mark Krzmarzick, Oklahoma State University, mark.krzmarzick@gmail.com. Oral and Posters.

T12. **Advances in Geologic Carbon Capture and Storage (CCS).** Jack Pashin, Oklahoma State University, jack.pashin@okstate.edu; Camelia Knapp, Oklahoma State University, camelia.knapp@okstate.edu. Oral and Posters.

T13. **Paleoecology of the South-Central United States.** Anne Weil, OSU Center for Health Sciences, anne.weil@okstate.edu; Oghalomeno Ononeme, Oklahoma State University, oghalomeno.evih.ononeme@okstate.edu. Oral and Posters.

T14. **Advances in Early to "Mid" Cretaceous Stratigraphy, Paleoclimate, Paleoenvironments, and Paleontology in the Gulf Coast and South-Central Region.** Marina B. Suarez, The University of Kansas, mb.suarez@ku.edu; Celina A. Suarez, The University of Arkansas, casuarez@uark.edu; Alexis Godet, The University of Texas at San Antonio, Alexis.Godet@utsa.edu; Dan Lehrmann, Trinity University, dlehrman@trinity.edu; Thomas Adams, Witte Museum, thomasadams@wittemuseum.org. Oral and Posters.

T15. **Geomorphological, Sedimentological, and Pedological Archives of Human-Environmental Change.** Carlos Cordova, Oklahoma State University, carlos.cordova@okstate.edu. Oral and Posters.

T16. **Shale Lab and Field Projects: Sciences and Techniques on Unconventional Resources.** Yulun Wang, Oklahoma State University, yulun.wang@okstate.edu; Carl Symcox, Oklahoma Geological Survey, carl.w.symcox-1@ou.edu; Fengyang Xiong, Oklahoma State University, fxiong@okstate.edu; Jim Puckette, Oklahoma State University, jim.puckette@okstate.edu; Michael Grammer, Oklahoma State University, michael.grammer@okstate.edu; Nicholas Hayman, Oklahoma Geological Survey, hayman@ou.edu; Mileva Radonjic, Oklahoma State University, mileva.radonjic@okstate.edu. Oral and Posters.

T17. **Mississippian Formation Reservoir Characterization: The Need to Improve Future Development Results.** Bob Springman, GTSeis, LLC, rspringman@gtseis.com. Oral and Posters.

T18. **From Pore- to Field-Scale Petrophysical and Elastic Characterization of Rocks and Fluid Flow Simulations.** Javier Vilcaez, Oklahoma State University, vilcaez@okstate.edu; Priyank Jaiswal, Oklahoma State University, priyank.jaiswal@okstate.edu. Oral and Posters.

FIELD TRIPS

For additional information, please contact the field trip co-chairs: Jim Puckette, jim.puckette@okstate.edu, and Brandon Spencer, spbr@okstate.edu.

Geology of the Wichitas and Slick Hills: Rifts, Ruptures, and Modern Consequences. Brandon Spencer, Oklahoma State University, spbr@okstate.edu; Shannon Dulin, University of Oklahoma, sdulin@ou.edu; Carla Eichler, Oklahoma Geological Society, carla.eichler@ou.edu; Molly Turko, Turko Tectonics, turkotectonics@gmail.com.

Tar Creek Superfund Site Field Trip: A Journey to Metal Contamination and Remediation. Tingying Xu, Oklahoma State University, tingying.xu@okstate.edu; Robert W. Nairn, University of Oklahoma, nairn@ou.edu; Kato Tsosie Dee, University of Oklahoma, kdee@ou.edu.

Managed Aquifer Recharge in the Arbuckle Simpson Aquifer. Guy Sewell, East Central University, gsewell@ecok.edu; William Andrews, Oklahoma State University, william.andrews@okstate.edu; Madison Culver, Oklahoma State University, madison.culver@okstate.edu; Duane Smith, Oka' Institute, dasmith@ecok.edu.

Recent to Modern Sedimentary Processes in Northwestern Oklahoma: Caves, Crystals, and Dunes. Carla Eichler, Oklahoma Geological Survey, carla.eichler@ou.edu; Brandon Spencer, Oklahoma State University, spbr@okstate.edu.

SHORT COURSES

Core Workshop: Introduction to Carbonate and Siliciclastic Depositional Systems for Oil and Gas, Groundwater, and Carbon Capture and Storage. Michael Grammer, Oklahoma State University, michael.grammer@okstate.edu; Jim Puckette, Oklahoma State University, jim.puckette@okstate.edu.

Geomicrobiology Culturing Strategies: From Sediment to Microbial Culture. Sabrina Beckmann, Oklahoma State University, sabrina.beckmann@okstate.edu; Tingying Xu, Oklahoma State University, tingying.xu@okstate.edu.

The Future of Geoscience Education: Implementing Technology for Engagement and Recruitment. Ashley Burkett, Oklahoma State University, ashley.burkett@okstate.edu; Caitlin Barnes, Oklahoma State University, caitlin.barnes@okstate.edu; Tracy M. Quan, Oklahoma State University, tracy.quan@okstate.edu.

Fundamentals of Petroleum-Produced Water Characterization, Treatment, and Disposal into the Subsurface. Javier Vilcaez, Oklahoma State University, vilcaez@okstate.edu.

Field Geophysics. Andrew Katumwehe, Midwestern State University, andrew.katumwehe@msutexas.edu; Ahmed Ismail, Oklahoma State University, ahmed.ismail@okstate.edu.

Fundamentals of Geologic CO_2 Storage. Jack Pashin, Oklahoma State University, jack.pashin@okstate.edu; Camelia Knapp, Oklahoma State University, camelia.knapp@okstate.edu.

Direct Imaging with Direct Push Technology. Dan Pipp, Geoprobe Systems, pippd@geoprobe.com; Nick Basore, Geoprobe Systems, basoren@geoprobe.com.

REGISTRATION

Early registration deadline: 6 Feb.
Cancellation deadline: 13 Feb.

Registration opens in December. For further information or if you need special accommodations, please contact Todd Halihan at todd.halihan@okstate.edu.

OPPORTUNITIES FOR GSA STUDENTS AND EARLY CAREER PROFESSIONALS

Career Mentoring Luncheons

Ask your career-related questions and learn about non-academic pathways in the geosciences while networking with professionals at the Roy J. Shlemon and John Mann Mentor luncheons. GSA student members are welcome.

Career Workshop Series

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

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

PROFESSIONALS

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

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

LOCAL COMMITTEE

General Chair: Todd Halihan, todd.halihan@okstate.edu
Technical Program Co-Chairs: Ahmed Ismail, ahmed.ismail@okstate.edu; Tracy M. Quan, tracy.quan@okstate.edu
Field Trip Co-Chairs: Jim Puckette, jim.puckette@okstate.edu; Brandon Spencer, spbr@okstate.edu
Exhibits/Sponsorship Co-Chairs: Jack Pashin, jack.pashin@okstate.edu; Lawrence Walker, lpwalk62@icloud.com
Student Volunteer Chair: Tingying Xu, tingying.xu@okstate.edu
Judging Coordinator: Natascha Riedinger, natascha.riedinger@okstate.edu

THE GEOLOGICAL SOCIETY OF AMERICA®

Mark your Calendar for Meetings Closer to Home

South-Central Section

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

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

Joint Southeastern & Northeastern Sections

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

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

North-Central Section

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

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

Cordilleran Section

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

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

Rocky Mountain Section

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

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

2023

Joint Southeastern & Northeastern Sections

72nd Annual Meeting of the Southeastern Section, GSA
58th Annual Meeting of the Northeastern Section, GSA

Reston, Virginia, USA | 17–19 March 2023

www.geosociety.org/se-mtg

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

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

In 2020, ten days before the Joint Meeting of the 69th Annual Meeting of GSA's Southeastern Section and the 55th Annual Meeting of GSA's Northeastern Section, we made the critical decision to cancel the meeting due to the rising global threat from COVID-19. In the following days, a global pandemic and national emergency were declared, and our lives have since changed. Two and a half years later, we are excited to have the opportunity to host the joint meeting of the Southeastern and Northeastern Sections. We have rebuilt a robust and diverse technical program that links together the geology of the southeastern and northeastern U.S. and examines many key issues, including sea-level rise, climate and environmental change, energy and critical minerals, and diversity, equity, and inclusion in the geosciences. The program has many opportunities for students—our greatest resource for the future—to develop and build their career paths. We look forward to seeing you at the joint meeting. Reston will rock!

LOCATION

The meeting will be held in Reston, Virginia, USA. Situated at the Fall Zone and the transition from the southern to the central and northern Appalachians, Reston provides a unique vantage point to examine all aspects of eastern geology. Reston is a modern, planned community located in northern Virginia. The numerous historic and cultural attractions of Washington, D.C., are just a short distance away and ready to be explored. Immediately outside of the Hyatt Regency Reston lies a mix of bistros, restaurants, and shops along an extensive pedestrian mall. Take a field trip across the Blue Ridge or to the Atlantic Coastal Plain, visit Capitol Hill, or see the connections between geology and the terrain of a Civil War battlefield. We invite you to join us at Reston 2023 to enjoy a broad scope of technical sessions, symposia, short courses, and field trips that will help us keep a keen eye on eastern geology.

CALL FOR PAPERS

Abstracts deadline: 13 Dec.
Submit online at **www.geosociety.org/se-mtg**
Abstract submission fee: GSA members: professionals US$30; students US$18; non-members: professionals US$60; students US$36.

If you cannot submit an abstract online, please contact Heather Clark, hclark@geosociety.org.

TECHNICAL PROGRAM

Symposia

S1. **Sea-Level History from the U.S. East Coast—Insights for Projecting Future Change.** Robert Poirier, U.S. Geological Survey, rpoirier@usgs.gov; Michael Toomey, U.S. Geological Survey, mtoomey@usgs.gov; Thomas M. Cronin, U.S. Geological Survey, tcronin@usgs.gov.

S2. **Deciphering the Devonian World, from Biotic to Environmental Crises across the Globe.** Sarah Carmichael, Appalachian State University, carmichaelsk@appstate.edu; Cole Edwards, Appalachian State University, edwardsct4@appstate.edu; Diana Boyer, Winthrop University, boyerd@winthrop.edu; Daniel Doctor, U.S. Geological Survey, dhdoctor@usgs.gov.

S3. **Internal and External Controls on Landscape Evolution.** Kristin Chilton, Virginia Tech, kchilton@vt.edu; Charlie Shobe, West Virginia University, charles.shobe@mail.wvu.edu.

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

S5. **Environmental Radionuclides: Geochemical Behavior, Tracer Applications, and Potential Health Consequences.** Jim Kaste, William & Mary Geology, jmkaste@wm.edu; Joshua D. Landis, Dartmouth College, Joshua.D.Landis@dartmouth.edu.

S6. **The Grenville Orogen in Eastern North America.** Greg Walsh, U.S. Geological Survey, gwalsh@usgs.gov; Paul Mueller, University of Florida, pamueller@ufl.edu; Peter Valley, U.S. Geological Survey, pvalley@usgs.gov.

S7. **From the Margins to the Deep: A Tribute to the Science and Art of A. Conrad Neumann.** Blair Tormey, Western Carolina University, btormey@wcu.edu; Al Hine, University of South Florida, hine@usf.edu; Paul Hearty, University of Texas at Austin, kaisdad04@gmail.com.

Theme Sessions

T1. **Resilience and Resource Strategies for the Coastal and Nearshore Zone in a Changing World.** Joshua Long, U.S. Geological Survey, jhlong@usgs.gov; Till Hanebuth, Coastal Carolina University, thanebuth@coastal.edu; Katherine Luciano, South Carolina Geological Survey, LucianoK@dnr.sc.gov; Clark Alexander, Skidaway Institute of Oceanography, Clark.Alexander@skio.uga.edu.

T2. **So Near But Yet so Far: A Review of U.S. Offshore Resources of Minerals for Renewable Energy.** Frank T. Manheim, George Mason University, fmanhei1@gmu.edu.

T3. **Geologic Maps, Geophysical Maps, 3-D Geological Models, Digital Mapping Techniques, Map Derivatives, and Digital Map Preparation (Posters).** Randy L. Kath, University of West Georgia, rkath@westga.edu; Karen S. Tefend, University of West Georgia, ktefend@westga.edu.

T4. **Taconic Orogeny in the North, Central, and Southern Appalachians: Tectonics of the Early Paleozoic Margin of Laurentia.** Clinton Barineau, Columbus State University, barineau_clinton@columbusstate.edu; James Tull, Florida State University, jtull@fsu.edu; Steven Whitmeyer, James Madison University, whitmesj@jmu.edu; Paul Karabinos, Williams College, pkarabin@williams.edu.

T5. **Solid and Aqueous Contaminant Fate and Transport in the Watershed (Posters).** Golam Kibria, Morehead State University, m.kibria@moreheadstate.edu.

T6. **Geoscience and Hydrology of Your Federal and Other Public Lands: STEM Internships, Research, Science, Mapping, Resource Management, and Education (Posters).** Matt Dawson, Geological Society of America, mdawson@geosociety.org.

T7. **Integrated Ichnostratigraphy: Trace Fossils at Unconformities.** Andrew K. Rindsberg, University of West Alabama, arindsberg@uwa.edu; Corey J. Hensen, Cornell University, cjh352@cornell.edu.

T8. **Small-Scale Geologic Mapping in the Northeastern U.S.: Addressing the USGS National Cooperative Geologic Mapping Program's Goals for a Seamless, National 2D/3D Geologic Framework Model of the United States.** Donald Sweetkind, U.S. Geological Survey, dsweetkind@usgs.gov; Joseph Colgan, U.S. Geological Survey, jcolgan@usgs.gov; David Soller, U.S. Geological Survey, drsoller@usgs.gov; Jenna Shelton, U.S. Geological Survey, jlshelton@usgs.gov.

T9. **Landslide Investigations in the Eastern United States.** Jonathan Kim, Vermont Geological Survey, jon.kim@vermont.gov; George Springston, Norwich University, gsprings@norwich.edu; Keith Klepeis, University of Vermont, kklepeis@uvm.edu.

T10. **Trace Elements in the Environment.** Melissa Lombard, U.S. Geological Survey, mlombard@usgs.gov; Isabelle Cozzarelli, U.S. Geological Survey, icozzare@usgs.gov; Madeline Schreiber, Virginia Tech, mschreib.vt.edu.

T11. **Geomorphic Evolution of River Corridors in the Eastern United States from the Pleistocene to the Anthropocene.** Max Huffman, University of Delaware, mhuffman@udel.edu; Samantha Dow, University of Connecticut, samantha.dow@uconn.edu; Brad Johnson, Davidson College, brjohnson@davidson.edu.

T12. **Undergraduate Research Poster Session (Posters).** *Endorsed by Council on Undergraduate Research Geosciences Division.* Lee Phillips, University of North Carolina at Greensboro, plphilli@uncg.edu; Jeff Ryan, University of South Florida, ryan@mail.usf.edu.

T13. **Advances in Machine-Learning–Based Applications to Surficial Geologic Questions.** William Odom, U.S. Geological Survey, wodom@usgs.gov; Daniel Doctor, U.S. Geological Survey, dhdoctor@usgs.gov; Aaron Maxell, West Virginia University, Aaron.Maxwell@mail.wvu.edu; Charlie Shobe, West Virginia University, Charles.Shobe@mail.wvu.edu.

T14. **Oil- and Gas-Produced Water—Accidental Releases and Intentional Re-Use Considerations.** Isabelle Cozzarelli, U.S. Geological Survey, icozzare@usgs.gov; Madalyn Blondes, U.S. Geological Survey, mblondes@usgs.gov; Denise Akob, U.S. Geological Survey, DAkob@usgs.gov; Matthew Varonka, U.S. Geological Survey, mvaronka@usgs.gov.

T15. **Using the Sedimentary Record to Investigate Appalachian and Ouachita Tectonics.** William T. Jackson, Jr., University of Memphis, wtjckson@memphis.edu; Matthew P. McKay, Missouri State University, matthewmckay@missouristate.edu; Brian S. Cook, Geological Survey of Alabama, bcook@gsa.state.al.us.

T16. **Geoscience for National Security and Law Enforcement.** Christopher Bernhardt, U.S. Geological Survey, cbernhardt@usgs.gov; Peter Chirico, U.S. Geological Survey, pchirico@usgs.gov.

T17. **The Mineral-Security Nexus: Toward a Practical Roadmap for Integrative Strategic Mineral Analysis (PRISM).** *Endorsed by GSA Mineralogy, Geochemistry, Petrology and Volcanology Division; Mineralogical Society of America (MSA).* Thomas Hale, Friends of Mineralogy, hthomas94@gwu.edu; Alex Speer, Mineralogical Society of America, jaspeer@minsocam.org.

T18. **Alleghanian Overprinting of Pre-Alleghanian Accreted Terranes.** Ryan McAleer, U.S. Geological Survey, rmcaleer@usgs.gov; Ryan Deasy, U.S. Geological Survey, rdeasy@usgs.gov; Rebecca Stokes, U.S. Geological Survey, mstokes@usgs.gov.

T19. **Mapping in the Geosciences: Processes and Products (Posters).** Libby Ives, U.S. Geological Survey, eives@usgs.gov; Greg Walsh, U.S. Geological Survey, gwalsh@usgs.gov.

T20. **Early Career Voices of Appalachian Tectonics.** *Endorsed by GSA Geochronology Division; GSA Structural Geology and Tectonics Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division.* Allie Nagurney, University of South Carolina, nagurney@vt.edu; Elizabeth Bollen, Geological Survey of Alabama, EBollen@gsa.state.al.us; Zach Foster-Baril, University of Texas, zfosterbaril@utexas.edu; Jonny Prouty, Virginia Tech, jonathanprouty@vt.edu.

T21. **Bridges to Our Shared Future: Support for K–12 Geoscience Education.** *Endorsed by Southeast/New England Sections of National Association of Geoscience Teachers (NAGT).* Mary I. Abercrombie, Florida Gulf Coast University, mabercrombie@fgcu.edu; Susan Meabh Kelly, CSDE and University of Connecticut, susankelly.ct@gmail.com.

T22. **Building Student Knowledge of Geoscience Careers.** *Endorsed by GSA Geoscience Education Division; National Association of Geoscience Teachers (NAGT).* Joyce Smith, North Carolina State University, jsmith45@ncsu.edu; David McConnell, North Carolina State University, damcconn@ncsu.edu.

T23. **Soil, Water, and Biogeochemical Interactions.** *Endorsed by GSA Soils and Soil Processes Division; GSA Hydrogeology Division; GSA Geobiology and Microbiology Division.* Zsuzsanna Balogh-Brunstad, Hartwick College, balogh_brunz@hartwick.edu; Justin Richardson, The University of Massachusetts Amherst, jbrichardson@umass.edu; Oluyinka Oyewumi, Central Connecticut State University, oyewumi@ccsu.edu.

T24. **Undergraduate and Graduate Geoscience Student Showcase (Posters).** *Endorsed by Counsel on Undergraduate Research Geoscience Division.* James H. MacDonald, Florida Gulf Coast University, jmacdona@fgcu.edu; Marian Buzon, Western Georgia University, mbuzon@westga.edu; Mary Abercrombie, Florida Gulf Coast University, mabercrombie@fgcu.edu.

T25. **What do the Ages Mean? Overcoming the Challenges for Geo- and Thermochronology in the Polydeformed Appalachian Orogenic System.** Ryan Thigpen, University of Kentucky, ryan.thigpen@uky.edu; Maggie Curry, North Carolina State University, mcurry2@ncsu.edu; Ryan McAleer, U.S. Geological Survey, rmcaleer@usgs.gov.

T26. **Young Features in an Old Range: Quaternary Landscape Evolution in the Appalachian Mountains and Foothills.** Brad Johnson, Davidson College, brjohnson@davidson.edu; Mark Carter, U.S. Geological Survey, mcarter@usgs.gov.

T27. **Energy Geology Research.** Joao S. Meyers, U.S. Geological Survey and George Mason University, jsmeyers@usgs.gov; Marc L. Buursink, U.S. Geological Survey, mbuursink@usgs.gov.

T28. **Engineering and Environmental Aspects of Karst Terrains.** Wendell Barner, Barner Consulting, LLC, wendell.barner@gmail.com; David German, Volusia County Schools, dpgerman@volusia.k12.fl.us.

T29. **Mapping Surficial Deposits in the Appalachians: Field Methods, Digital Techniques, and Classification Strategies (Posters).** Matt Heller, Virginia Department of Energy, matt.heller@energy.virginia.gov; Anne Witt, Virginia Department of Energy, anne.witt@energy.virginia.gov; William Andrews, Kentucky Geological Survey, wandrews@uky.edu; Phil Dinterman, West Virginia Geological and Economic Survey, pdinterman@wvgs.wvnet.edu; Steve Kite, West Virginia University, jkite@wvu.edu.

T30. **The 200th Anniversary of the First State Geological Survey—the North Carolina Geological Survey.** Kenneth B. Taylor, North Carolina Geological Survey, kenneth.b.taylor@ncdenr.gov; Phil Bradley, North Carolina Geological Survey, pbradley@ncdenr.gov; Kathleen Farrell, North Carolina Geological Survey, kathleen.farrell@ncdenr.gov; James Chapman, North Carolina Geological Survey, james.chapman@ncdenr.gov; Bart Cattanach, North Carolina Geological Survey, bart.cattanach@ncdenr.gov; Heather Hanna, North Carolina Geological Survey, heather.hanna@ncdenr.gov; Norman Gay, North Carolina Geological Survey, kenny.gay@ncdenr.gov; Amy Pitts, North Carolina Geological Survey, amy.pitts@ncdenr.gov.

T32. **Conventional and Unconventional Critical Mineral Resources in the Eastern United States.** *Endorsed by GSA Geophysics and Geodynamics Division; GSA Environmental and Engineering Geology Division; GSA Sedimentary Geology Division; GSA Soils and Soil Processes Division; GSA Structural Geology and Tectonics Division.* Anjana K. Shah, U.S. Geological Survey, ashah@usgs.gov; Nora K. Foley, U.S. Geological Survey, nfoley@usgs.gov; Bernard Hubbard, U.S. Geological Survey, bhubbard@usgs.gov; Arthur Merschat, U.S. Geological Survey, amerschat@usgs.gov.

T33. **Structural Geology and Tectonics Undergraduate Research (Oral Presentations Only)**. *Endorsed by GSA Structural Geology and Tectonics Division; Council of Undergraduate Research.* Jackie Langille, University of North Carolina–Asheville, jlangill@unca.edu; Cheryl Waters-Tormey, Western Carolina University, cherylwt@email.wcu.edu.

T34. **Geological, Seismological, and Paleoseismological Research into Eastern North American Earthquakes.** Kevin Stewart, University of North Carolina–Chapel Hill, Kevin_Stewart@unc.edu; Mark Carter, U.S. Geological Survey, mcarter@usgs.gov.

T35. **Breaking Barriers and Challenging Traditions in Geoscience Education.** *Endorsed by Southeastern Section National Association of Geoscience Teachers (NAGT).* Stephanie L. Shepherd, Auburn University, slshepherd@auburn.edu; Melissa Hage, Oxford College of Emory University, melissa.hage@emory.edu.

T36. **Mapping and Stratigraphic Studies of the Atlantic Coastal Plain and Inner Shelf.** Kathleen M. Farrell, North Carolina Geological Survey, Kathleen.Farrell@ncdenr.gov; William R. Doar, III, South Carolina Geological Survey, DoarW@dnr.sc.gov; M. Scott Harris, College of Charleston, HarrisS@cofc.edu.

T37. **Student Oral Presentations.** Marian Buzon, University of West Georgia, mbuzon@westga.edu; Brittani McNamee, University of North Carolina Asheville, bmcnamee@unca.edu.

T38. **Opportunities for Students in a Time of Systemic Change.** Aisha Morris, National Science Foundation, armorris@nsf.gov; Eleanour Snow, U.S. Geological Survey, esnow@usgs.gov.

T39. **Driving Systemic Change in the Geosciences.** Eleanour Snow, U.S. Geological Survey, esnow@usgs.gov; Aisha Morris, National Science Foundation, armorris@nsf.gov.

T40. **Igneous and Metamorphic Petrology Enigmas in Eastern North America: A Session in Honor of Brent Owens.** Chuck Bailey, William & Mary, cmbail@wm.edu; Kristie Caddick, Virginia Tech, kcaddick@vt.edu.

T41. **Barrier Island and Backbarrier Sediment Dynamics.** Zoe Hughes, Boston University, zoeh@bu.edu; Lucila Houttuijn Bloemendaal, Boston University, lbloem@bu.edu; Alice Staro, Boston University, astaro@bu.edu.

T42. **Paleoenvironment and Paleobiology of Late Cretaceous Sediments Near Coon Creek, Tennessee.** Michael Gibson, University of Tennessee–Martin, mgibson3@utm.edu; Tom Byl, U.S. Geological Survey and Tennessee State University, tdbyl@usgs.gov.

T43. **Geoscience Careers for New Geoscience Graduates.** Michael Lawless, Draper Aden Associates, mlawless@daa.com; Ronald Wallace, rw30075@yahoo.com.

PLENARY TALK

Please join us for the 2023 Southeastern & Northeastern GSA Plenary Talk: **Drilling into the Chicxulub Impact Crater and a World-Wide Calamity 66 Million Years Ago,** by David Kring, Lunar and Planetary Institute, Universities Space Research Association.

FIELD TRIPS

Trip registration opens in December. For additional information, please contact the field trip co-chairs: Jean M. Self-Trail, jstrail@usgs.gov, and Laurel M. Bybell, lbybell@usgs.gov.

Geology and the Civil War at the North Anna River Fall Zone, Virginia. Chuck Bailey, William & Mary, cmbail@wm.edu.

Geology and Paleontology of Cretaceous and Paleocene Sediments of Cabin Branch and Tinkers Creek, Prince Georges County, Maryland. Jean M. Self-Trail, U.S. Geological Survey, jstrail@usgs.gov; David L. Govoni, U.S. Geological Survey (emeritus), dgovoni@usgs.gov; Laurel M. Bybell, U.S. Geological Survey (emeritus), lbybell@usgs.gov.

Experience Capitol Hill: Geoscience and Public Policy in Washington, D.C. Kasey White, Geological Society of America, kwhite@geosociety.org.

Proterozoic and Paleozoic Tectonic Evolution of the Northern Shenandoah Massif. Bill Burton, U.S. Geological Survey, bburton@usgs.gov; J. Steven Schindler, U.S. Geological Survey, sschindl@usgs.gov; Alan Pitts, U.S. Geological Survey, apitts@usgs.contractor.gov.

SHORT COURSES

Short course registration opens in December. For additional information, please contact the short course co-chairs: Daniel H. Doctor, dhdoctor@usgs.gov, and Katie Tamulonis, ktamulonis@allegheny.edu.

Applied Micropaleontology for Non-Paleontologists: How to Interpret and Use Fossil Data. Marci M. Robinson, U.S. Geological Survey, mmrobinson@usgs.gov; Jean M. Self-Trail, U.S. Geological Survey, jstrail@usgs.gov.

Stormwater Management in Karst Terrain—A Regional Perspective. Robert K. Denton, Jr., Terracon Consultants, Inc., robert.denton@terracon.com.

Integrating ESRI Mobile, Online, and Desktop GIS for Real-Time Collaborative Field Data Acquisition. Alan Pitts, U.S. Geological Survey, apitts@usgs.contractor.gov; Daniel H. Doctor, U.S. Geological Survey, dhdoctor@usgs.gov

REGISTRATION

Early registration deadline: 13 Feb.
Cancellation deadline: 21 Feb.

Registration opens in December. For further information or if you need special accommodations, please contact one of the general co-chairs, Arthur Merschat, amerschat@usgs.gov, or Patrick Burkhart, patrick.burkhart@sru.edu.

ACCOMMODATIONS

Hotel registration deadline: 22 Feb., 5 p.m., EST

A block of rooms has been reserved at the Hyatt Regency Reston, 1800 Presidents Street, Reston, Virginia 20190, USA, located in the vibrant Reston Town Square. The meeting rate is US$159 per night plus tax. The hotel offers many amenities (restaurants, bar, pool, wi-fi) and a complimentary shuttle to/from Dulles International Airport. Reservations can be made by calling +1-703-709-1234. Please be sure to identify yourself with the group code SEGSA23 and that you are attending the GSA Southeastern and Northeastern

Sections Joint Meeting. Parking is available at the hotel and at the Reston Town Parking Garage next to the hotel.

OPPORTUNITIES FOR STUDENTS AND EARLY CAREER PROFESSIONALS

Career Mentoring Luncheons

Ask your career-related questions and learn about non-academic pathways in the geosciences while networking with professionals at the Roy J. Shlemon and John Mann Mentor luncheons. GSA student members are welcome.

Career Workshop Series

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

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

Student Volunteers

Take advantage of work opportunities to earn free meeting registration. Students interested in helping with the various aspects of the meeting should contact Michael H. Trippi, U.S. Geological Survey, mtrippi@usgs.gov.

PROFESSIONALS

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

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

LOCAL COMMITTEE

General Co-Chairs: Arthur Merschat, amerschat@usgs.gov; Patrick Burkhart, patrick.burkhart@sru.edu
Technical Program Co-Chairs: Chuck Bailey, cmbail@wm.edu; Wendell Barner, wendell.barner@gmail.com
Field Trip Co-Chairs: Jean M. Self-Trail, jstrail@usgs.gov; Laurel M. Bybell, lbybell@usgs.gov
Sponsorships Chair: Patrick Burkhart, patrick.burkhart@sru.edu
Short Course Co-Chairs: Daniel H. Doctor, dhdoctor@usgs.gov; Katie Tamulonis, ktamulonis@allegheny.edu
Exhibits Chair: Daniel Harris, harris_d@calu.edu
Treasurer: Patrick Burkhart, patrick.burkhart@sru.edu
Student Volunteer Chair: Michael H. Trippi, mtrippi@usgs.gov

Field Guide 62

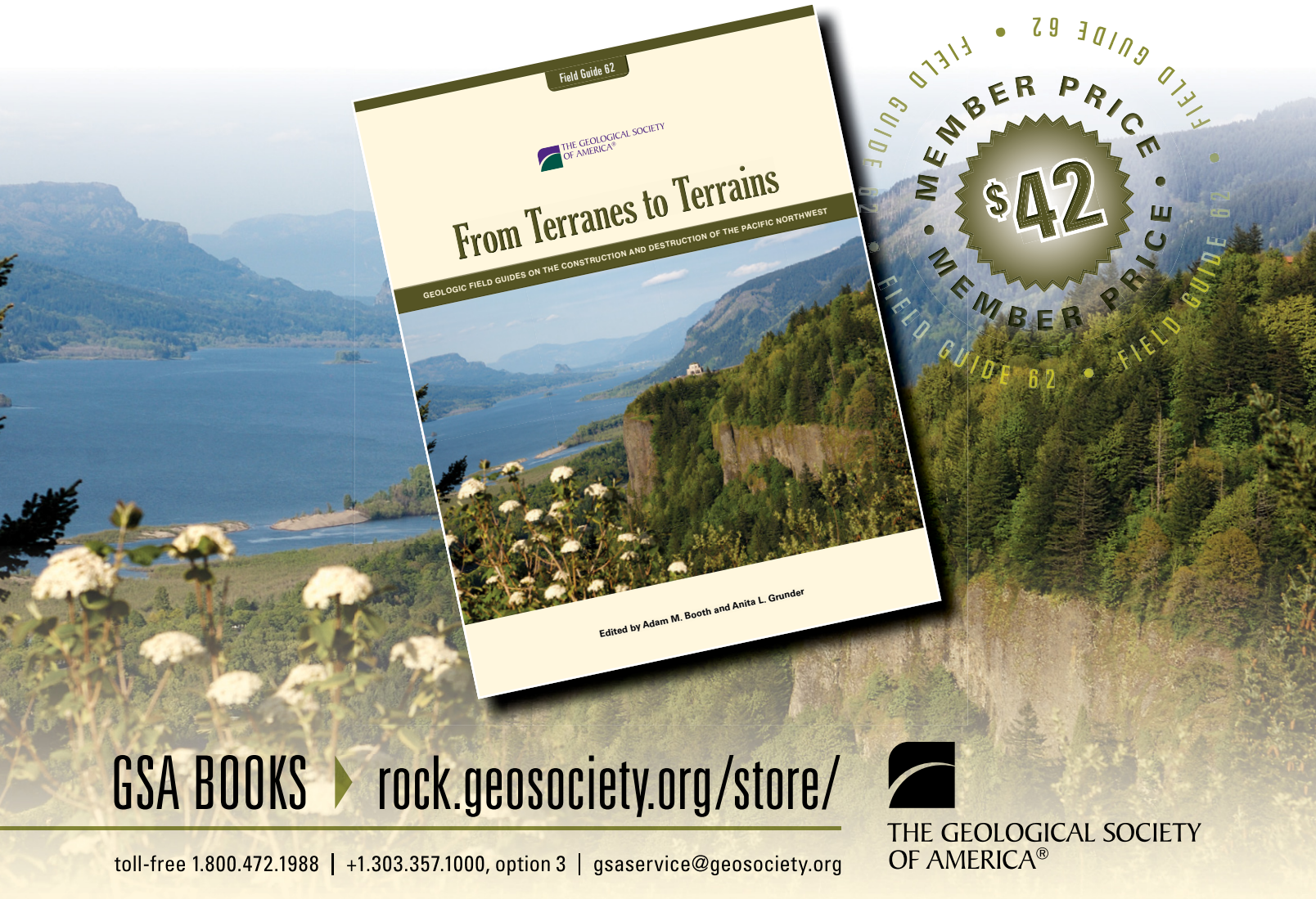
From Terranes to Terrains

GEOLOGIC FIELD GUIDES ON THE CONSTRUCTION AND DESTRUCTION OF THE PACIFIC NORTHWEST

Edited by Adam M. Booth and Anita L. Grunder

The eight field trips in this volume, associated with GSA Connects 2021 held in Portland, Oregon, USA, reflect the rich and varied geological legacy of the Pacific Northwest. The western margin of North America has had a complex subduction and transform history throughout the Phanerozoic, building a collage of terranes. The terrain has been modified by Cenozoic sedimentation, magmatism, and faulting related to Cascadia subduction, passage of the Yellowstone hot spot, and north and westward propagation of the Basin and Range province. The youngest flood basalt province on Earth also inundated the landscape, while the mighty Columbia watershed kept pace with arc construction and funneled epic ice-age floods from the craton to the coast. Additional erosive processes such as landslides continue to shape this dynamic geological wonderland.

FLD062, 352 p., ISBN 9780813700625 | list price $60.00 | **member price $42.00**



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THE GEOLOGICAL SOCIETY OF AMERICA®

GSA's Environmental and Engineering Geology Division Diamond Jubilee

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Robert Mitchell, Past Chair

The Environmental and Engineering Geology Division (EEGD) was established 75 years ago in 1947 as the first Division of the Geological Society of America, making it the oldest engineering geology organization in the United States. The EEGD is celebrating its Diamond Jubilee at GSA Connects 2022 from 9 to 12 October in Denver, Colorado, USA, with a number of events, including a Pardee Keynote Symposium and an Awards and Anniversary Banquet. The EEGD Board Members cordially invite all GSA Connects attendees to join in this celebration.

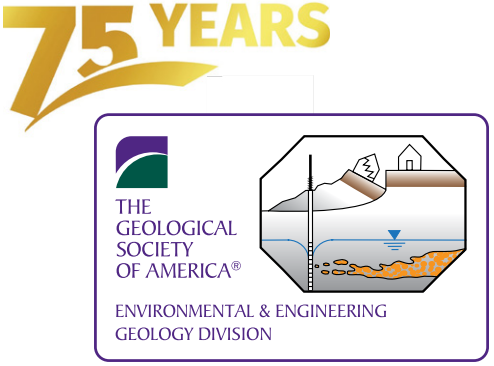
As a GSA Division, our mission has been to advance the ability of geoscientists to identify, characterize, and mitigate adverse geological conditions and hazards in the interest of public health and safety and the protection of property. The Division promotes research and science communication to members. This Division supports publications within GSA such as *Reviews in Engineering Geology* and *Environmental and Engineering Geoscience*, which is co-sponsored with the Association of Environmental and Engineering Geologists (AEG), an organization independent of GSA. The EEGD also advocates for properly trained professionals to promote public health and safety. The core of our practicing members are licensed professional geologists in the states they serve.

In 1947, the Engineering Geology Division passed from dream to reality. Charles P. Berkey served as the first chair, and its first formal meeting took place during GSA's 1947 annual meeting in Ottawa, Canada. One of the earliest publications produced by the Division was *The Application of Geology to Engineering Practice*, a volume of twelve papers by specialists in various facets of engineering geology. In 1951, the Soil Mechanics and Foundation Division of the American Society of Civil Engineers (ASCE) joined with EEGD to form a joint committee on engineering geology. The initial Division representatives were Roger Rhodes and Edward Burwell. Karl Terzaghi served as the chair of this collective effort.

In his 1986 presidential address, GSA President W.G. Ernst reviewed the "Earth Sciences Status and Future: How Bad, How Good." He highlighted the growing importance of engineering geology, giving several examples. While the Division initially centered on the role of engineering geologists in the built environment and hazard assessments, the growing sector of geologists involved in environmental issues led the 2010 Division leadership to add "Environmental" to our name.

When the Division was formed, its founders probably did not know that it would grow to embody an exemplary multidisciplinary approach to geoscience research, but 75 years onward our Division supports research that highlights the full range of complexities of humans interacting with their environments. The Pardee Keynote Symposium at GSA Connects 2022 provides an excellent opportunity to highlight the many connections between environmental and engineering geologic research on the one hand with the many facets of geology, geotechnical engineering, mining engineering, geologic hazards, remote sensing, geophysics, hydrogeology, and other disciplines on the other hand. The invited presentations will provide a historical perspective, as well as insight into the future of the EEGD utilizing new tools and methods for addressing environmental and engineering geology challenges of tomorrow.

We look forward to seeing you at GSA Connects 2022 in Denver and celebrating this historical moment for the EEGD!



GSA FOUNDATION Update

A Benefit for GSA Foundation Supporters: Donor Field Trips

Camaraderie over happy hour after dusty days in the field, friendships forged under the hot desert sun, new personal and professional connections: Although these things may not be what lured attendees to the GSA Foundation's first-ever *Death Valley Rendezvous* in 2019, they are the kinds of experiences and connections that 25 participants left with after our six-day trip together based in Shoshone, California, USA.

GSAF decided to pilot this type of trip because we wanted a meaningful way to show appreciation for those who support GSA and its programs through donations to the Foundation. Offering unique field experiences for donors and their guests proved to be an ideal avenue, and when one of our committee members suggested we call the trips "rendezvous," all agreed it was the perfect reference for the fellowship we hoped to foster.

Some attendees were longtime friends of the Foundation, and some we were meeting for the first time; some were students, some current professional geologists across disciplines, others retired from long careers, and some were family members of geologists attending. The trip held interest for all: Death Valley and the surrounding area offer a fascinating spectrum of geology to ponder, from the towering walls of Titus Canyon to the Amargosa River Valley. Trip leader Darrel Cowan (University of Washington) led lively, rich discussions at each site. In addition, we spent time talking about the ecology of the area with a local Nature Conservancy naturalist: from pupfish once thought to be extinct to the curious migration of the *Phainopepla*. One of the students—a Wright-Troxel Research Grant recipient—gave an evening presentation on his research focused on a nearby site. And Shoshone Village was a welcoming homebase conducive for us to gather, relax, share ideas and reflections on the days over meals, and explore on foot between scheduled activities.

After two seasons on hold due to the pandemic, our second *Death Valley Rendezvous* this past spring was another grand excursion. Feedback from participants has been so positive, and the slots filled so quickly, that we have a third trip to Death Valley coming in the spring of 2023.

Stops during GSAF's 2022 *Death Valley Rendezvous*.

This September, we will travel internationally with a *Rendezvous in the Mountains of Saint Francis*. Our trip leaders are Alessandro Montanari and Paula Metallo (Osservatorio Geologico di Coldigioco), Frank Pazzaglia (Lehigh University), and Jan Smit (Vrije Universiteit Amsterdam), each with extensive experience in the Apennines and the Marche region of Italy. We are eager to bring together another group of geology-minded friends for a rich experience exploring the area's geologic wonders and cultural history over six field days, from a medieval landslide on the coast to a walk up the Bottaccione Gorge and the original K-T boundary outcrop, with geo-archaeologic museums, caves, Jurassic ammonoid collections in a Renaissance castle, historic villages, and, of course, food of the region to round out the trip.

GSAF will continue offering one to two *Rendezvous* each year for our donors, and we have a growing list of potential trip sites as you have responded with such interest in continued opportunities. Please watch for 2023 trip announcements, and feel free to contact Debbie Marcinkowski at +1-303-357-1047 or dmarcinkowski@geosociety.org if you would like information.

Visiting sites for GSAF's 2022 *Rendezvous* in the Mountains of Saint Francis.

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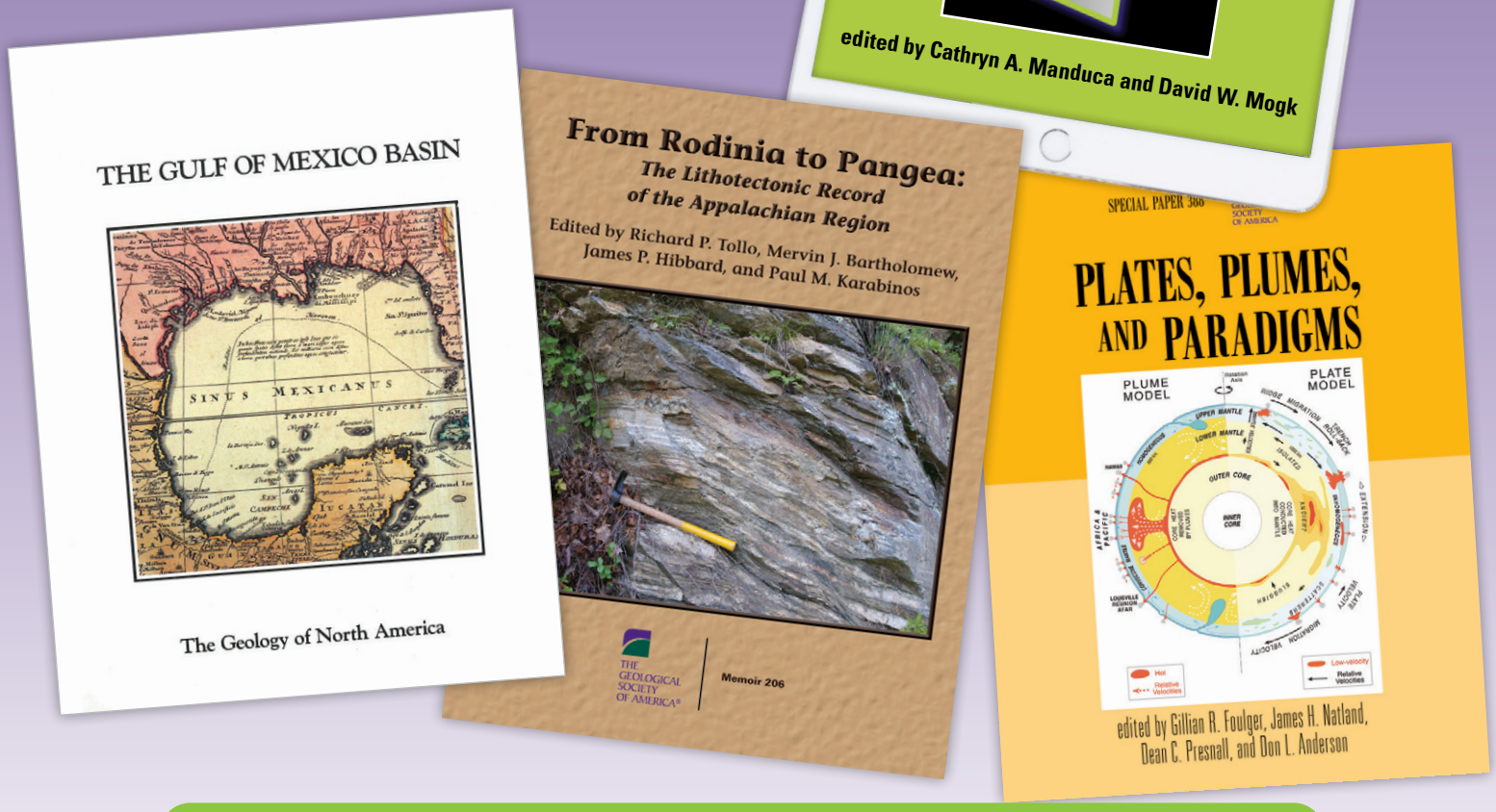
Each book is available as a PDF, including plates and supplemental material. Popular topics include ophiolites, the Hell Creek Formation, mass extinctions, and plates and plumes.



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

OPEN POSITION

Assistant Professor of Earth and Environmental Geoscience, Washington and Lee University

The Department of Earth and Environmental Geoscience at Washington and Lee University, in Lexington, Virginia, seeks applications for a tenure-track assistant professor starting in Fall 2023. The department and University have a strong desire to enhance diversity and we enthusiastically welcome applications from members of groups underrepresented in the geosciences. We seek a dynamic, creative teacher/scholar, dedicated to effective teaching and able to develop a vibrant research program that includes collaboration with undergraduates. This position represents an expansion of our department, and we are open to candidates with disciplinary expertise in any area of the Earth and Environmental Geosciences. The successful candidate will teach courses in their disciplinary area at the majors level and also develop introductory courses to support the university's new General Education curriculum.

Washington and Lee University promotes a dynamic and inclusive environment that allows students and employees of multiple backgrounds, cultures, and perspectives to learn, work, and thrive together. Successful candidates will contribute to that environment and exhibit potential for excellence in teaching and for vigorous scholarship. This position represents an expansion of our department, and we are open to candidates with disciplinary expertise in any area of the Earth and Environmental Geosciences. The successful candidate will teach courses in their disciplinary area at the majors level and also develop introductory courses to support the university's new General Education curriculum. In keeping with the University Strategic Plan, we welcome applications from underrepresented minority candidates and members of other communities that are traditionally underrepresented in academia.

Washington and Lee University is a highly selective, independent, co-educational, liberal arts college of approximately 1850 undergraduate and 400 law students and located in Lexington, VA, three hours southwest of Washington, DC. W&L is consistently ranked among the top 12 national liberal arts colleges. The Earth and Environmental Geoscience Department (https://my.wlu.edu/department-of-earth-and-environmental-geoscience) has excellent analytical facilities and resources, makes great use of the Appalachians in field courses and labs, and is a member of the Keck Geology Consortium.

Qualifications. Ph.D. or close to completion by the time of appointment.

The university requires employees to become fully vaccinated for COVID-19, and new employees must provide proof of at least their first shot prior to the first day of employment. A minimum of one booster is required. Individuals may seek a medical or a religious exemption to the vaccination requirement.

Application Instructions. Review of applications will begin on September 15 and will continue until the position is filled. We will be available to meet with potential candidates at the fall GSA meeting in Denver. Candidates should submit: a letter of application demonstrating the ability to work with a diverse student population, a CV, a statement of teaching interests and philosophy, a research statement, and contact information for three references. All materials should be submitted via Interfolio at http://apply.interfolio.com/110258. For more information, you may contact Jeffrey Rahl at rahlj@wlu.edu.

Faculty Position in Solid Earth Geohazards, Utah State University

The Department of Geosciences at Utah State University invites applications for an academic-year (9-month), tenure-track Assistant Professor position in Solid Earth Geohazards, anticipated to begin August 2023. Qualified applicants may be considered at the Associate level. We seek candidates who conduct innovative, interdisciplinary, and quantitative investigation of Earth processes that contribute to geologic hazards. Disciplinary expertise may include but is not limited to neotectonics, paleoseismology, geodesy, structural geology and lithospheric deformation, and subduction-zone geohazards. Successful candidates will demonstrate outstanding potential for excellence in research through development of a vibrant, externally funded research program and contribute to our graduate and undergraduate curriculum. The successful candidate may join faculty members in USU's College of Science JEDI STEM Collaboratory to enhance justice, equity, diversity, and inclusion in STEM fields. To find out more about our growing and vibrant department, go to https://geo.usu.edu.

For more information and to apply for this position, visit https://careers-usu.icims.com/jobs/5395/assistant-or-associate-professor/job. Required materials include cover letter; CV; statement of research interests and vision; statement of teaching philosophy, experiences, and interests; statement of contributions and vision of approach toward diversity, equity, and inclusion; names and contact information for three references; and one representative publication. Please contact Alexis Ault, Search Committee chair, alexis.ault@usu.edu, with any inquiries. USU is an AA/EO employer. Review of applications begins on September 15, 2022.

Tenure Track Faculty Position, Mineralogy, Miami University

The Department of Geology and Environmental Earth Science at Miami University invites applications for a tenure-track faculty position at the Assistant Professor level, beginning August 2023. Applicants must have a Ph.D. degree at the time of appointment. The successful applicant will be expected to teach effectively at the undergraduate and graduate levels, supervise student research at the undergraduate, M.S., and Ph.D. levels, initiate and maintain a vigorous, externally funded research program, and provide service to the university.

We seek a candidate who is undertaking significant research in mineralogy. The particular research emphasis should contribute to our programs in both Geology and Environmental Earth Science and should complement current program strengths indicated below.

The successful applicant will join an active department that consists of 14 faculty members, 3 research/technical staff members, and approximately 150 undergraduate and 30 graduate students. The department maintains active research programs in geobiology, geomicrobiology, geomorphology, geophysics, hydrogeology, igneous petrology, isotope geochemistry, mineralogy, paleoclimatology, paleontology, planetary geology, sedimentology and stratigraphy, structural geology, tectonics, and volcanology. The department is housed in a recently renovated building with state-of-the-art research and teaching facilities in support of the above. Please visit http://www.miamioh.edu/geology for additional information.

Submit letter of application, curriculum vitae, statement of research plans, statement of teaching philosophy and evidence of teaching effectiveness, and a one-page statement addressing past and/or potential contributions to advancing diversity, equity, and inclusion through research, teaching, and/or service to https://jobs.miamioh.edu/cw/en-us/job/500601/assistant-professor. Letters of reference will be requested upon receipt of application. Inquiries can be directed to Cathy Edwards at edwardca@miamioh.edu. Review of applications will begin on September 12, 2022 and continue until position is filled.

Miami University is committed to creating an inclusive and effective teaching, learning, research, and working environment for all. For more information on Miami University's diversity initiatives, please visit the Office of Institutional Diversity & Inclusion website.

Miami University, an EO/AA employer, encourages applications from minorities, women, protected veterans and individuals with disabilities. Miami does not permit, and takes action to pre-

vent, harassment, discrimination and retaliation. Requests for reasonable accommodations for disabilities related to employment should be directed to ADAFacultyStaff@MiamiOH.edu or 513-529-3560. Annual Security and Fire Safety Report may be found at: http://www.MiamiOH.edu/campus-safety/annual-report/index.html. Criminal background check required. All campuses are smoke- and tobacco-free.

OPPORTUNITIES FOR STUDENTS

M.S. and Ph.D. Opportunities in Economic Geology, Colorado School of Mines. The Department of Geology and Geological Engineering at the Colorado School of Mines seeks students interested in pursuing graduate degrees (M.S. and Ph.D.) focused on mineral exploration, economic geology, and the geochemistry and petrology of ore deposits. Motivated applicants could enter our graduate program in January or August 2023. Successful students will be embedded into the NSF-supported Center for Advanced Subsurface Earth Resource Models (CASERM) with funding provided by industry partners. Successful students will gain significant experience and preparation for a booming mineral industry sector over the course of their study. Opportunities are also available through the parallel Professional Master's degree in Mineral Exploration, a one-year non-thesis study program. For more information, please contact mineralexploration@mines.edu.

Soliciting Community Input on Culture and Ethics of Geologic Sampling

Marjorie A. Chan, *Dept. of Geology & Geophysics, University of Utah, Salt Lake City, Utah 84112, USA;* ***David W. Mogk,*** *Dept. of Earth Sciences, Montana State University, Bozeman, Montana 59717, USA*

ETHICS OF SAMPLING

It is common for earth scientists to collect samples from a wide range of environments and settings as a routine part of our work. Samples may include a range of earth and planetary materials such as rocks, minerals, fossils, soils/sediments, meteorites, and natural fluids, and comprise the full range of sizes, from large dinosaur bones to microscopic fossils. In our Anthropocene age of increasing world populations, decreased accessibility to field sites, shrinking resources, more sensitivity to cultural Indigenous areas, and unprecedented pressures on unique geoheritage sites, the ethics of sampling is important to all geoscientists. The provenance of samples that support our research—where they came from, how they were collected, terms of permission for access and use, and their ultimate fate in archives or disposal—really do matter (e.g., Planavsky et al., 2020). As a discipline, we need to examine: What is our culture of sampling? Do we, or should we, have established guidelines or standard sampling codes we abide by (e.g., *Nature Geoscience*, 2021)? Should we teach sampling ethics to our students as part of our training of the next generations of geoscientists? Ethics examine the moral principles that affect both our personal and professional behavior, and the ethics of sampling may reveal conflicting values with personal, professional, environmental, and societal implications.

Over the past half century, the rising international geoconservation movement has recognized that special geological features need to be protected and managed as part of our geoheritage. The Geological Society of America (GSA) Position Statement on Geoheritage defines "sites or areas of geologic features with significant scientific, educational, cultural, and/or aesthetic value," which are key to advancing knowledge and support the broad understanding of the environment, its geodiversity and biodiversity, and the factors that influence climate change (see America's Geoheritage II workshop proceedings [National Academies of Sciences, Engineering, and Medicine et al., 2021]). Furthermore, there is a growing body of literature and commentary on the broader field of geoethics (e.g., Di Capua et al., 2021) that embraces our responsibility to protect our geoheritage.

The ethics of geological sampling is a long-standing issue because there is an increased international awareness of the need to protect and preserve iconic geologic sites for future generations (e.g., through geoheritage initiatives such as the UNESCO Global Geopark Network, the International Union of Geological Sciences [IUGS] International Commission on Geoheritage, and the International Union for Conservation of Nature [IUCN] World Commission on Protected Areas Geoheritage Specialist Group, to identify classical geosites). Notwithstanding these international programs to identify and preserve classic geologic sites, rock outcrops are being irreversibly damaged (Fig. 1) due to indiscriminate sampling in the name of science (e.g., MacFadyen, 2010; Druguet et al, 2013; Butler, 2015; Chan and Kamola, 2017; Foss, 2019; Di Capua et al., 2022). In addition, many geologic sites also hold significant cultural and spiritual value for Indigenous people, landowners, and local communities, and there is a need to minimize the impacts of sampling activities or marking outcrops. It is increasingly important for geoscientists to examine the ethics of our communal sampling practices, and our personal responsibilities as scientists and citizens for stewardship of Earth, its resources, and its people.

GSA'S ROLE IN EVALUATING ETHICS

Community input is needed to find a path forward for our professional societies to influence sampling practices. Thus, the purpose of this short paper is to (1) raise awareness about the ethics of sampling, and (2) offer the opportunity for the GSA membership, and geoscientists at-large, to provide input on our current culture of sampling through two venues—an online survey to collect data about geoscientists' attitudes and practices, and an interactive Noontime Lecture forum at GSA Connects 2022 in Denver, Colorado, USA. We are soliciting the input of geoscientists from diverse backgrounds and experience, and at all career stages from interested students to experienced professionals, to obtain the broadest representation of perspectives and attitudes to evaluate the existing culture of geologic sampling. The survey and interactive forum build on liaisons with the American Geophysical Union (AGU) and the Town Hall on geological sampling convened at their 2021 Fall Meeting.

SURVEY—OPEN TO ALL GEOSCIENTISTS

We invite *all* GSA members as well as allied professional society members to participate in a pre-meeting survey with the purpose of collecting information to better

Figure 1. This pre-2017 example of geovandalism (sampling without a permit), shown by paleomagnetic drill holes (red arrows), is a reminder of exceptionally poor judgement that left a scarred arch-aeological petroglyph site on a Miocene tuff, Nevada, USA. What personal or professional values guided the decision to sample here? What are the consequences? What information or training could have led to better decision-making? Image credit: S. Foss.

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understand past and current attitudes and practices of geologic sampling. Please help us start this conversation by participating in the short survey (open until 15 Sept.: www.surveymonkey.com/r/geologic-sampling). The anonymous, aggregated information will serve as a springboard for discussions at an interactive forum at GSA Connects 2022 and will also provide important baseline data to be considered in developing future recommendations or guidelines or a possible GSA Position Statement on geologic sampling.

INVITATION TO THE LECTURE FORUM

The 2022 GSA Connects meeting will highlight an informal one-hour Noontime Lecture forum titled **Culture and Ethics of Geologic Sampling,** on Monday, 10 Oct. This forum will present some of the survey results and will utilize small interest-group discussions to explore contemporary attitudes and practices of the geoscience community about sampling natural sites, as well as review relevant policies and guidelines that already exist from related professional societies. In particular, this interactive forum will explore topics such as:

A. **Experiences** encompassing levels of priorities/needs for samples.
B. **Alternatives** to renewed or continuing sampling, such as multi-use purposes for samples, openly shared databases for available samples and repositories, and sample exchanges.
C. **Archiving** and maintaining current sample collections.
D. **Legal** and liability issues involving permitting, permissions, and licenses. (Note: What is legal is not necessarily ethical and sampling guidelines may differ internationally.)
E. **Best practices** for sampling on lands of Indigenous people and other culturally sensitive areas, and possible repatriation.
F. **Limits on sampling** and a possible process for oversight, particularly for sensitive geoheritage sites.
G. **Impacts** and consequences of sampling (including unintended), including marking outcrops.

FUTURE

Responsible sampling is relevant to protecting exemplary sites, being respectful of Indigenous cultures, and other societal issues. Sampling is a global issue related to geodiversity and geoconservation and is important to all geoscientists. It is also related to much larger issues of extractive industries, as well as colonialism in the field and parachute science that can be intertwined with ethics of collecting without input or participation by local Indigenous communities (e.g., Monarrez et al., 2021; Cisneros et al., 2022; Raja et al., 2022).

Community responses via survey data and input from the Noontime Lecture forum will comprise a foundation to formulate actionable recommendations for a future GSA Position Statement, potential ethical sample guidelines for publishing in Society journals, as well as educational training materials for geoscience curriculum. Although some guidelines exist in various societies (e.g., Society of Vertebrate Paleontology, the Geological Society of London [see references]), GSA has yet to adopt any sampling guidelines or requirements. Another desirable outcome is to encourage reduced needs for physical sampling through alternatives that could involve better archiving of existing samples, infrastructure that is related to preservation of samples, and more sample sharing or repurposing. Now is the time for GSA to have more open communication and involvement on this relevant topic that affects teaching, research, and our geoheritage.

The GSA survey and Noontime Lecture forum on **Culture and Ethics of Geologic Sampling** are co-sponsored by the U.S. National Committee on Geological Sciences (USNC-GS), AGU, the American Geosciences Institute (AGI), the Mineralogical Society of America (MSA), the National Association of Geoscience Teachers (NAGT), and the International Association for Promoting Geoethics (IAPG).

ACKNOWLEDGMENTS

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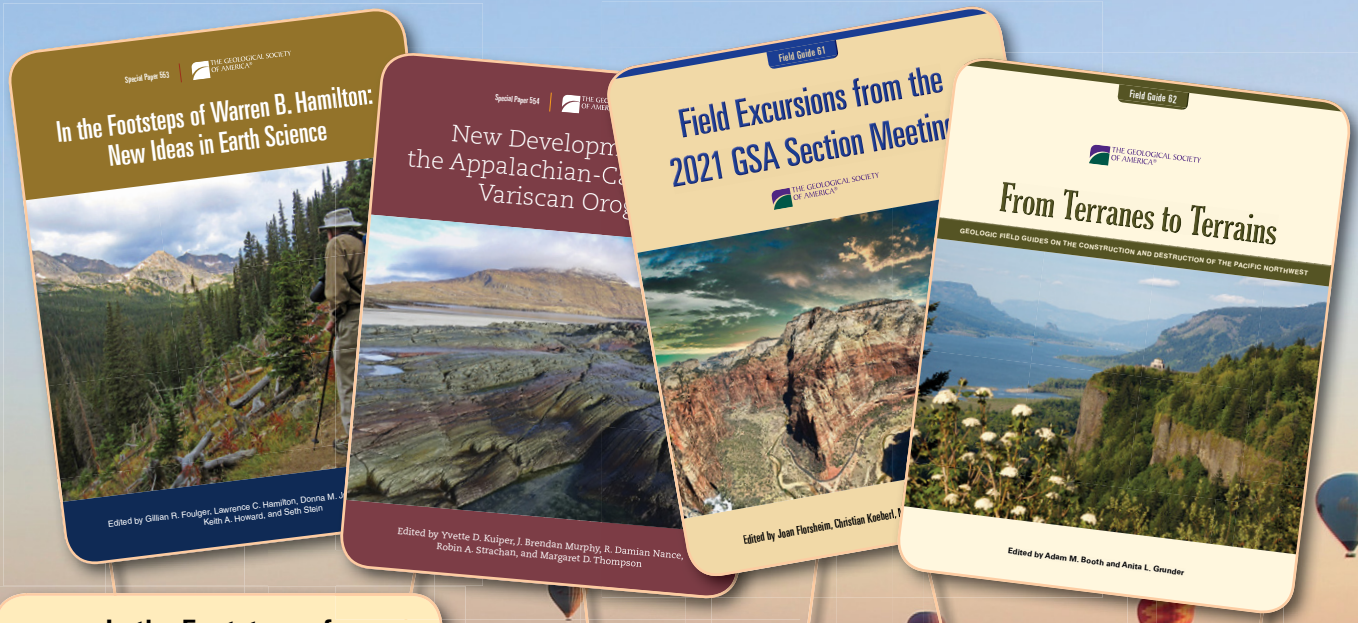

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