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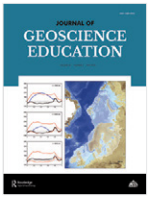

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SCIENCE

Cover: Bedrock fault plane with freshly exposed free-face exhumed during the Oct. 2016 MW 6.5 Norcia earthquake (Italy). The fault surface topography is imaged at submillimeter resolution using a smartphone, a gimbal stabilizer, and a compass. The acquired images coupled with the proposed workflow were used to produce a fully georeferenced 3D model. For the related article, see pages 4–10.

GSA CONNECTS 2021

GSA NEWS

THE GEOLOGICAL SOCIETY OF AMERICA®

Virtual Outcrops in a Pocket: The Smartphone as a Fully Equipped Photogrammetric Data Acquisition Tool

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ABSTRACT

Since the advent of affordable consumer-grade cameras over a century ago, photographic images have been the standard medium for capturing and visualizing outcrop-scale geological features. Despite the ubiquity of raster image data capture in routine fieldwork, the development of close-range 3D remote-sensing techniques has led to a paradigm shift in the representation and analysis of rock exposures from two- to three-dimensional forms. The use of geological 3D surface reconstructions in routine fieldwork has, however, been limited by the portability, associated learning curve, and/or expense of tools required for data capture, visualization, and analysis. Smartphones are rapidly becoming a viable alternative to conventional 3D close-range remote-sensing data capture and visualization platforms, providing a catalyst for the general uptake of 3D outcrop technologies by the geological community, which were up until relatively recently the purview of a relatively small number of geospatial specialists. Indeed, the continuous improvement of smartphone cameras, coupled with their integration with global navigation satellite system (GNSS) and inertial sensors provides 3D reconstructions with comparable accuracy to survey-grade systems. These developments have already led many field geologists to replace reflex cameras, as well as dedicated handheld GNSS receivers and compass clinometers, with smartphones, which offer the equivalent functionality within a single compact platform. Here we demonstrate that through the use of a smartphone and a portable gimbal stabilizer, we can readily generate and register high-quality 3D scans of outcropping geological structures, with the workflow exemplified using a mirror of a seismically active fault. The scan is conducted with minimal effort over the course of a few minutes with limited equipment, thus being representative of a routine situation for a field geologist.

INTRODUCTION AND BACKGROUND

Rapid improvements in the fidelity of consumer-grade cameras, coupled with novel computer vision–based photogrammetric image processing pipelines (i.e., structure from motion–multiview stereo photogrammetry: SfM-MVS), have revolutionized outcrop studies over the past decade, bringing traditional field geology into the digital age. These developments are also closely tied to major methodological improvements for virtual outcrop model (VOM) interpretation. All these advancements have accelerated the use of digital outcrop data capture and analysis in field geology, transforming what was principally a visualization medium into fully interrogatable quantitative geo-data objects (Jones et al., 2004; Bemis et al., 2014; Howell et al., 2014; Hodgetts et al., 2015; Biber et al., 2018; Bruna et al., 2019; Caravaca et al., 2019; Thiele et al., 2019; Triantafyllou et al., 2019). Initially, close-range remote-sensing studies seeking to reconstruct and analyze rock outcrops were dominantly built around terrestrial laser scanning systems (terrestrial lidar), which became commercially available around two decades ago (e.g., Bellian et al., 2002). These initial works tended to be technology demonstrations rather than routine field studies, with the expense, weight, and challenging operational learning curve limiting replication to a few highly specialized geospatial specialists and groups. Receiving greater interest from the archaeological community, the adoption of digital photogrammetry by outcrop geologists was initially slow (e.g., Hodgetts et al., 2004; Pringle et al., 2004), with legacy photogrammetric reconstruction techniques requiring highly specialized, expensive metric cameras or software (Chandler and Fryer, 2005), and commonly carried the limitation of cumbersome manual assignment of key points on the targeted rock surface (e.g., Simpson et al., 2004). Many of these disadvantages were addressed with the advent of low-cost or open-source SfM-MVS photogrammetry image processing pipelines (e.g., Snavely et al., 2006; Furukawa and Ponce, 2009; Wu, 2011), which facilitated the use of uncalibrated consumer-grade cameras and enabled automated image key-point detection and matching (e.g., James and Robson, 2012). The potential of producing 3D rock-surface models using consumer-grade cameras attracted the interest of numerous workers. These developments coupled with the increasing availability of lightweight and low-cost drones able to carry cameras and other sensors, have finally boosted the use of SfM-MVS reconstruction in geosciences.

For many geoscience applications, it is necessary to register 3D rock-surface reconstructions within a local or global coordinate frame. The use of survey-grade total stations and/or real-time kinematic (RTK) differential global navigation satellite system (GNSS) antennas permit both terrestrial (Jaud et al., 2020) and aerial (Rieke et al., 2012) image data and/or ground control points (GCPs) to be georeferenced within the mapped scene with centimeter to millimeter accuracy (Bemis et al., 2014). Those survey tools are, however, bulky and expensive, and are not standard tools for geoscientists engaged in fieldwork. Improvements in consumer-grade GNSS receivers, capable of harnessing

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multiple constellations (i.e., GPS, Glonass, Galileo, and BeiDou), now permit model geo-registration with greater simplicity and accuracies that are acceptable for many geoscientific applications. Most current smartphones are equipped with such GNSS chipsets, which enable the positioning of photos and GCPs with meter-level accuracy, or even spatial-decimeter accuracy for dual-frequency chipsets, with >20 min acquisition times for individual locations (Dabove et al., 2020; Uradziński and Bakuła, 2020). Under these conditions, the use of smartphones permits georeferencing of >~100-m-wide photogrammetric models generated via terrestrial imagery (Fig. 1). The availability of photo orientation information, provided by the smartphone's inertial measurement unit (especially the magnetometer and gyroscope/accelerometer sensors), in conjunction with the GNSS position, can further improve the quality of the model registration procedure. Indeed, the photo orientation information mitigates the positional error associated with the Z component, and full georeferencing of >50–60-m-wide exposures can be achieved with a consumer-grade dual-frequency GNSS chipset–equipped smartphone (Tavani et al., 2019, 2020).

Confident georeferencing of smaller-scale outcrops with minimal equipment, however, remains challenging, limiting the utility of photogrammetric acquisition in routine geological fieldwork. In this article, we present a workflow using a smartphone and minimal accessories to address this challenge (Fig. 1) and demonstrate the applicability of using smartphone photo and video surveys of an active fault in the Apennines (Italy). Those 3D models are georeferenced by integrating the use of Agisoft Metashape and OpenPlot software tools (Tavani et al., 2019).

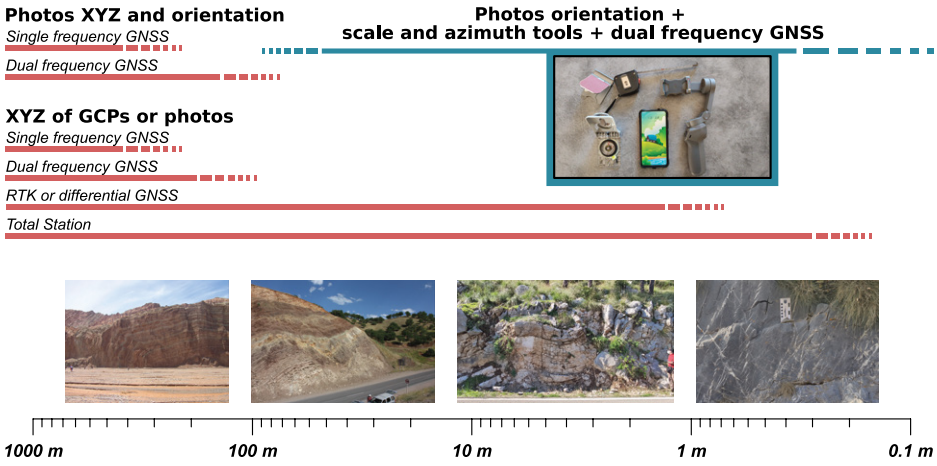

Figure 1. Scale-ranges of applicability of different methods for the registration of 3D models of outcrops, and tools used in this work. GCPs—ground control points; GNSS—global navigation satellite system; RTK—real-time kinematic.

METHODS AND DATA

The Acquisition Site

The survey method proposed herein was performed on an outcrop of an active normal fault located within the Apennines, central Italy. A high-resolution 3D surface reconstruction of the outcrop is already available (Corradetti et al., 2021), thus allowing us to compare our results with a ground-truth model. The area contains outcropping Mesozoic rocks affected by active normal faulting. For the aforementioned survey, we focused upon one segment striking N135°–160° (Fig. 2A). A wide (~0.3–1 m) portion of this fault was exposed after the

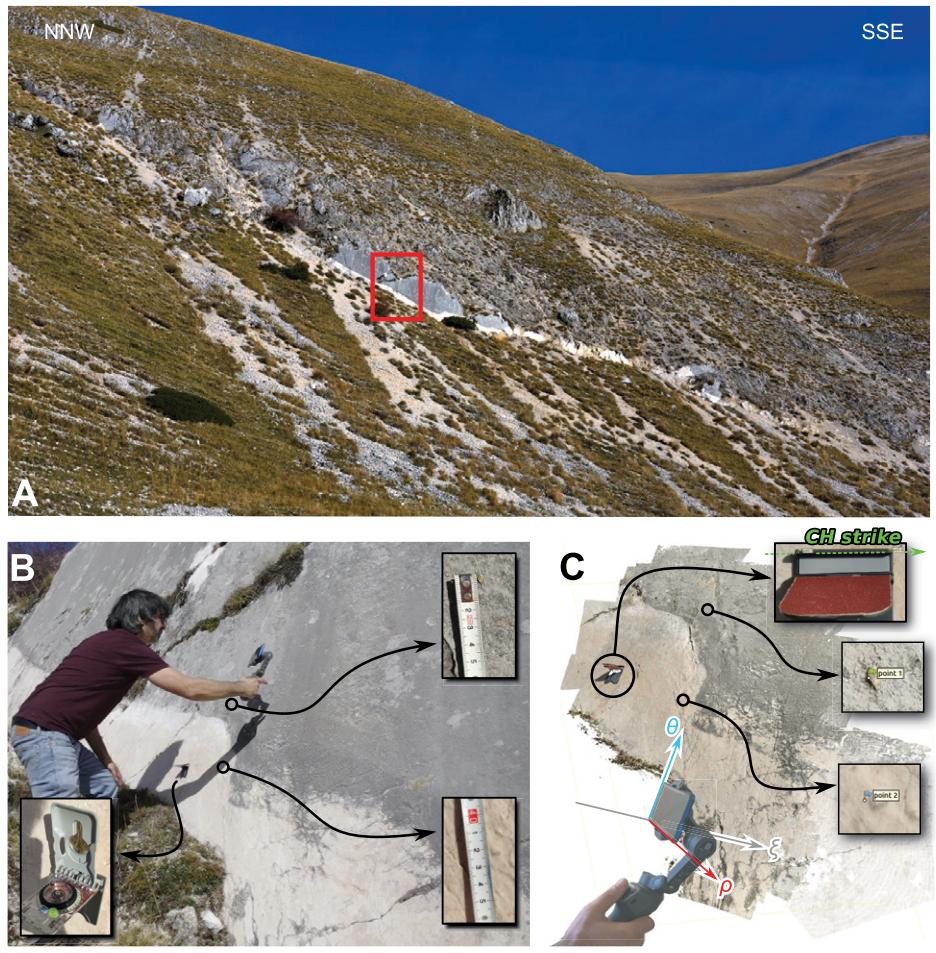

Figure 2. Photograph of the active normal fault modeled in this work (A). (B) Field set up and measurements taken before image acquisition. A ruler is used to measure the length between two points, each photographed for later recognition. A stand (compass holder, CH) is placed on the outcrop and its attitude measured defining the CH strike. The operator can then proceed with the photo/video acquisition providing that the CH is left on the outcrop to be included in the model. (C) Dense point cloud of the Photo Model. In the model, four markers are added, representing the two points whose distance was measured with the tape, and two points along the CH strike. The θ, ξ, and ρ vectors of the images are also indicated.

dramatic M_w 6.5 earthquake that struck the area on 30 Oct. 2016 (e.g., Chiaraluce et al., 2017), offering the opportunity to study this "fresh" portion of the fault surface (the white ribbon shown over the bottom of the fault surface in Fig. 2A).

Pre-Acquisition Setup

Image acquisition was carried out on 30 Oct. 2020, between 12:46 p.m. and 1:01 p.m., using a dual-frequency GNSS-equipped smartphone (Xiaomi 9T pro), hand-held gimbal, compass holder, compass-clinometer, and metric tape measure (see Fig. 1). In the field (Fig. 2B), the compass holder was placed within the scene using a detachable sticky pad with its edge approximately horizontal in relation to the Earth frame, and its trend (CH strike in Fig. 2C) measured using a Brunton TruArc 20 compass. The metric tape was used to measure the distance between two arbitrary features that later must be identified in the 3D model to provide its scaling factor. Both the compass and the metric measuring tape were removed before scene acquisition.

Image Acquisition

We produced two digital models of the fault using different approaches. The first model (from here on referred to as the Photo Model) was generated using 200 photos (4000 × 2250 pixels and 4.77 mm focal length). The second model (from here on referred to as the Video Model) was built using 528 photos (3840 × 2160 pixels and 4.77 mm focal length) extracted using VLC software from a 257-second-long video file (i.e., 2.6 frames per second). Both acquisitions were carried out using the smartphone mounted on a DJI OM4 gimbal, at a distance of ~30 cm from the fault plane. To include images oblique to the fault plane, required to mitigate doming of the reconstructed scene (James and Robson, 2014; Tavani et al., 2019), the view direction was repeatedly changed within an ~60° wide cone. Nevertheless, avoiding operator-induced shadows into the scene meant that the main acquisition was sub-perpendicular to the strike of the fault, being ~ENE.

Image Processing and Model Registration

Images were processed in Agisoft Metashape (version 1.6.2), resulting in two unregistered dense point clouds (Fig. 2C). Four specific markers were manually added in Metashape. In Figure 2C, Point 1 and Point 2 represent the two points whose distance was manually measured in the field. Point 3 and Point 4 were instead picked along one edge of the digitized compass holder (CH; Fig. 2C). These are used to retrieve the trend of the CH strike, here coinciding with the strike of the fault plane. The rotational transformation is the most critical aspect of model registration for many geoscience applications (e.g., discontinuity, bedding plane, or geobody orientation analysis). Our survey carries different assumptions for the orientation of photographs: the short axis of the photo (θ in Fig. 2C) is pointing upward; the view direction (ξ in Fig. 2C) is gently plunging and at a high angle to the fault plane; the long axis of the photo (ρ in Fig. 2C) is lying horizontal, due to gimbal stabilization. The goal is to use the stabilized direction of the long axis of photos to register the vertical axis and the markers placed on the CH (defining the CH strike) to reorient the model around this vertical axis. This is done after exporting from Metashape the cameras' extrinsic parameters using the N-View Match (*.nvm) file format. The exported data include θ, ξ, and ρ vectors expressed in the arbitrary reference frame. Then, we exported the markers in *.txt format, which saves the estimated position of markers in the arbitrary reference frame. These files are imported in OpenPlot, where the photos' directions and the CH strike are computed and graphed in a stereoplot (Plot 1 in Fig. 3). For both Photo and Video models, the ρ direction is clustered along a great circle, which, thanks to the gimbal, represents the horizontal plane in the real-world frame. For each model, the entire data set (i.e., the three directions of photos and the four markers) are rotated to set the ρ great circle horizontal (Plot 2 in Fig. 3). Notice that the rotation axis is univocally defined, being coincident to the strike of the best-fit plane. The amount of rotation instead can be either the dip of the plane or 180° + dip. The correct placement of the view direction (ξ) means that the selection between these two options by the user is trivial. The resulting trend of the CH strike is N211° and N105° for the Photo and Video models, respectively. A rotation about the vertical axis (57° counterclockwise for the Photo Model and 49° clockwise for the Video Model) was applied to the entire data set to match the CH strike to its measured value, i.e., N154° (Plot 3 in Fig. 3). The twice-rotated markers were then scaled using the measured distance between Point 1 and Point 2 and were eventually fully georeferenced using the measured position of Point 1. These two steps are achieved during the export stage from OpenPlot, which compiles a *.txt file containing the correctly

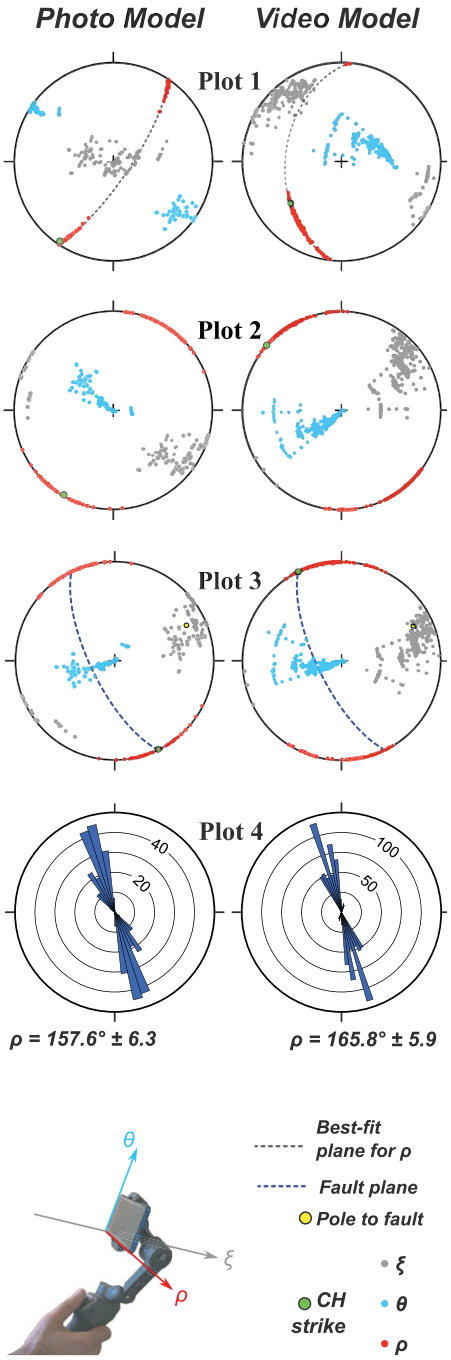

Figure 3. Lower hemisphere stereographic projection (stereonet) of the camera vectors for both the Photo and Video models, after model building (Plot 1), and after horizontalization of the ρ-vector great-circle envelope (Plot 2). In essence, after this rotation, the vertical axis is paralleled to the true vertical, but the azimuth is yet randomly oriented. (Plot 3) Stereonet of the camera vectors after rotation around the vertical axis. (Plot 4) Rose diagram showing the distribution of the ρ vectors in both models. CH—compass holder.

georeferenced coordinates of the four markers. This file was imported into Metashape, which allows the direct georeferencing of the model. The whole procedure, from the export or unregistered data from Metashape, through the rotations, scaling, and referencing in OpenPlot and the final re-import in Metashape takes just a few minutes and can be followed step-by-step in the supplementary video provided (see Supplementary Material[1]). A good practice consists of checking the results and re-exporting the cameras' extrinsic data of the registered model to possibly repeat the procedure if residual rotations occur (i.e., if ρ is not perfectly lying on a horizontal plane), which may relate to the proximity of the markers used for the transform and on their positional accuracy.

RESULTS

For the Photo Model, all of the 200 uploaded photos were successfully aligned and used to produce a point cloud made of ~6 × 10^7 points (Fig. 4A). For the Video Model, we uploaded 735 video frames, but only 528 of them were successfully aligned and used to produce a dense cloud of ~11.6 × 10^7 points (Fig. 4A). Some of the excluded images were manually removed after alignment, improving the quality of the 3D scene reconstruction. These images were identified through manual selection of points associated with unrealistic or blurry geometries within the sparse cloud. Often those were frames characterized by extreme overlap.

Both point clouds are characterized by zones on their boundaries, in which the 3D scene reconstruction relies on oblique images (Fig. 4B). These zones are asymmetrical, due to the aforementioned obliquity between the fault-perpendicular direction and the average photo view direction. Accordingly, we cropped the point clouds to exclude these zones and areas where the 3D reconstruction relied upon less than nine images (Fig. 4B).

The cropped point cloud for the Photo Model is composed of ~2.5 × 10^7 points, whereas the cropped Video Model consists of ~7.8 × 10^7 points (Fig. 4C). The accuracy of these 3D surface reconstructions was tested by generating difference maps from the two smartphone-generated models, and between each smartphone-generated model and a high-resolution ground-truth model (from here on referred to as the Reflex Model) built in 2016 using an image survey captured from the same outcrop with a dSLR camera (Fig. 4C). In this regard, the same fault was mapped in 2016 (Corradetti et al., 2021), using 640 images (4272 × 2848 pixels) taken with a Canon EOS 450D reflex mounted on a tripod to suppress motion blur. The reconstructed area for the Reflex Model was ~2.67 m^2, and the point cloud included ~2.7 × 10^8 points. These three point clouds were uploaded in CloudCompare (Girardeau-Montaut, 2015), where they were first manually aligned using ~15 control points for each matched point cloud, and then they were compared using the cloud-to-cloud distance tool. The resulting distance among the three clouds was generally below 4 mm (Fig. 4D), which decreases down to <2 mm for the Photo Model versus Reflex Model.

The georeferenced Photo and Video models were then compared to evaluate differences in scaling and rotation (translation was not investigated here). To achieve this, we uploaded the two scaled and rotated models, using the compass holder as the origin of the reference frame. We aligned the two clouds using 15 control points, and the

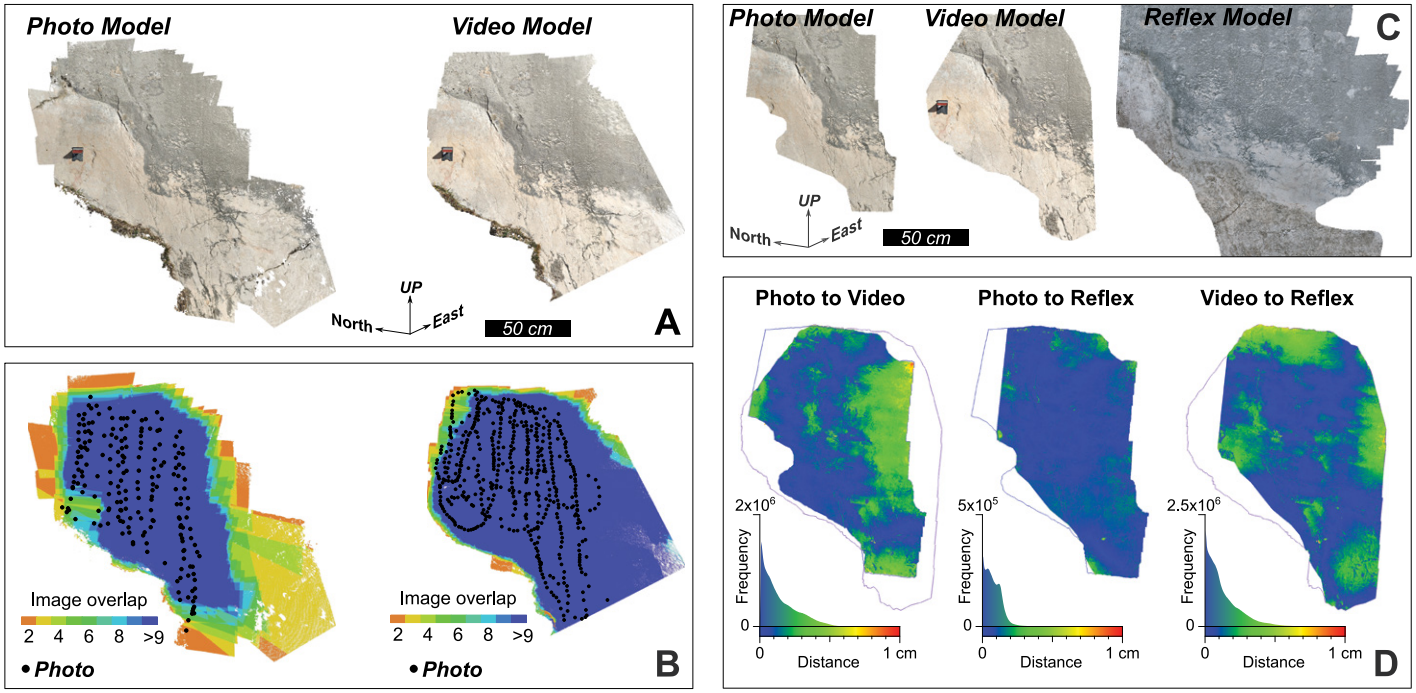

Figure 4. The Photo and Video models dense point cloud (A). (B) Images positions with respect to the models and number of images overlapping areas. (C) Cropped Photo and Video models. The Reflex Model from Corradetti et al. (2021). (D) Cloud to cloud distance between each pair of point clouds computed in CloudCompare.

[1]Supplemental Material. Video of the registration procedure in Metashape and OpenPlot. Metashape reports. Go to https://doi.org/10.1130/GSAT.S.14751042 to access the supplemental material; contact editing@geosociety.org with any questions.

result is a transformation matrix indicating that to align the two point clouds, a scaling factor of 1.0012 is required. The rotations around the X, Y, and Z axes are –0.38°, 1.00°, and 0.34° (1.1° around the strike direction and 0.29° around the horizontal direction perpendicular to the strike).

DISCUSSION

We have described a workflow for generating georeferenced 3D models of geological outcrops ranging in size from tens of meters down to a few centimeters. The required tools are extremely portable. Their use in the field is straightforward, with survey acquisition taking a few minutes for our case study. During the development and testing of the procedure, it was notable that video sequence acquisition can provide a more coherent scene, assuming that the mapped area is relatively continuous. On the other hand, video sequences may generate excessive scene overlap, complicating image matching. Also, the use of video frames implies the lack of control on shutter speed, aperture, ISO, etc., limiting the use of video frames mostly to small outcrops. Thus, selectively captured still images generally ensure a better result and a shorter processing time, as long as the acquisition is correctly carried out. Video models instead provide a simpler acquisition scheme, albeit with greater risk of reconstruction artifacts.

Once the models are built, post-processing registration using the proposed method is also straightforward for geoscientists with limited knowledge of geospatial data processing and analysis. From a practical point of view, the use of a low-cost, lightweight gimbal smartphone stabilizer offers a key improvement to similar workflows proposed previously (e.g., Tavani et al., 2020), and it is encouraged that geoscientists who want to replicate the presented acquisition strategy include this item as part of their standard equipment. Using a gimbal offers two substantial advantages. First, stabilization of the smartphone during acquisition improves image quality (i.e., by limiting motion blur), with the produced 3D model rivaling an equivalent surface reconstruction produced with a higher resolution dSLR mounted on a tripod. The second but most fundamental advantage of using a gimbal is the stabilization of the smartphone along its long axis, so that all the images produced are oriented along a horizontal plane, providing a constraint for our georeferencing procedure.

Two data sets, (i.e., photos and images extracted from a video sequence) have been tested to produce and later register the Photo and Video models, respectively. These models have been compared together and with the Reflex Model, which represents a benchmark build with photos obtained in 2016, although probably minor morphological changes due to weathering can have occurred since then. Manual alignment of the Photo and Video models shows that discrepancies ranging from 0 to 5 mm occur between the surface reconstructions. There are notable discrepancies between the Video and Reflex models, whereas the Photo and Reflex models are much more comparable, with surface displacements ranging between 0 and 2 mm. Despite the lower number of input photos, the Photo Model outperforms the Video Model in terms of accuracy. The major reason for this is the problematic reconstruction of the scene from extremely narrow baseline images extracted from the video sequence. Despite the video capture having a more straightforward acquisition procedure, it may require a more complex and time-consuming user-assisted procedure of image selection and repeated runs of photo alignment.

Apart from minor differences in reconstruction quality and errors that may arise from manual detection of the key points used in the similarity transform, the registration procedure of the two smartphone-generated models led to models with consistent orientation and scaling characteristics. In detail, we observed a rotation about the vertical axis of 0.34°. This error, which mostly relates to digitization of the reconstructed CH placed within the scene, is negligible for many geological applications, particularly if compared with the accuracy of analog compasses (e.g., Allmendinger et al., 2017). Such minimal value, however, does not reflect field measurement accuracy, since only one measurement was made of the same object present in the two models. Models of the same geological object, created by different individuals at different times, could introduce additional rotational errors. A slight misalignment of the registered horizon between the two models is reflected by the observed rotations around the *x* and *y* axes of –0.38° and 1.00°, respectively. This misalignment is attributable to the procedure of horizontalization of ρ: as seen in the rose diagram of Figure 3, ρ in both models is clustered along a direction that is nearly parallel to the strike of the fault, providing a greater constraint along the fault parallel direction than along its perpendicular. Indeed, the discrepancy in the estimated horizontal plane between the two models, considering the orientation of the fault, is 1.1° around the strike direction and 0.29° around the horizontal direction perpendicular to the fault's strike. In other words, the registration of the horizontal plane is sensitive to the orientation of the photographs, so that the inclusion of oblique to the scene photographs may improve the "horizontalization" of ρ.

CONCLUSION

This paper faces the need encountered by many field geologists to efficiently capture images of outcrops with ultra-portable tools to produce detailed, scaled, and properly oriented "pocket" 3D digital representations of rock exposures. Submillimeter point-cloud resolution is achieved with the suggested procedure, equaling that of models obtained by means of reflex cameras, and proving the efficiency of the proposed registration procedure for several quantitative applications in geology (e.g., fracture and fault orientation and associated kinematic indicators, bedding attitude and thickness, fault roughness, etc.). Furthermore, the proposed method is intuitive so that it can be applied by all geoscientists irrespective of background or experience. In this regard, we hope that this workflow will favor the widespread use of 3D models from smartphones.

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THE GEOLOGICAL SOCIETY OF AMERICA®
CONNECTS 2021
10–13 October
Portland, Oregon, USA

Registration, Housing, and Other Need-to-Know Information

Early registration deadline: 11:59 p.m. MDT on 7 Sept.
Cancelation deadline: 11:59 p.m. MDT on 1 Oct.
https://community.geosociety.org/gsa2021/registration

CRITICAL HOUSING DATES

7 Sept.: Last day to cancel rooms without a penalty.
15 Sept.: Room rates are guaranteed as long as rooms are available in the GSA room block.
After 15 Sept.: Hotel room rates and /or availability cannot be guaranteed.
30 Sept.: All changes, cancelations, and name substitutions must be finalized through Connections Housing/Travel Portland.

Once you receive your hotel acknowledgment and have booked your travel, please review your 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 date, contact the hotel directly to make them aware of your new arrival date.

CHILDCARE

Kiddie Corp is providing childcare services for GSA attendees on Sun.–Wed., 7 a.m.–6 p.m. The program is open to children six months to 12 years. The cost is US$10 per hour per child for children two years or older and US$12 per hour per child for children 23 months and under. Register at **https://community.geosociety.org/gsa2021/information/family.**

STUDENT VOLUNTEERS

GSA student members: Sign up to volunteer for ten hours at the meeting and receive complimentary registration for the in-person meeting. Find more information and the sign-up link at **https://community.geosociety.org/gsa2021/registration/volunteers.**

ACCOMMODATIONS & SERVICES

GSA strives to create a pleasant and rewarding experience for every attendee. Let us know in advance if you have needs that require attention. Most dietary considerations can be met without any extra charge. Be sure to check the appropriate box when registering online, and a GSA staff member will contact you. GSA will have a self-care room on-site as well as nursing suites. Learn more at **https://community.geosociety.org/gsa2021/information/services.**

EVENTS REQUIRING TICKETS/ADVANCE REGISTRATION

Some groups will hold breakfast, lunches, or receptions that require a ticket and/or advance registration. Ticketed events are open to everyone, and tickets can be purchased 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.

GSA Student and Early Career Professionals Social Reception
Sun., 10 Oct., 7–9:30 p.m. US$15, increases to US$20 after the early registration deadline (7 Sept.).

Association for Women Geoscientists (AWG) Networking and Awards Breakfast
Mon., 11 Oct., 6:30–8:30 a.m. Professionals: US$50; students: US$20.

GSA History and Philosophy of Geology Division Luncheon & Awards Ceremony
Tues., 12 Oct., noon–2 p.m. Professionals: US$50.

Pardee Keynote Symposia

Joseph Thomas Pardee (1871–1960)

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

P1. **Linking Diversity, Equity, and Inclusion to the Climate Crisis: Inclusive Leadership and Practice in Geoscience**

Endorsers: *GSA Quaternary Geology and Geomorphology Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Soils and Soil Processes Division; GSA Geochronology Division; GSA Marine and Coastal Geosciences Division; GSA Geoscience Education Division; GSA Environmental and Engineering Geology Division; GSA Geochronology Division; GSA Geology and Society Division; GSA Limnogeology Division*
Disciplines: Geoscience and Public Policy, Geology and Health, Geoscience Information/Communication
Convenors: Jennifer L. Pierce; Stephanie Shepherd; Nick Sutfin; Nancy F. Glenn

Geoscience needs a tectonic-scale change; we are the least diverse of all STEM fields. Our planet faces a climate crisis that disproportionately affects people of color and disadvantaged populations. How can our discipline promote educational awareness and diverse leadership opportunities to tackle these two separate but related challenges? We encourage submissions that address the following: What can geoscientists do to increase diversity, equity, and inclusion (DEI) at personal, departmental, institutional, and organizational levels? How can we effectively understand and address climate and environmental justice in research, the field, and the classroom? How does increasing diversity in the geosciences promote more equitable solutions to environmental challenges?

P2. **Cordilleran Subduction Zones: Dynamics of Plate Deformation from Megathrust to Mountain Building**

Endorsers: *GSA International; GSA Geophysics and Geodynamics Division; GSA Quaternary Geology and Geomorphology Division; GSA Structural Geology and Tectonics Division; GSA Marine and Coastal Geosciences Division*
Disciplines: Tectonics/Tectonophysics, Geophysics/Geodynamics, Geomorphology
Convenors: Eric Kirby; Daniel Stockli; Kevin P. Furlong

Plate convergence along the western margin of the Americas occurs along an exceptional network of subduction zones. Lateral variations in the geometry and characteristics of subducting slabs and overriding plates affords an opportunity to address fundamental questions regarding the mechanics of great earthquakes, the nature of transient and permanent strain, and the relative roles of crustal deformation and mantle buoyancy generating forearc topography. This symposium will feature a diverse group of international researchers with expertise on subduction zones from Alaska to Chile to showcase recent developments in our understanding of the dynamics of these systems and identify key remaining questions.

P3. **Geoheritage: Celebrating Our Past, Protecting Our Future**

Endorsers: *GSA History and Philosophy of Geology Division; GSA Geology and Health Division; GSA Geology and Society Division; GSA Geoscience Education Division; Association of American State Geologists; History of Earth Sciences Society; National Association of Geoscience Teachers (NAGT); GSA Soils and Soil Processes Division; GSA Marine and Coastal Geosciences Division; GSA Limnogeology Division*
Disciplines: History and Philosophy of Geology, Geoscience and Public Policy, Geoscience Education
Convenors: Renee Clary; William Andrews; David Mogk; Steven Semken

Geoheritage impacts our professional, public, and personal lives. Your voices and perspectives ARE important. Join us for awareness of the importance of geoheritage to the ongoing health of our profession, and the empowerment to recognize, conserve, and sustain the landscapes that impact our lives.

P5. **Geoscience and Society: Action and Interdisciplinary Engagement on Local and Global Scales**

Endorsers: *GSA Geology and Society Division; GSA International; GSA Geology and Public Policy Committee; European Geosciences Union; American Geophysical Union; Geological Survey of Sweden; The Global Network for Geoscience and Society; Geology in the Public Interest; Geology for Global Development; Department of Geology and Environmental Science, Wheaton College; Clean Water Institute, Calvin University; Department of Geology, San Jose State University; Department of Geological & Mining Engineering & Sciences, Michigan Technological University; Department of Earth, Environmental and Resource Sciences, The University of Texas at El Paso; GSA Soils and Soil Processes Division; GSA Environmental and Engineering Geology Division; GSA Marine and Coastal Geosciences Division; GSA Limnogeology Division*
Disciplines: Geoscience Education, Geoscience Information/Communication, Geoscience and Public Policy
Convenors: Gregory R. Wessel; Rudy Schuster; Chloe Hill; Nina Burkhardt

The critical role that geoscience plays in advancing society is increasingly apparent to scientists, geoscience organizations, and the public. This session aims to highlight how we, as a scientific community, can facilitate engagement and interdisciplinary activities that will benefit society on both global and local levels. It will highlight existing activities that scientific organizations are coordinating, how scientists can get involved with them, and how they can be replicated or expanded. It will also address systemic issues that prevent these initiatives from being as effective as they can, such as funding and communication challenges, and illustrate the benefits of co-creation.

The Geological Society of America®
GEOCAREERS

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

ONLINE GEOCAREERS PROGRAMS BEFORE THE MEETING

Go to **https://community.geosociety.org/gsa2021/connect/student-ecp/geocareers** for event details. You must be registered for GSA Connects 2021 to attend these events.

GeoCareers Résumé Workshop
4 Oct., noon–1 p.m. PDT
Presenters will review the fundamentals of crafting a winning résumé.

Women in Geology
4 Oct., 2–3 p.m. PDT
Speakers will address issues faced by women in geology. Short presentations will be followed by networking in breakout rooms.

GeoCareers Company & Agency Information Session
5 Oct., noon–1 p.m. PDT
Visit with agency and company representatives to ask your career questions in breakout rooms. Learn about each unique work culture and types of internships and careers available.

Networking Event
5 Oct., 2–3 p.m. PDT
Learn the importance of networking to your career and meet some professionals who will offer advice and answer questions in breakout rooms.

GeoCareers Career Pathways Webinar
6 Oct., noon–1:30 p.m. PDT
Panelists from industry, government, academia, and non-traditional sectors will answer questions and offer advice in preparation for a career in these fields.

Early Career Networking Event
6 Oct., 2–3 p.m. PDT
This panel will contain representatives from several non-profits who have activities of interest to early career professionals.

GEOCAREERS CENTER AT THE MEETING

10–12 Oct., 9 a.m.–5 p.m.

GSA will provide a safe environment for participants by following health and safety guidelines as outlined by the Oregon Convention Center in addition to using plexiglass partitions and other interventions to reduce transmission risk.

- Post or view jobs
- Drop-in mentoring: Mentoring will be on a first-come, first-served basis. Sign up in the GeoCareers Center to secure your 30-minute consultation.
- Résumé/CV review clinic: Review will be on a first-come, first-served basis. Sign up in the GeoCareers Center to secure your 30-minute consultation.

Make an Impact—Be a Mentor

"I enjoyed mentoring and found it interesting to reflect on my career." —2021 mentor

GSA invites professionals, early career professionals, graduate students, and retirees to mentor students. All mentors are asked to read and abide by GSA's Events Code of Conduct (**https://www.geosociety.org/ethics**).

DROP-IN MENTORING (IN PERSON)

This one-on-one mentoring activity takes place in the GeoCareers Center. Students have 30 minutes to ask questions and seek advice from a mentor on a first-come, first-served, drop-in basis. Mentors are asked to complete a block of time (one-hour minimum). Mentors needed: 28.

RÉSUMÉ/CV MENTOR (IN PERSON)

A résumé or CV mentor volunteers for a block of time (one-hour minimum) to review student résumés or CVs, providing advice and guidance on building a winning document. Mentors needed: 28.

ON TO THE FUTURE MENTOR (ONLINE OR IN PERSON)

On To the Future (OTF) mentors are paired with students who are part of the OTF program, which supports those from diverse groups who are attending their first GSA Connects meeting. Mentors will meet with their mentee each day of the meeting (either virtually or in person), introduce the mentee to five contacts, and share their professional experiences in the geosciences. Matching will be completed using an online platform. Mentors needed: 75.

NETWORKING EVENT MENTOR (ONLINE)

The Networking Event is a gathering of students, early career professionals, and mentors. Mentors answer questions, offer advice about careers plans, and comment on job opportunities within their fields in breakout sessions. This event will be held on 5 Oct., 2–3 p.m. PDT. Mentors needed: 40.

WOMEN IN GEOLOGY MENTOR (ONLINE)

Mentors from a variety of sectors answer career questions and offer advice in breakout sessions during the women in geology program. This event will be held on 4 Oct., 2–3 p.m. PDT. Mentors needed: 20.

Learn more at **https://forms.gle/bZeKibPue7BXEsyQ9.**

Diversity Events

DIVERSITY AND OTF RECEPTION

Celebrate Diversity at the Diversity in the Geosciences and On To the Future Alumni Reception
Tues., 12 Oct., in-person

Everyone is welcome at this celebration sponsored by the GSA Diversity in the Geosciences Committee. Socialize and share ideas at this informal gathering for those interested in broadening diversity in the geosciences. Space will be provided for diverse identity and community groups to gather. On To the Future (OTF) participants, OTF research grant recipients, and minority scholarship awardees will be recognized. Appetizers provided.

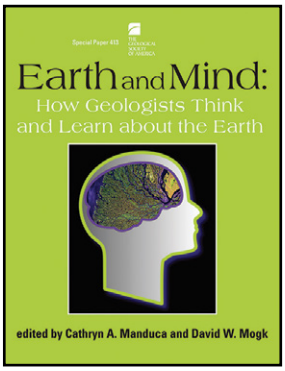
LGBTQIA+ SOCIAL

Gather with community at the LGBTQIA+ Social
Tues., 12 Oct., 7:30–9 p.m., in person

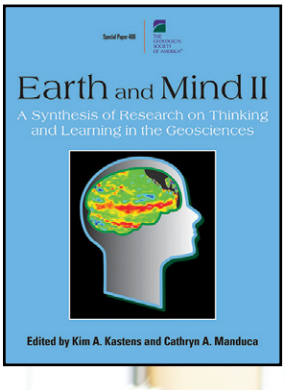
Meet and socialize with other LGBTQIA+ people as we celebrate being together. The event will be adjacent to and following the Diversity in the Geosciences and On To the Future Alumni Reception for those with intersecting identities to attend both.

Geology in the Classroom

If you're an educator looking for insight and inspiration to help keep you motivated, you'll want to check out these Special Papers from GSA. Both volumes, which are available for download from the GSA bookstore, explore how improved understanding of how humans think and learn about the Earth can help educators prepare the next generation of geoscientists.



Earth and Mind: How Geologists Think and Learn about the Earth presents essays by geoscientists, cognitive scientists, and educators that explore how geoscientists learn and what the implications are for student learning. (SPE413P, 188 p., ISBN 0813724139, US$9.99)



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

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https://rock.geosociety.org/store

THE GEOLOGICAL SOCIETY OF AMERICA®

Short Courses

Learn and explore a new topic!

Early registration deadline: 7 Sept.
Registration after 7 Sept. will cost an additional US$30.
Cancellation deadline: 13 Sept.

Can I take a short course if I am not registered for the meeting? YES! You're welcome to—just add the meeting non-registrant fee (US$55) by 7 Sept. to your course enrollment cost. Should you then decide to attend the meeting, your payment will be applied toward meeting registration.

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

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

See **community.geosociety.org/gsa2021/science-careers/courses** or contact Jennifer Nocerino, jnocerino@geosociety.org, for course abstracts and additional information.

The following short courses are open to everyone. Early registration is highly recommended to ensure that courses will run.

ONLINE SHORT COURSES

501. **Geophysics for Bedrock and Formation Mapping.** Tues., 14 Sept., 7–11 a.m. PDT. US$35. Limit: 50. CEU: 0.4. **Instructors:** Jimmy Adcock, Guideline Geo AB; Morgan Sander-Olhoeft, Guideline Geo Americas Inc. **Endorser:** *Guideline Geo.*

502. **Climate Adaptation Planning for Emergency Management.** Tues., 14 Sept., 11 a.m.–3 p.m. PDT *and* Wed., 15 Sept., 11 a.m.–3 p.m. PDT. FREE. Limit: 45. CEU: 0.8. **Instructors:** Jeff Rubin, semi-retired emergency manager; Douglas Stolz, Cross Product Atmospheric. **Endorsers:** *GSA Geology and Society Division; GSA Marine and Coastal Geology Division; GSA Geology and Health Division; National Disaster Preparedness Training Center (NDPTC); Federal Emergency Management Agency (FEMA).*

503. **Age-Depth Modeling of Sedimentary Deposits.** Wed., 15 Sept., 9–11 a.m. PDT. *and* Wed., 22 Sept., 9–11 a.m. PDT. *and* Wed., 29 Sept., 9–11 a.m. PDT. US$30. Limit: 50. CEU: 0.6. **Instructors:** Lisa Park Boush, University of Connecticut; Maarten Blauw, Queen's University; Amy Myrbo, University of Wisconsin. **Endorsers:** *GSA Limnogeology Division; GSA Geochronology Division; GSA Continental Drilling Division; GSA Quaternary Geology and Geomorphology Division; GSA Sedimentary Geology Division; EarthRates RCN.*

504. **Introduction to Field Safety Leadership.** Thurs., 16 Sept., 8 a.m.–noon. PDT. US$45 professionals; US$25 students. Limit: 50. CEU: 0.6. **Instructors:** Kevin Bohacs, ExxonMobil (retired); Kurt Burmeister, California State University, Sacramento; Greer Barriault, ExxonMobil Upstream Integrated Solutions. **Endorser:** *ExxonMobil Upstream Integrated Solutions.*

505**. NASA Data Made Easy: Getting Started with Synthetic Aperture Radar.** Thurs., 16 Sept., 10 a.m.–2 p.m. PDT. US$20 (those who complete the course can get three free GSA e-books of their choice). Limit: 50. CEU: 0.4. **Instructors:** Cynthia Hall, NASA Headquarters; Andrea Nicolau, Spatial Informatics Group; Africa Flores-Anderson, NASA SERVIR; Heidi Kristenson, Alaska Satellite Facility.

506. **Your Thesis is Software: Tools for the Geoscientist to Help Write Better Code, from Version Control to Test-Driven Development.** Fri., 17 Sept., 9 a.m.–3 p.m. PDT. US$10. Limit: 50. CEU: 0.6. **Instructors:** Simon Goring, University of Wisconsin; Socorro Dominguez, University of Wisconsin–Madison. **Endorser:** *Throughput Database.*

507. **Ground-Penetrating Radar—Principles, Practice, and Processing.** Fri., 17 Sept., 7 a.m.–2 p.m. PDT. US$45. Limit: 50. CEU: 0.7. **Instructors:** Greg Johnston, Sensors & Software; Troy De Souza, Sensors & Software. **Endorser:** *Sensors & Software.*

508. **From Airborne Electromagnetic Method Data to 3D Hydrogeological Conceptual Model.** Mon., 20 Sept., 9 a.m.–1 p.m. PDT *and* Tues., 21 Sept., 9 a.m.–1 p.m. PDT. US$35. Limit: 50. CEU: 0.8. **Instructors:** Tom Martlev Pallesen, I•GIS; Thomas Bager Rasmussen, I•GIS; Simon Boetker Rasmussen, I•GIS. **Endorser:** *I•GIS.*

INDUSTRY TRACKS

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

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

509. **3D Hydrogeological Modeling: How to Build Them and Why?** Wed., 22 Sept., 9 a.m.–1 p.m. PDT. *and* Thurs. 23 Sept., 9 a.m.–1 p.m. PDT. US$35. Limit: 50. CEU: 0.8. **Instructors:** Tom Martlev Pallesen, I•GIS; Simon Boetker Rasmussen, I•GIS. **Endorser:** *I•GIS.*

510. **Introduction to Seismic Structural Interpretation.** Fri., 24 Sept., 8 a.m.–3 p.m. PDT. US$35. Limit: 50. CEU: 0.7. **Instructors:** Kellen Gunderson, Chevron Energy Technology Company; Timothy Shin, Total E&P Americas LLC. **Endorsers:** *GSA Structural Geology and Tectonics Division; GSA Energy Geology Division.*

511. **Foundations in the Design and Teaching of Geoscience Courses Using Active Learning Strategies.** Mon., 27 Sept., 8 a.m.–3 p.m. PDT. US$45. Limit: 50. CEU: 0.7. **Instructors:** Leilani Arthurs, University of Colorado Boulder; Chu-Lin Cheng, University of Texas Rio Grande Valley; Ming-Tsan Lu, The University of Texas Rio Grande Valley; Patrick Shabram, Front Range Community College.

512. **Find Your Voice: Hazards and Science Communication in Crisis and Calm.** Tues., 28 Sept., 9 a.m.–1 p.m. PDT. US$20 professionals; US$10 students and early career professionals. Limit: 50. CEU: 0.4. **Instructors:** Elizabeth Westby, USGS Cascades Volcano Observatory; Beth Bartel, Michigan Technological University; Wendy Stovall, USGS Yellowstone Volcano Observatory; Wendy Bohon, Incorporated Research Institutions for Seismology.

513. **Head, Shoulders, Knees, and Toes: Medical Geology Fundamentals.** Tues., 28 Sept., 8 a.m.–2 p.m. PDT. US$45 professionals; US$25 students. Limit: 50. CEU: 0.6. **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. **Endorsers:** *GSA Geology and Health Division; International Medical Geology Association.*

514. **An Introduction to Stratigraphic Data Analysis in R (SDAR), a Quantitative Toolkit to Analyze Stratigraphic Data.** Wed., 29 Sept., 11 a.m.–3 p.m. PDT, *and* Thurs., 30 Sept., 11 a.m.–3 p.m. PDT. US$35. Limit: 50. CEU: 0.4. **Instructor:** John Ortiz, Colombian Geological Survey and Corporación Geológica ARES.

515. **Geosciences and Society: A Teaching Workshop.** Thurs., 30 Sept., 8–11 a.m. PDT. US$30. Limit: 50. CEU: 0.3. **Instructors:** Anne Marie Ryan, Dalhousie University; Carl-Georg Bank, University of Toronto.

516. **3D Printing for Geoscience and Engineering: Emerging Technology in Education, Research, and Communication.** Fri., 1 Oct., 9 a.m.–3 p.m. PDT. US$35. Limit: 50. CEU: 0.6. **Instructors:** Rick Chalaturnyk, University of Alberta; Sergey Ishutov, University of Alberta; Kevin Hodder, University of Alberta; Gonzalo Zambrabo, University of Alberta. **Endorsers:** *GeoPrint; Petroleum Institute of Mexico.*

517. **Machine Learning in Geosciences: Existing and Novel Tools to Mine Geologic Data.** Fri., 1 Oct., 9 a.m.–3 p.m. PDT. US$35. Limit: 50. CEU: 0.6. **Instructors:** Velimir Vesselinov, Los Alamos National Laboratory; Bulbul Ahmmed, Los Alamos National Laboratory. **Endorser:** *Computational Earth Science Group, Los Alamos National Laboratory.*

518. **Forensic Geochemistry: Contaminant Sources/Release Ages and Aquifer Continuity in Soil/Groundwater Systems Using Stable Radiogenic Isotopes of Strontium (Sr) and Lead (Pb).** Mon., 4 Oct., 9 a.m.–3 p.m. PDT. US$35. Limit: 50. CEU: 0.6. **Instructor:** Richard W. Hurst, Hurst Forensics. **Endorsers:** *GSA Hydrogeology Division; GSA Geoarchaeology Division; GSA Quaternary Geology and Geomorphology Division.*

519. **Introduction to Structure from Motion (SfM) Photogrammetry.** Mon., 4 Oct., 9 a.m.–3 p.m. PDT. US$35. Limit: 50. CEU: 0.6. **Instructors:** Christopher Crosby, UNAVCO; J Ramon Arrowsmith, Arizona State University; Chelsea Scott, Arizona State University. **Endorsers:** *OpenTopography; UNAVCO.*

520. **Resistivity Surveying: Getting the Best and Making the Most from Electrical Resistivity Tomography and Induced Polarization Data.** Tues., 5 Oct., 7 a.m.–1 p.m. PDT. US$35. Limit: 50. CEU: 0.6. **Instructors:** Jimmy Adcock, Guideline Geo AB; Morgan Sander-Olhoeft, Guideline Geo Americas Inc. **Endorser:** *Guideline Geo.*

521. **New Approaches to Date Brittle and Ductile Deformation.** Tues., 5 Oct., 6–9 p.m. PDT. US$20. Limit: 50. CEU: 0.3. **Instructor:** Yu Wang, China University of Geosciences (Beijing).

522. **Introduction to Planetary Image Analysis with ArcGIS.** Wed., 6 Oct., 9 a.m.–3 p.m. PDT. US$25. Limit: 50. CEU: 0.6. **Instructor:** Zoe Learner Ponterio, Cornell University. **Endorsers:** *Spacecraft Planetary Image Facility; Cornell University.*

523. **Teaching Quantitative Structural Geology.** Wed., 6 Oct., 9 a.m.–3 p.m. PDT. US$20. Limit: 50. CEU: 0.6. **Instructors:** David Pollard, Stanford University; Stephen Martel, University of Hawaii.

PORTLAND IN-PERSON SHORT COURSES

524. **Sequence Stratigraphy for Graduate Students.** Fri.–Sat., 8–9 Oct., 8 a.m.–5 p.m. PDT. US$25 (those who complete the course can get three free GSA e-books of their choice). Limit: 55. CEU: 1.6. **Instructors:** Morgan Sullivan, Chevron Energy Technology Company; Bret Dixon, Tall City Exploration. **Endorser:** *Chevron Energy Technology Company.*

525. **Methods and Geological Applications in Geo-Thermo-Petro-Chronology I.** Fri., 8 Oct., 8 a.m.–5 p.m. PDT. US$40. Limit: 40. CEU: 0.8. **Instructors:** George Gehrels, University of Arizona; Kurt Sundell, University of Arizona; Sarah George, University of Arizona; Mauricio Ibanez, University of Arizona; Peter Reiners, University of Arizona; Allen Schaen, University of Arizona.

526. **Methods and Geological Applications in Geo-Thermo-Petro-Chronology II.** Sat., 9 Oct., 8 a.m.–5 p.m. PDT. US$40. Limit: 40. CEU: 0.8. **Instructors:** George Gehrels, University of Arizona; Kurt Sundell, University of Arizona; Sarah George, University of Arizona; Mauricio Ibanez, University of Arizona; Peter Reiners, University of Arizona; Allen Schaen, University of Arizona.

527. **Introduction to Drones (sUAS) in the Geosciences.** Sat., 9 Oct., 8 a.m.–5 p.m. PDT. US$112. Limit: 24. CEU: 0.8. **Instructor:** Gregory Baker, Colorado Mesa University. **Endorsers:** *GSA Hydrogeology Division; GSA Geoarchaeology Division; GSA Quaternary Geology and Geomorphology Division.*

528. **Talking Science: A Communicating Science Workshop.** Sat., 9 Oct., 8 a.m.–5 p.m. PDT. US$150. Limit: 30. CEU: 0.8. **Instructor:** Steven Jaret, American Museum of Natural History. **Endorser:** *GSA Planetary Geology Division.*

529. **Quantitative Analysis, Visualization, and Modelling of Detrital Geochronology Data.** Sat., 9 Oct., 8 a.m.–5 p.m. PDT. US$75 professionals; US$50 students. Limit: 50. CEU: 0.8. **Instructors:** Joel Saylor, University of British Columbia; Kurt Sundell, University of Arizona; Glenn Sharman, University of Arkansas.

530. **Geodynamic History of the Middle Part of the Alpine-Himalayan Orogenic Belt.** Sat., 9 Oct., 9 a.m.–5 p.m. PDT. US$112. Limit: 20. CEU: 0.7. **Instructors:** Abdollah Saidi, Deputy for the Middle East Sub-Commission; Akram Shahhosseini, Geological Survey of Iran.

531. **Applying Virtual Microscopy to Geoscience.** Sat. 9 Oct., 9 a.m.–5 p.m. PDT. US$100 professionals; US$50 students. Limit: 25. CEU: 0.7. **Instructors:** Christopher Prince, PetroArc International; Suzanne Kairo, Indiana University. **Endorser:** *PetroArc International.*

532. **How to Create your Own 3D Videogame–Style Geologic Field Trip and Host it Online: Accessible, Immersive Data Visualization for Education and Research.** Sat., 9 Oct., 9 a.m.–5 p.m. PDT. US$70. Limit: 20. CEU: 0.7. **Instructors:** Mattathias (Max) Needle, University of Washington; John F. Akers, University of Washington; Juliet G. Crider, University of Washington. **Endorsers:** *GSA Structural Geology and Tectonics Division; GSA Geoinformatics Division; GSA Geoscience Education Division.*

533. **Improv to Improve the Geoscience Community.** Sat., 9 Oct., 1–5 p.m. PDT. US$20. Limit: 20. CEU: 0.4. **Instructor:** Erik Haroldson, Austin Peay State University (APSU). **Endorsers:** *APSU Department of Geosciences; APSU College of STEM; APSU Diversity Committee.*

534. **Stormwater Infiltration in Washington State Using Deep Underground Injection Control Wells.** Sat., 9 Oct., 1–5 p.m. PDT. US$100. Limit: 20. CEU: 0.4. **Instructors:** Jay Chennault, Associated Earth Sciences Inc.; Curtis Koger, Associated Earth Sciences Inc.; Jennifer Saltonstall, Associated Earth Sciences Inc. **Endorser:** *Associated Earth Sciences Inc.*

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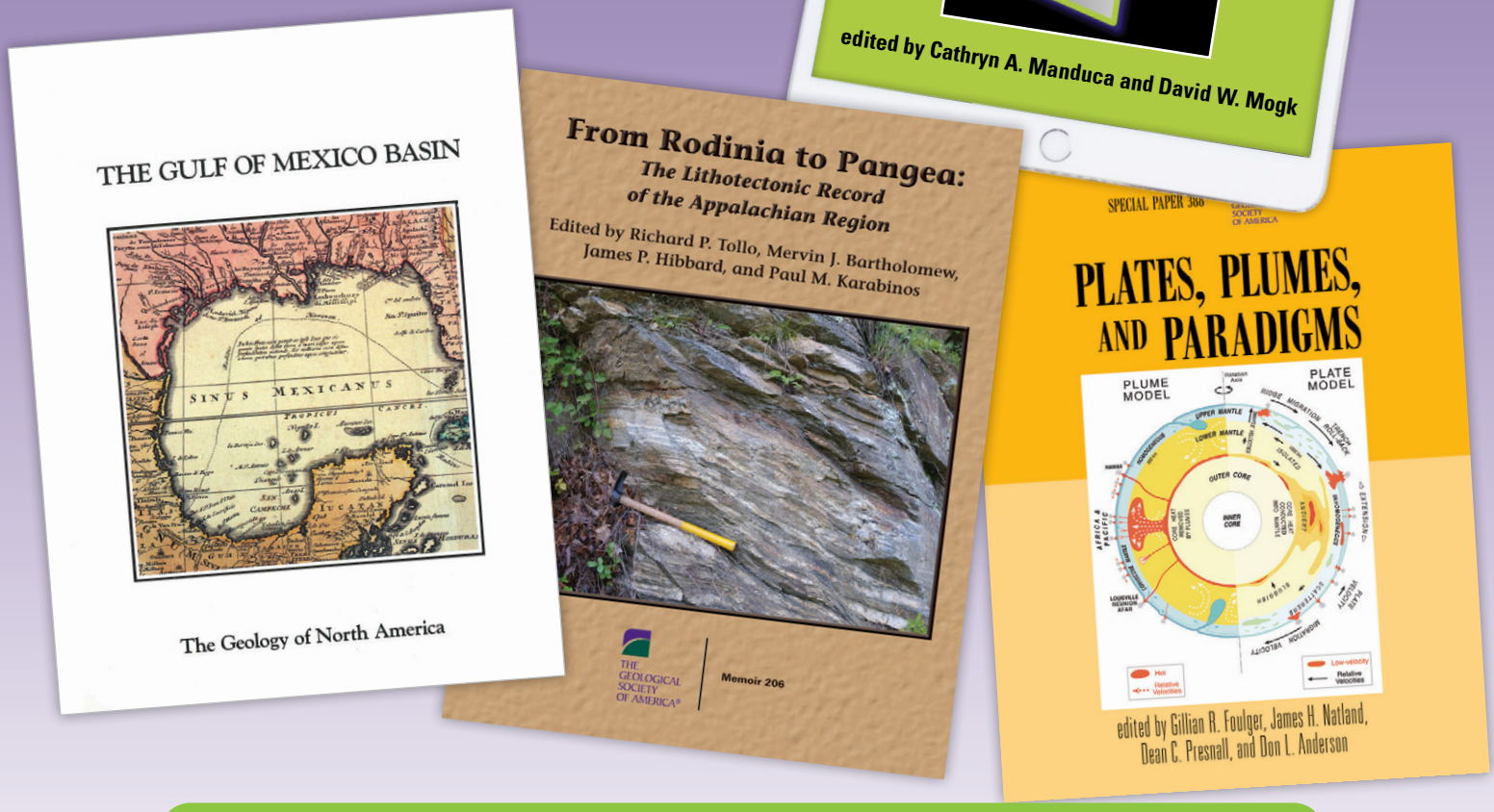

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Travel & Transportation

TRAVELING SAFELY

While the mask mandate for the state of Oregon was lifted on 30 June, masks are still required at all U.S. airports. Both the CDC and TSA continue to require that masks be worn at all U.S. airports, on airplanes, and on other forms of public transportation. (This information is current as of July 2021.)

If you're traveling to Portland International Airport (PDX) from another U.S. city, Oregon does not require a negative COVID-19 test upon arrival. If you plan to fly into PDX from another country, a negative COVID-19 test may be required. Please check with your airline for the latest updates regarding masks and COVID-19 testing requirements.

https://www.flypdx.com/TravelSafe
https://www.travelportland.com/plan/coronavirus-faq/

TRAVEL TO PORTLAND

Portland International Airport

Why do so many travelers love PDX? An easy 38-min. light-rail connection to downtown, nonstop flights from nearly 60 cities, and great local food and drink (including microbrews, craft spirits, and even food carts) are just a few of the most popular reasons. **https://www.flypdx.com/**

Amtrak/Union Station

Conveniently located at the foot of the Broadway Bridge in Old Town Chinatown, just minutes from the center of downtown, Union Station is served by three passenger trains: Amtrack Cascades, Coastal Starlight, and Empire Builder. **https://www.travelportland.com/plan/amtrak-union-station/**

BoltBus and Greyhound

Greyhound's iconic brand is synonymous with affordable long-distance travel in North America. In addition to BoltBus and Greyhound, several other bus services provide convenient, affordable, and frequent service from cities in the Pacific Northwest. **https://www.travelportland.com/plan/boltbus-and-greyhound/**

Credit: Travel Portland.

Traveling from PDX to Downtown

The Trimet Max/Light Rail can be found on the main level, at the south end of the ticket lobby beyond the Starbucks. The Red Line services PDX; trains depart every 15 min. **https://trimet.org/max**

The pickup location for app-based ride share services (Uber, Lyft, or Wingz) is on island 2 outside of baggage claim.

Rental car pick-up and drop-off at PDX is located on level 1 of the short-term parking garage. For pick-up, proceed past the baggage claim area to the tunnel and take the first elevator bank to level 1.

GETTING AROUND PORTLAND

Complimentary Trimet Transit Pass Program for GSA Connects Attendees

Registered GSA Connects attendees are eligible to receive complimentary transit passes. Transit passes are intended to assist attendees traveling from contracted hotels to the Oregon Convention Center (OCC) and back and are valid on all buses, MAX light rail, and streetcars in Portland. Pick up your pass at the GSA information desk (OCC, level 1) during registration hours. Passes will be valid 9–14 Oct.

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HOTELS

- Oregon Convention Center
- 1 Hyatt Regency Portland at OCC (HQ)
- 2 Doubleree by Hilton Portland (Co-HQ)
- 3 Crowne Plaza Portland-Downtown Convention Center
- 4 Hilton Portland Downtown
- 5 Hotel Rose Downtown Portland
- 6 Portland Marriott Downtown Waterfront

Poster Tips from GSA 2021 Section Meeting Student Poster Winners

Juliet Ryan-Davis, *California Institute of Technology;* ***Aaron Kilmury,*** *University of Manitoba;* ***Alex Nazzaro,*** *College of the Holy Cross;* ***Justin Sharpe,*** *University of Texas at San Antonio*

1. What advice would you give a student who is presenting a poster for the first time?

Talk through your poster with someone who is not familiar with your project. This could be a non-scientist or family member. It helps to see what the logical flow of the poster is to someone else so that you can adjust the content to emphasize important points with a box or bold font.

Since you typically do not have much time to present, make sure to focus on the most important parts of your research. Often, the questions you receive will give you an opportunity to share other aspects of the research.

Poster presentations are also an excellent time to get some insights on your project. Showing what you know from your research is just the start—people who talk to you during your poster presentation often have interesting questions or comments that can teach you a lot about your topic. This can be a great time to ask questions of experts on the subject, and it can be especially exciting when you have read someone's paper and they come talk to you.

Finally, prepare an elevator speech on your career aspirations and practice it on your peers. These speeches should be no more than one minute and should give a quick jargon-free overview of your interests.

2. What tips would you give another student who is designing a poster (software, formatting, or printing)?

Adobe Illustrator can be used to create posters and then export them to a pdf. Other options include Affinity Designer and PowerPoint. If problems come up, the most helpful resources concerning navigating software and finding answers to formatting issues are YouTube video tutorials and community support pages.

For formatting, starting with figures can be helpful because these will take up a lot of space. Next, create headings for each section to keep your poster organized. Under your title, you might consider adding a short description that gets the main point of your poster across.

Attendees will be drawn to posters with large figures and relatively little text, since it is easier to absorb information through a detailed and adequately labeled figure rather than reading large blocks of text. For text size, 20 to 24 point is suggested. Too many different fonts can be confusing and distracting. You might choose one for the headings/title and a second for the text and figure captions, but not more than two if possible.

Consider using black, white, and gray for text and text backgrounds—colored text and colored text backgrounds can be very hard to read for people with vision issues. Online resources include color palettes for colorblind people, and there is a phone app that uses the camera to show you what something would look like to people with different types of colorblindness to make sure that everything is readable and accessible.

When formatting your reference list, refer to the most recent edition of the reference style you are using and be sure all your reference entries have consistent formatting. Finally, do not wait till the last day to print. You might realize that there are issues with things like colors and formatting. There are ways of setting the colors in your file to match the printer; someone who knows the features of that printer can help.

3. Do you have any suggestions for how to draw attention to your poster?

Consider asking some of the people whose papers you cited to come talk to you about your poster. They can offer insight, and they will usually be excited to talk to you about a topic they have worked on. Ask your advisor to introduce you someone at the meeting who is working on similar topics before the poster session to put you at ease and help you be less nervous when they come to your poster.

You might also ask a friend or two to come see your poster presentation toward the beginning of the session. This can help calm your nerves down, and it catches the attention of people passing by who might be interested if they overhear you talking about your project.

4. Were there any strategies you found helpful when answering questions about your poster?

Present your poster to your advisor(s) or a fellow student and write down the questions that they ask. Prepare to fully explain your methods and interpretations, why they were chosen, what led you to your conclusions, and perhaps why other currently acceptable methods or techniques were not feasible for your study. Be prepared to address what you may have done differently if you had the chance to do it again and where you see areas for improvement for future work.

Talking through your poster in advance will help with the questions, discussion, and presentation on-site. If you have gone through the poster many times, you will have a better idea of what to focus on to answer specific questions. Skipping around the poster based on peoples' questions becomes easier the more times you have talked through the poster.

5. What factors influenced you the most in deciding how to organize your poster?

One resource for getting started on a poster is to look through other examples. You might walk the halls of your department and take notes on how other posters were laid out. Consider looking online for ideas on organization, including this resource: https://colinpurrington.com/tips/poster-design by Colin Purrington.

When deciding how to organize a poster, you should consider the most influential factors to be (1) the required poster dimensions, (2) the quantity of figures you need to concisely present your research and how large they must be to be legible from a one-meter distance, and (3) how large text boxes need to be so that they are legible from a one-meter distance, since the font size will determine how much information can be included.

Begin by drawing a rough sketch of how you imagine the main figure(s) will look, since the attention of most poster viewers is drawn in first by the figures. It is also a good idea to run your ideas by your advisor early and often in the planning stage before you get too far into designing your poster, because they will probably have great suggestions for a more effective way to illustrate the data and concepts.

One effective way to organize a poster is to divide it into three sections in a left to right sequence like a brochure—an introductory section, a middle "results" or data-rich section that also may include methods, and a discussion/implications section, from left to right. The middle section or center of the poster may be the widest because it is where the data and figures that are the bulk of the project will appear. Make sure to clearly label each section.

If your poster is focused on field photos and measurements, you might split up the central part of your poster into boxes for regions or categories like rock units of your field area, sized based on the amount of data you have for each. These could be arranged around a map of the field area in the center of the poster—so essentially, the map can be used to organize your data, which is consistently labeled as figures or results.

Carefully select the most important parts of your project that you want to discuss with people and that contribute to a clear understanding of your work—do not cram in too much detail. For the most part, people only have a few minutes to spend talking to you about your project, so less is more.

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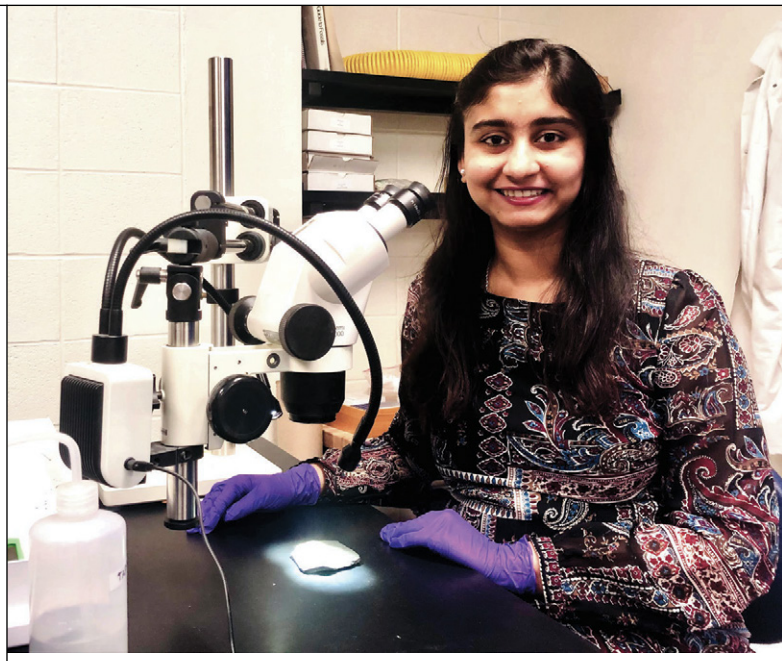

"GSA is full of opportunities for everyone; it does not matter if you are a student, early career researcher, academic, or industry professional. Never underestimate the scope of networking, and GSA is a great place for that."
—Sinjini Sinha, member since 2017

"Those early experiences—the financial support, the mentorship by established members of the earth-science community, and the shared love of geology—were fundamental to my development as a geologist. And for that, I am forever grateful to the GSA."
—Stephen Johnston, member since 1986

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Why GSA Membership Is Important to Me

I attended my first GSA meeting the year I joined the Society ~40 years ago. I went because it seemed to be the meeting that all geologists attended, and although a vertebrate paleontologist by inclination, I was trying to sharpen my geological skills. But then, how to go to two meetings per year—the vertebrate paleo meetings and the Geological Society meetings? Karen Prestegaard—who I'd known as a graduate student at UC Berkeley—told me to go to the annual GSA meeting every year; this would be enough to keep me at the forefront of the key developments in the geosciences as well as connect me with the people I needed to meet and with whom I might potentially collaborate.

It was great advice! While vertebrate paleontology turned more and more toward biology, I enriched and refined the geological lens through which I tried to address paleontological questions. All the while, I was supported at GSA by the Paleontological Society and SEPM (Society for Sedimentary Geology). The meetings were manageable enough not to get lost, but broad enough to drill down upon all the issues of greatest interest.

GSA welcomed me in unexpected ways. During my first visit to GSA headquarters in Boulder, Colorado, USA, as a first-time member of the Joint Technical Program Committee, I overheard concerns about filling a suddenly vacated editorial slot at *Geology*. I thought, "I could do that" ("fools rush in!"), applied, and got the job. And for the latter four of the next six years, Ben van der Pluijm and I each handled a new manuscript/day for the journal. It was crazy, but also exhilarating! Along with Ben and the fabulous GSA publications staff, I met—as reviewers—so many extraordinary people; people who later became my colleagues and friends.

And evidently I didn't learn my lesson from the *Geology* editorship: I subsequently signed up for two more editorships of GSA journals: *GSA Today* (four years) and *Geosphere* (six years).

My entire career has been intimately tied to GSA. The Society has been welcoming, supportive, and horizon-broadening, both personally and professionally. I would not be the same scientist had I not taken Karen Prestegaard's advice all those years ago.

David Fastovsky, University of Rhode Island, GSA member since 1986; GSA Fellow since 2007

PRELIMINARY ANNOUNCEMENT AND CALL FOR PAPERS

South-Central Section

56th Annual Meeting of the South-Central Section, GSA

McAllen, Texas, USA | 14–15 March 2022

https://www.geosociety.org/sc-mtg

A resistant layer of the Roma sandstone is exposed crossing the Rio Grande. Photo by Juan González.

Geology Has No Borders

LOCATION

The GSA 2022 South-Central Section Meeting is planned as an in-person meeting to be held in McAllen, Texas, USA, at the heart of the Rio Grande Valley, on 14–15 March. McAllen, considered the South Pole of Texas, has a subtropical climate, with a rich, binational and cultural history and authentic cuisines. South Padre Island is just an hour's drive away. McAllen has a vibrant downtown with museums, restaurants, art galleries, and live-music venues. The conference location is the brand-new Embassy Suites Hotel by the McAllen Convention Center, conveniently located at less than a 10-minute drive from the McAllen International Airport (MFE) and within walking distance of many restaurants, shopping centers, and other hotels. McAllen is easily accessible by plane from Houston (United) or from Dallas (American).

CALL FOR PAPERS

Abstract deadline: 7 Dec.
Submit online at **https://www.geosociety.org/sc-mtg**
Abstract submission fee: GSA members: professionals: US$30; students: US$18. Non-members: professionals: US$60; students: US$36.

TECHNICAL PROGRAM

Please direct questions related on the following sessions to the Technical Program co-chairs, Juan González, juan.l.gonzalez@utrgv.edu, and Chu-Lin Cheng, chulin.cheng@utrgv.edu.

Theme Sessions

T1. **Geology, Genesis, and Exploitation of Strategic Mineral Deposits (Posters).** Emily Fischer, Texas Tech University, emily.l.fischer@ttu.edu; Callum Hetherington, Texas Tech University, Callum.Hetherington@ttu.edu. Posters.

T2. **Petroleum-Produced Water.** Javier Vilcaez, Boone Pickens School of Geology, Oklahoma State University, vilcaez@okstate.edu; Todd Halihan, Boone Pickens School of Geology, Oklahoma State University, todd.halihan@okstate.edu. Oral and Posters.

T3. **U-Pb and Lu-Hf Detrital Zircon Geochronology and Provenance of the Missourian Cottage Grove Sandstone, Northern Anadarko Basin, Oklahoma.** Dylan Morton, Oklahoma State University, dylan.morton@okstate.edu. Oral and Posters.

T4. **Hydrogeology and Water Resources II: Extreme Events and Coastal Hazards: Flooding, Contamination, and Land Subsidence.** Dorina Murgulet, Texas A&M University Corpus Christi, dorina.murgulet@tamucc.edu; Mohamed Ahmed, Texas A&M University Corpus Christi, mohamed.ahmed@tamucc.edu. Oral and Posters.

T5. **From Grenvillian Basement to Neotectonics in Northeast Mexico: A 1.3-Billion-Year Journey of Geological Development.** Juan Alonso Ramirez-Fernandez, Universidad Autónoma de Nuevo León, alonso_fct@hotmail.com, juan.ramirezf@uanl.mx; Fernando Velasco-Tapia, Universidad Autónoma de Nuevo León, fernando.velascotp@uanl.edu.mx; Uwe Jenchen, Universidad Autónoma de Nuevo León, uwe.jenchen@gmail.com. Oral and Posters.

T6. **Environmental Significance and Preservation Mechanisms of Cretaceous Marginal-Marine and Terrestrial Ecosystems.** Alexis Godet, The University of Texas at San Antonio, alexis.godet@utsa.edu; Thomas Adams, The Witte Museum, San Antonio, thomasadams@wittemuseum.org. Oral and Posters.

T7. **Geoscience Education I: Geosciences Education Advancing Concepts and Inclusion.** Wendi J.W. Williams, South Texas College, wwilliam@southtexascollege.edu; Engil Isadora Pujol Pereira, The University of Texas Rio Grande Valley, engil.pereira@utrgv.edu. Oral and Posters.

T8. **Exploring Opportunities for Carbon Management through CO_2 Capture, Utilization, and Storage (CCUS).** Miles A. Henderson, The University of Texas Permian Basin, henderson_m@utpb.edu; Eric Brain, The University of Texas Permian Basin, brain_e39586@utpb.edu. Oral and Posters.

T9. **Geoscience Education II: Innovative Approaches to Teaching Geology Courses using Open Educational Resources (OER).** Ravindra Nandigam, South Texas College, rcnandigam@southtexascollege.edu. Oral and Posters.

T10. **Tracer Tests in the Hydrological Cycle.** Yongli Gao, The University of Texas at San Antonio, yongli.gao@utsa.edu. Oral only.

T11. **Tectonics and Sedimentation, Rio Grande Embayment/ Burgos Basin.** Thomas E. Ewing, Frontera Exploration Consultants, tewing@fronteraexploration.com. Oral and Posters.

T12. **General Geomorphology.** Juan L. González, The University of Texas Rio Grande Valley, juan.l.gonzalez@utrgv.edu. Oral only.

FIELD TRIPS

For additional information, please contact the field trip chair, Sarah Hardage, sarah.fearnlyhardage@utrgv.edu.

Ancient Landscapes: Exploring South Texas through Time. The University of Texas Rio Grande Valley, sarah.fearnlyhardage@utrgv.edu.

Rio Grande Delta. Thomas E. Ewing, Frontera Exploration Consultants, tewing@fronteraexploration.com; Juan L. González, The University of Texas Rio Grande Valley, juan.l.gonzalez@utrgv.edu.

SHORT COURSES

Get Techy and Walk through Ancient Landscapes through STEAM. Florestela Gomez, Donna ISD, fgomez@donnaisd.net.

Applications of Active Learning Strategies in the Design and Teaching of Geoscience Courses. Patrick Shabram, Front Range Community College, Patrick.Shabram@frontrange.edu; Chu-Lin Cheng, The University of Texas Rio Grande Valley, chulin.cheng@utrgv.edu; Leilani A. Arthurs, University of Colorado, leilani.arthurs@colorado.edu; Ming-Tsan Lu, The University of Texas Rio Grande Valley, mingtsan.lu@utrgv.edu.

Sustainable Management in Fluvial Aquifers and Transboundary Issues. Antonio Cardona, Universidad Autónoma de San Luis Potosí, acardona@uaslp.mx; Marusia Renteria-Villalobos, Universidad Autónoma de Chihuahua; Todd Halihan, Oklahoma State University, todd.halihan@okstate.edu; Rosario Sanchez, Texas A&M University, Maria.SanchezFlores@ag.tamu.edu; Raul Morales-Escalante, Moro Ingeniería, raul_agua@yahoo.com.mx; Martin Argueta-Hernandez, SIIMA, argueta_martin@yahoo.com.mx; Raul Mejia-Vázquez, Asociación Geohidrológica Mexicana.

Diversify Geoscience: Reveal Structural Racism and Make the Invisible Visible. Kristie Bradford, Lone Star College–Tomball, christine.d.bradford@lonestar.edu.

Résumé and Cover Letter Clinic: A Workshop for GSA On To the Future Students. Stephen K. Boss, University of Arkansas, sboss@uark.edu; Katherine Ellins, The University of Texas at Austin, kellins@jsg.utexas.edu.

ACCOMMODATIONS

Hotel registration deadline: 21 Feb.

A block of rooms has been reserved at the Embassy Suites by Hilton McAllen Convention Center Hotel at 800 Convention Center Blvd., McAllen, TX 78501, USA, at a special meeting rate of US$129 per night plus tax. Reservations should be made by calling the hotel at +1-956-688-8329 and referencing the group name "SCGSA22."

REGISTRATION

Early registration deadline: 7 Feb.
Cancellation deadline: 14 Feb.

Registration opens in December. For further information or if you need special accommodations, please contact one of the meeting co-chairs, Juan González, juan.l.gonzalez@utrgv.edu, and Chu-Lin Cheng, chulin.cheng@utrgv.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 **https://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 Co-Chairs: Juan González, juan.l.gonzalez@utrgv.edu; Chu-Lin Cheng, chulin.cheng@utrgv.edu
Technical Program Co-Chairs: Juan González, juan.l.gonzalez@utrgv.edu; Chu-Lin Cheng; chulin.cheng@utrgv.edu
Field Trip Chair: Sarah Hardage, sarah.fearnlyhardage@utrgv.edu
Exhibits/Sponsorship Chair: Saad Mohamed, saad.mohamed@utrgv.edu
Short Course Chair: Wendi J.W. Williams, wwilliam@southtexascollege.edu
Student Volunteer Chair: Engil Pereira, engil.pereira@utrgv.edu
Judging Coordinators: Engil Pereira, engil.pereira@utrgv.edu; Ravi Nandigam, rcnandigam@southtexascollege.edu

PRELIMINARY ANNOUNCEMENT AND CALL FOR PAPERS

Joint Cordilleran–Rocky Mountain Section

118th Annual Meeting of the Cordilleran Section, GSA

72nd Annual Meeting of the Rocky Mountain Section, GSA

Las Vegas, Nevada, USA | 15–17 March 2022

www.geosociety.org/cd-mtg

Red Rock Canyon, Nevada, USA. Photo by Daniel Halseth on Unsplash.

Rendezvous at the Geologic Crossroads

LOCATION

The 2022 GSA Cordilleran and Rocky Mountain Joint Section Meeting will be held in Las Vegas, Nevada, USA, for a *Rendezvous at the Geologic Crossroads* of the Cordillera, Great Basin, and Colorado Plateau. The meeting will be held at the student union on the University of Nevada, Las Vegas campus. This location provides easy access to museums, restaurants, shopping, and the neon metropolis of the Las Vegas strip. Las Vegas is pleasantly warm and dry in March, and it's a perfect time to explore the city, as well as the world-class geology in nearby Red Rock Canyon National Conservation Area, Valley of Fire State Park, Lake Mead National Recreation Area, the Mojave Preserve, and Death Valley National Park. A diverse array of technical sessions, field trips, and short courses will highlight the exceptional regional geology, including the Neoproterozoic–Paleozoic rift to passive margin stratigraphy; Mesozoic arc and retroarc histories and processes; and the magmatic, sedimentologic, and tectonic record of large magnitude Cenozoic extension. Additionally, current concerns of arid-zone hydrogeology, drought science and paleoclimatology, and emerging technologies and mining demands for low CO_2 energy solutions will be featured. Please join us in Las Vegas for all that a spring in-person meeting in the Mojave Desert has to offer!

CALL FOR PAPERS

Abstracts deadline: 7 Dec.
Submit online at **https://www.geosociety.org/cd-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, +1-303-357-1018, hclark@geosociety.org.

TECHNICAL PROGRAM

Symposia

S1. **Honorary Session for B. Clark Burchfiel and Gregory A. Davis for Their Seminal Contribution to the Modern Understanding of the North America Cordilleran Orogen.** An Yin, Univ. of California Los Angeles, yin@epss.ucla.edu; Brian Wernicke, Caltech, brian@gps.caltech.edu.

S2. **Mesozoic–Cenozoic Tectonic History of Northwestern Mexico and Southwestern USA: A Tribute to César Jacques-Ayala for His Career and Contributions to Sonoran Geology.** Arturo Barrón-Díaz, Universidad de Sonora, arturo.barron@unison.mx; Alexander Iriondo, Universidad Nacional Autónoma de Mexico, iriondo@geociencias.unam.mx; Felipe Escalona-Alcázar, Universidad Autónoma de Zacatecas, fescalona@uaz.edu.mx.

S3. **The Tectono-Magmatic Evolution of the Basin and Range Province: A Session in Honor of Ernie Anderson.** Paul J. Umhoefer, Northern Arizona Univ., paul.umhoefer@nau.edu; L. Sue Beard, U.S. Geological Survey (USGS), sbeard@usgs.gov; James E. Faulds, Nevada Bureau of Mines and Geology, Univ. of Nevada, Reno, jfaulds@unr.edu; David M. Miller, USGS, dmiller@usgs.gov.

S4. **Science at the Intersection of Soils, Weathering, Geomorphology, Climate, Ecology and Wildfire—A Tribute to the Careers of Les McFadden and Grant Meyer.** Jennifer Pierce, Boise State, jenpierce@boisestate.edu; Lyman Persico, Whitman College, persiclp@whitman.edu; Anne Tillery, USGS, actillery1@gmail.com; Jennifer Aldred, New Mexico Highlands Univ., jaldred@nmhu.edu.

S5. **Celebrating the 50th Anniversary of the Department of Geoscience at University of Nevada, Las Vegas.** Eugene Smith, Univ. of Nevada, Las Vegas, gene.smith@unlv.edu; Matthew Lachniet, Univ. of Nevada, Las Vegas, matthew.lachniet@unlv.edu.

Theme Sessions

T1. **Late Paleozoic Stratigraphy and Tectonics of the Southwestern Cordillera and Rocky Mountain Region.** John Singleton, Colorado State Univ., john.singleton@colostate.edu; Ryan Leary, New Mexico Institute of Mining and Technology, ryan.leary@nmt.edu; Dustin Sweet, Texas Tech Univ., Dustin.Sweet@ttu.edu; Sven Egenhoff, Colorado State Univ., Sven.Egenhoff@colostate.edu.

T2. **Neo-Insights into the Neoproterozoic of Western North America.** William Guenthner, Univ. of Illinois Urbana–Champaign, wrg@illinois.edu; Kendra Murray, Idaho State Univ., kendramurray@isu.edu; Devon Orme, Montana State Univ., devon.orme@montana.edu; David Pearson, Idaho State Univ., davepearson@isu.edu.

T3. **Unraveling the History of the Rio Grande Rift: From Contraction to Extension and Evolution of the Rift.** Theresa Schwartz, USGS, tmschwartz@usgs.gov; Amy Gilmer, USGS, agilmer@usgs.gov; Jens-Erik Lund Snee, USGS, jlundsnee@usgs.gov; Jeremy Caves Rugenstein, Colorado State Univ., jeremy.rugenstein@colostate.edu; Jason W. Ricketts, The Univ. of Texas at El Paso, jricketts@utep.edu.

T4. **Cryptic and Slow-Moving Quaternary-Active Faults in the Western United States.** Richard Koehler, Univ. of Nevada, Reno, and Nevada Bureau of Mines and Geology, rkoehler@unr.edu; Joanna Redwine, Bureau of Reclamation, jredwine@usbr.gov; Sylvia Nicovich, Bureau of Reclamation, snicovich@usbr.gov.

T5. **Slip Behavior and Seismic Potential of Active Faults in the North American Cordilleran.** Sinan Akciz, California State Univ. Fullerton, sakciz@fullerton.edu; Alexis K. Ault, Utah State Univ., alexis.ault@usu.edu.

T6. **From the Sevier to Laramide: Connecting Hinterland to Foreland by Tectonics, Structure, and Sedimentation.** Carla Eichler, Oklahoma Geological Survey, carla.eichler@ou.edu; Jacob Thacker, New Mexico Bureau of Geology & Mineral Resources, Jacob.Thacker@nmt.edu.

T7. **Geology of Death Valley: Old versus New Ideas, Hypotheses, and Theories.** Jeffery R. Knott, California State Univ. Fullerton, jknott@fullerton.edu; Jim P. Calzia, USGS, jcalzia@usgs.gov.

T8. **New Insights into the Paleogeographic and Tectonic Evolution of the Cordilleran Foreland Basin.** Jennifer Aschoff, Univ. of Alaska Anchorage, jaschoff@alaska.edu; Zhiyang Li, Univ. of Alaska Anchorage and Colorado College, zli@coloradocollege.edu.

T9. **Battery and Energy Metals: Mineral Potential of the Southwestern USA.** Simon Jowitt, Univ. of Nevada, Las Vegas, simon.jowitt@unlv.edu; Brian McNulty, Univ. of Nevada, Las Vegas, brian.mcnulty@unlv.edu.

T10. **Mining in the Rocky Mountain and Cordilleran Regions and Beyond: Risks and Opportunities.** Steven H. Emerman, Malach Consulting, SHEmerman@gmail.com.

T11. **Continental Arc Volcanism: A Crystal's Perspective.** Mai Sas, Western Washington Univ., sasm@wwu.edu; Nathan Andersen, USGS, nandersen@usgs.gov.

T12. **Advances in Understanding Arc Magmatism in the Southwestern Cordillera.** Robinson Cecil, California State Univ., Northridge, robinson.cecil@csun.edu; Joshua Schwartz, California State Univ., Northridge, joshua.schwartz@csun.edu; Jade Star Lackey, Pomona College, jadestar.lackey@pomona.edu.

T13. **Directly Dating Deformation, Metamorphism, and Metasomatism through Petrochronology.** Margaret Odlum, Univ. of Nevada, Las Vegas, margaret.odlum@unlv.edu; Cailey Condit, Univ. of Washington, ccondit@uw.edu; Stacia Gordon, Univ. of Nevada, Reno, staciag@unr.edu.

T14. **Paleomagnetism, Rock Magnetism, Environmental Magnetism, Instrumentation, Archaeomagnetism, Planetary Magnetism, and Petrofabrics.** Klaus Petersen, LP-Research Inc., klaus@lp-research.com; Emilio Herrero-Bervera, Univ. of Hawai'i at Mānoa, herrero@soest.hawaii.edu.

T15. **Records of Quaternary Paleoclimate in the Great Basin.** Matthew Lachniet, Univ. of Nevada, Las Vegas, matthew.lachniet@unlv.edu; Brendon Quirk, Purdue Univ., brendonjamesq@gmail.com; Benjamin Laabs, North Dakota State Univ., benjamin.laabs@ndsu.edu.

T16. **Quaternary Paleoclimate Records of the Rocky Mountain Region.** Shannon Mahan, USGS, smahan@usgs.gov; Tammy Rittenour, Utah State Univ., tammy.rittenour@usu.edu; Peter Fawcett, Univ. of New Mexico, fawcett@unm.edu.

T17. **Contemporary Topics in Arid Zone Hydrogeology.** Bruce Darling, Groundwater and Geochemistry Consultants LLC, bkdarling@protonmail.com; Barry Hibbs, California State Univ., Los Angeles, bhibbs@calstatela.edu.

T18. **Integrated Drought Science and Technology.** Rebecca J. Frus, USGS, rfrus@usgs.gov; Katharine G. Dahm, USGS, kdahm@usgs.gov; Todd J. Hawbaker, USGS, tjhawbaker@usgs.gov; Adrian P. Monroe, USGS, amonroe@usgs.gov; Patrick J. Anderson, USGS, andersonpj@usgs.gov.

T19. **Groundwater Contribution to Flow in Headwater Streams.** William Sanford, Colorado State Univ., william.sanford@colostate.edu.

T20. **Advances and Applications of River Science in the West.** Erich Mueller, Southern Utah Univ., erichmueller@suu.edu; Alan Kasprak, Fort Lewis College, akasprak@fortlewis.edu.

T21. **Hydrogeology of the Nevada National Security Site.** Rebecca J. Frus, USGS, rfrus@usgs.gov.

T22. **Landscape Evolution across Time Scales from the High Plains to the Colorado Plateau.** Sean Gallen, Warner College of Natural Resources, Colorado State Univ., sean.gallen@colostate.edu; Eyal Marder, Warner College of Natural Resources, Colorado State Univ., Eyal.Marder@colostate.edu.

T23. **Trilobites to Tectonics: Advances in Understanding the Lower Paleozoic Stratigraphic Record of the Western United States.** Carol M. Dehler, Utah State Univ., carol.dehler

@usu.edu; Ganqing Jiang, Geoscience, Univ. of Nevada, Las Vegas, ganqing.jiang@unlv.edu.

T24. **Sedimentary Record of Cordilleran Orogenic Systems.** Tomas Capaldi, Univ. of Nevada, Las Vegas, tomas .capaldi@unlv.edu; Alexander R. Tye, Dixie State Univ., alex.tye@dixie.edu; Elizabeth A. Balgord, Weber State Univ., elizabethbalgord@weber.edu.

T25. **Cretaceous Source Rocks from Texas to Alaska: Depositional, Diagenetic, and Geochemical Signatures across the Western Interior Seaway.** Katherine Whidden, USGS, kwhidden@usgs.gov; Justin Birdwell, USGS, jbirdwell@usgs.gov; Kate French, USGS, kfrench@usgs .gov; Richard Lease, USGS, rlease@usgs.gov; Jason Flaum, USGS, jflaum@usgs.gov.

T26. **Carbon Capture, Utilization, and Storage (CCUS) in the Rocky Mountain Region.** Lisa Stright, Colorado State Univ., lisa.stright@colostate.edu; Breck Johnson, Occidental Petroleum Corporation, breck_johnson@oxy.com.

T27. **Undergraduate Research (Posters).** Jeff Marshall, California State Polytechnic Univ. Pomona, marshall@cpp.edu.

T28. **Engaging Communities in Geo-STEM with Technology.** Ping Wang, pingwang@nova77.org.

FIELD TRIPS

Field-trip registration opens in December. For additional information, please contact the field trip co-chairs: Carol Dehler, carol .dehler@usu.edu, and Ganqing Jiang, ganqing.jiang@unlv.edu.

Structure, Metamorphism, and Geodynamic Significance of the Catalina Schist Terrane. John Platt, Univ. of Southern California, jplatt@usc.edu; Marty Grove, Stanford Univ., mjgrove@stanford.edu.

Unraveling the Multi-Phase History of Southern Death Valley Geology. Zachariah Fleming, Occidental College, zfleming@oxy .edu; Terry Pavlis, The Univ. of Texas at El Paso, tlpavlis@utep.edu.

The Buckskin-Rawhide and Northern Plomosa Mountains Metamorphic Core Complexes, West-Central Arizona. John Singleton, Colorado State Univ., john.singleton@colostate.edu; Nikki Seymour, Stanford Univ., nseymour@stanford.edu; Evan Strickland, evanstrickland87@gmail.com.

Miocene Extension and Magmatism in the Northern Colorado River Extensional Corridor. Phillip B. Gans, Univ. of California, Santa Barbara, gans@geol.ucsb.edu; Evan Monroe, Univ. of California, Santa Barbara, emonroe@ucsb.edu.

Landslide Deposits and Mechanisms in the Eastern Spring Mountains, Nevada. Nicholas Ferry, Univ. of Kansas, nferry@ ku.edu; Daniel M. Sturmer, Univ. of Cincinnati, Daniel.Sturmer@ uc.edu.

Geologic Highlights of Death Valley National Park. Allen F. Glazner, Univ. of North Carolina at Chapel Hill, afg@unc.edu; Arthur G. Sylvester, Univ. of California, Santa Barbara, sylvester@ ucsb.edu; Nathan Niemi, Univ. of Michigan, naniemi@umich.edu.

Cretaceous Plutonic Rocks of the Mojave Desert: Markers of Subduction Dynamics. Nicholas J. Van Buer, California State Polytechnic Univ. Pomona, njvanbuer@cpp.edu; Rita C. Economos, Southern Methodist Univ., reconomos@smu.edu; David M. Miller, USGS, dmiller@usgs.gov; Allen F. Glazner, Univ. of North Carolina, Chapel Hill, afg@unc.edu; Keith A. Howard, USGS, khoward@usgs.gov; Calvin F. Miller, Vanderbilt Univ., calvin.f.miller@vanderbilt.edu.

Development of Basin and Range Faults and Basins in the Lake Mead Domain: A Tribute to Ernie Anderson. Paul J. Umhoefer, Northern Arizona Univ., paul.umhoefer@nau.edu; L. Sue Beard, USGS, sbeard@usgs.gov; Thomas Hickson, Univ. of St. Thomas, tahickson@stthomas.edu; Melissa Lamb, Univ. of St. Thomas, malamb@stthomas.edu.

Microbialites Right under Our Noses: A Trip to the Miocene Lakes of Northern Lake Mead. Thomas Hickson, Univ. of St. Thomas, tahickson@stthomas.edu; Melissa Lamb, Univ. of St. Thomas, malamb@stthomas.edu.

Geology and Paleontology of Tule Springs Fossil Beds National Monument. Kathleen Springer, USGS, kspringer@usgs.gov; Jeff Pigati, USGS, jpigati@usgs.gov; Eric Scott, Cogstone Resource Management, escott@cogstone.com.

Vertebrate Paleontology and Cenozoic Depositional Environments of Death Valley National Park, California. Torrey Nyborg, Loma Linda Univ.; Bruce Lander, Paleo Environmental Associates Inc. and Natural History Museum of Los Angeles County, paleo@earthlink.net.

The Cryogenian Kingston Peak Formation. Lyle Nelson, Johns Hopkins Univ., lylelnelson@jhu.edu; Emmy Smith, Johns Hopkins Univ., efsmith@jhu.edu.

Geology of Frenchman Mountain and Rainbow Gardens. Steve Rowland, Univ. of Nevada, Las Vegas, steve.rowland@unlv.edu.

Revisiting the Origin and Evolution of the Lower Colorado River: New Ages, New Mapping, Refined Ideas. P. Kyle House, USGS, khouse@usgs.gov; Philip A. Pearthree, Arizona Geological Survey, pearthre@email.arizona.edu; Ryan S. Crow, USGS, rcrow@usgs.gov.

SHORT COURSES

Online Course:

Critical Metal and Mineral Deposits: An Overview. Simon Jowitt, Univ. of Nevada, Las Vegas, simon.jowitt@unlv.edu.

In-Person Courses:

OSL Dating: Essential Guide for Sampling and Dark Secrets behind the Technique. Tammy Rittenour, Utah State Univ., tammy.rittenour@usu.edu.

Using the StraboSpot2 Digital Data System. Doug Walker, Univ. of Kansas, jdwalker@ku.edu; Nick Roberts, Univ. of Wisconsin, nmroberts@wisc.edu; Alex Lusk, Univ. of Wisconsin, alusk@wisc.edu; Basil Tikoff, Univ. of Wisconsin, basil@geology.wisc.edu.

Practical PYTHON for Earth Scientists. Matthew W. Bauer; Colorado School of Mines and Sabata Energy Consultants, bauer@mines.edu.

Introduction to Inductively Coupled Plasma–Mass Spectrometry. Chris DeFelice, Univ. of Nevada, Las Vegas, defelc1@unlv.nevada.edu; Shichun Huang, Univ. of Nevada, Las Vegas, Shichun.huang@unlv.edu.

REGISTRATION

Registration opens in early Dec.
Early registration deadline: 7 Feb.
Cancellation deadline: 14 Feb.

For further information or if you need special accommodations, please contact one of the general co-chairs, Alexis Ault, alexis.ault@usu.edu, or Michael Wells, michael.wells@unlv.edu.

ACCOMODATIONS

Hotel registration deadline: 21 Feb.

A block of rooms has been reserved at the Embassy Suites, 4315 S. Univ. Center Drive, Las Vegas, NV 89119, USA, a five-minute walking distance to the Univ. of Nevada, Las Vegas, student union (4505 S. Maryland Pkwy, Las Vegas, NV 89154, USA), which is the meeting location. The meeting rate is US$120 per night plus tax. Reservations can be made by calling +1-800-362-2779. Please be sure to identify yourself with the group code CORD/RMGSA22 and that you are attending the GSA Cordilleran and Rocky Mountain Section Meeting. Hotel booking can also be made online at https://www.hilton.com/en/book/reservation/deeplink/?&ctyhocn=LASESES&groupCode=CESCOR&arrival=20220310&departure=20220322&cid=OM,WW,HILTONLINK,en,DirectLink&fromId=HILTONLINKDIRECT.

GSA STUDENT MENTOR PROGRAMS AND CAREER WORKSHOPS

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 to attend.

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 **https://www.geosociety.org/mentors/.** Questions? Contact Jennifer Nocerino at jnocerino@geosociety.org.

PROFESSIONALS

Interested in sharing information about your applied geoscience or hydrology career with students? Being a mentor is a rewarding experience. To learn more about serving as a mentor at this meeting contact Jennifer Nocerino at jnocerino@geosociety.org.

The joint Cordilleran–Rocky Mountain GSA Section Meeting also offers an excellent opportunity to earn CEUs toward your continuing education requirements for your employer, K–12 school, or professional registration. Please check the meeting website after the meeting to download your CEU certificate.

LOCAL COMMITTEE

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Technical Program Co-Chairs: Tomas Capaldi, tomas.capaldi@unlv.edu; Dennis Newell, dennis.newell@usu.edu
Field Trip Co-Chairs: Carol Dehler, carol.dehler@usu.edu; Ganqing Jiang, ganqing.jiang@unlv.edu
Short Course Chair: Bethany Coulthard, bethany.coulthard@unlv.edu
Sponsorships Chair: Simon Jowitt, simon.jowitt@unlv.edu
Exhibits Chair: Michael Nicholl, michael.nicholl@unlv.edu
Student Volunteer Chair: Pamela Burnley, pamela.burnley@unlv.edu

PRELIMINARY ANNOUNCEMENT AND CALL FOR PAPERS

Northeastern Section

57th Annual Meeting of the Northeastern Section, GSA

Lancaster, Pennsylvania, USA | 20–22 March 2022

https://www.geosociety.org/ne-mtg

Susquehanna River, southern Lancaster County Pennsylvania, USA. Photo by Emily Wilson.

Geoscience in a Changed and Changing World

LOCATION

The 2022 GSA Northeastern Section Meeting is planned as an in-person meeting to be held in Lancaster, Pennsylvania, USA. Lancaster is a welcoming and walkable small city with a rich history and arts and cultural community. The conference location is the Lancaster County Convention Center and Marriott at Penn Square, in the heart of downtown and convenient to shops, galleries, music venues, and restaurants, including the oldest operating indoor farmers' market in the country. Lancaster is easily accessible by car, train, and from the Harrisburg airport. We are pleased to announce a wide-ranging set of symposia, theme sessions, field trips, and short courses aligned with our meeting theme.

CALL FOR PAPERS

Abstract deadline: 14 Dec.

Submit online at **https://www.geosociety.org/ne-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, +1-303-357-1018, hclark@geosociety.org.

TECHNICAL PROGRAM

Symposia

S1. **Devonian of New York: A New, Extensive Volume on The North American Standard Section.** *Endorsed by Eastern Section, SEPM (Society for Sedimentary Geology); Paleontological Research Institution.* Charles Ver Straeten, New York State Museum/Geological Survey, Charles.VerStraeten@nysed.gov; D. Jeffrey Over, SUNY Geneseo, over@geneseo.edu; Donald L. Woodrow, cardonwoodr@comcast.net.

S2. **Teaching the Anthropocene: A New Paradigm for Geoscience Education.** Gary A. Gomby, Central Connecticut State University, garygomby@ccsu.edu.

S3. **Adapting to Global Climate Disruption at Multiple Scales.** *Endorsed by GSA Hydrogeology Division; GSA Geology and Society Division; GSA Environmental and Engineering Geology Division.* Donald I. Siegel, Syracuse University, disiegel@syr.edu.

S4. **Latest Science Results and Updates in Planetary Science Research, Programs, and Flight Projects.** *Endorsed by GSA Planetary Geology Division.* Michael S. Kelley, NASA Headquarters, michael.s.kelley@nasa.gov; Mitch Schulte, NASA Headquarters, mitchell.d.schulte@nasa.gov.

Theme Sessions

T1. **Leaving Footprints, Changing Landscapes: Advances in Ichnological and Zoogeomorphological Research.** *Endorsed by Eastern Section, SEPM (Society for Sedimentary Geology).* Ilya V. Buynevich, Temple University, coast@temple.edu; Stephen T. Hasiotis, University of Kansas, hasiotis@ku.edu; Logan A. Wiest, Mansfield University, lwiest@mansfield.edu; Hayden A. Thacker, Temple University, hayden.thacker@temple.edu.

T2. **Earth & Space Sciences at the K–12 Level: Importance, Successes, and Next Generation Science Standards–Based Examples.** Nancy Price, SUNY Plattsburgh, npric002@plattsburgh.edu.

T3. **Role of Natural History Museums in K–20 Education.** *Endorsed by National Association of Geoscience Teachers (NAGT); GSA Geoscience Education Division.* Lauren Neitzke Adamo, Rutgers and Geology Museum, Lneitzke@eps.rutgers.edu; Patricia Irizarry Barreto, Rutgers University, Science Explorer and Geology Museum, patricia.irizarry@rutgers.edu.

T4. **Celebrating Allan Ludman's First 56 Field Seasons in Maine: What Do We Know of Northern Appalachian Geology and What Questions Remain?** *Endorsed by GSA Structural Geology and Tectonics Division; Maine Geological Survey.* David P. West Jr., Middlebury College, dwest@middlebury.edu; Henry N. Berry IV, Maine Geological Survey, Henry.N.Berry@maine.gov; Chunzeng Wang, University of Maine at Presque Isle, chunzeng.wang@maine.edu.

T5. **A Patchwork Quilt of Petrology: New Techniques, Methods, and Approaches to Deep Crustal Rocks in the Northeastern United States.** Joshua M. Garber, Penn State, jxg1395@psu.edu; Andrew J. Smye, Penn State, aus702@psu.edu; Jesse R. Reimink, Penn State, jreimink@psu.edu; Alicia Cruz-Uribe, University of Maine, alicia.cruzuribe@maine.edu.

T6. **Rosetta Stones: Decoding Tectonic Ciphers from Thin Section through Outcrop.** *Endorsed by GSA Structural Geology and Tectonics Division.* Howell Bosbyshell, West Chester University of Pennsylvania, hbosbyshell@wcupa.edu; Nancy Price, SUNY Plattsburgh, npric002@plattsburgh.edu.

T7. **The Grenville Orogen in Eastern North America.** Greg Walsh, U.S. Geological Survey, gwalsh@usgs.gov; John Aleinikoff, U.S. Geological Survey, jaleinikoff@usgs.gov.

T8. **Tectonic Evolution of the Eastern North American Margin from Birth to Demise of the Iapetus and Rheic Oceans: Insights from the Sedimentary Record.** *Endorsed by GSA Sedimentary Geology Division; Canadian Tectonics Group.* David Lowe, Memorial University, dlowe@mun.ca; Shawna White, St. Mary's University, shawna.white@smu.ca; Yvette Kuiper, Colorado School of Mines, ykuiper@mines.edu.

T9. **Tectonic Evolution of Eastern North America: Insights from Geology and Geophysics.** *Endorsed by GSA Structural Geology and Tectonics Division; GSA Geophysics and Geodynamics Division.* Yvette D. Kuiper, Colorado School of Mines, ykuiper@mines.edu; Maureen D. Long, Yale University, maureen.long@yale.edu; Allison R. Severson, Minnesota Geological Survey, sever270@d.umn .edu; Yantao Luo, Yale University, Luo, yantao.luo@yale.edu.

T10. **Tectono-Metamorphic Processes at Convergent Boundaries: Insights from Northeastern North America and Beyond.** Adrian E. Castro, Wellesley College, ac114@ wellesley.edu; Wentao Cao, SUNY Fredonia, Wentao.Cao@ fredonia.edu; Emily M. Peterman, Bowdoin College, epeterma@bowdoin.edu.

T11. **North Atlantic Arcs, Rifts, and Plumes: Ordovician to Today.** *Endorsed by GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division.* Tamara Carley, Lafayette College, carleyt@lafayette.edu; Tenley Banik, Illinois State University, tjbanik@ilstu.edu.

T12. **The Influence of Tectonic and Magmatic Processes on the Development of the Eastern North American Rift System and Passive Margin.** *Endorsed by GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Structural Geology and Tectonics Division; GSA Geophysics and Geodynamics Division.* Martha Oliver Withjack, Rutgers University, drmeow3@eps.rutgers.edu; LeeAnn Srogi, West Chester University, lsrogi@wcupa.edu; MaryAnn Love Malinconico, Lafayette College, lovem@lafayette.edu.

T13. **Current Research in Coastal and Nearshore Processes.** *Endorsed by GSA Marine and Coastal Geosciences Division.* Bryan Oakley, Eastern Connecticut State University, OakleyB@easternct.edu; Mark Borrelli, University of Massachusetts Boston Center for Coastal Studies, Mark.Borrelli@umb.edu.

T14. **Soil Processes and Biogeochemical Interactions.** *Endorsed by GSA Soils and Soil Processes Division; GSA Hydrogeology Division; GSA Geobiology and Geomicrobiology Division.* Zsuzsanna Balogh-Brunstad, Hartwick College, balogh_brunz@hartwick.edu; Justin Richardson, University of Massachusetts Amherst, JBRichardson@umass.edu.

T15. **In Cahoots: Interdisciplinary Studies of Climate Change Impacts to Archaeological Resources.** Alice R. Kelley, University of Maine, akelley@maine.edu; Heather Wholey, West Chester University, HWholey@wcupa.edu; Carole Nash, James Madison University, nashcl@jmu.edu.

T16. **Glacial Geology and Proxy Records in Northeastern North America and Beyond.** *Endorsed by GSA Quaternary Geology and Geomorphology Division.* Greg de Wet, Smith College, gdewet@smith.edu; Sarah Principato, Gettysburg College, sprincip@gettysburg.edu.

T17. **Pleistocene to Modern Landforms and Change: Using Field and High-Resolution Topographic Data to Unravel Landscape History and Quantify Change.** Dorothy Merritts, Franklin and Marshall College, dorothy.merritts@fandm.edu; Noah Snyder, Boston College, noah.snyder@bc.edu.

T18. **Techniques for Acquiring Elevation-Derived Hydrography (EDH): Contributions and Collaborations.** Shane Csiki, New Hampshire Geological Survey, Shane.Csiki@des.nh.gov; Gale Blackmer, Pennsylvania Geological Survey, gblackmer@ pa.gov.

T19. **Geologic Applications of Unmanned Aerial Systems.** Craig Ebersole, Pennsylvania Geological Survey, craebersol@ pa.gov; Ryan Mathur, Juniata College, mathurr@juniata.edu.

T20. **Deep Learning-Enabled Remote Sensing Applications for Geology.** Thomas Y. Chen, Academy for Mathematics, Science, and Engineering, thomaschen7@acm.org.

T21. **How is the Practice of Geoscience Keeping Pace with a Changing World?** *Endorsed by GSA Geology and Society Division.* Tim Lutz, West Chester University, tlutz@wcupa.edu.

T22. **Applied Research at Northeastern State Geological Surveys.** Jonathan Kim, Vermont Geological Survey, jon.kim@vermont.gov; Richard Ortt, Maryland Geological Survey, richard.ortt@maryland.gov; Gale Blackmer, Pennsylvania Geological Survey, gblackmer@pa.gov.

T23. **Private Wells—Current Challenges and Opportunities.** Joseph Ayotte, U.S. Geological Survey New England Water Science Center, jayotte@usgs.gov; Kelsey Pieper, Northeastern University, k.pieper@northeastern.edu; Paul Susca, New Hampshire Dept. of Environmental Services, paul.a.susca@ des.nh.gov; Jon Kim, Vermont Geological Survey, jon.kim@ vermont.gov; Patti Casey, Vermont Dept. of Agriculture, Food, and Markets, Patti.Casey@vermont.gov.

T24. **Implementing the U.S. Geological Survey National Cooperative Geologic Mapping Program's U.S. GeoFramework Initiative: Constructing a Seamless, National 2D/3D Geologic Framework Model of the U.S.** Jenna Shelton, U.S. Geological Survey National Cooperative Geologic Mapping Program, jlshelton@usgs.gov; David Soller, U.S. Geological Survey National Cooperative Geologic Mapping Program, drsoller@usgs.gov; Don Sweetkind, U.S. Geological Survey Geosciences and Environmental Change Science Center, dsweetkind@usgs.gov.

FIELD TRIPS

Field trips will run on Sat., 19 March. Trip registration opens in December. For additional information, please contact the field trip chair, Jaime Tomlinson, jaimet@udel.edu.

Mesozoic Rifting and Magmatic Processes: A 3D Perspective from the Morgantown-Jacksonwald Igneous Complex, Central Atlantic Magmatic Province, Southwestern Newark Rift Basin, Pennsylvania. *Endorsed by GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Structural Geology and Tectonics Division.* Trip organizer: LeeAnn Srogi, West Chester University, lsrogi@wcupa.edu.

Quaternary Evolution and Contemporary Fluvial Processes, White Clay Creek, Delaware–Pennsylvania. Trip organizer; Jim Pizzuto, University of Delaware, pizzuto@udel.edu.

Accreted Forearc, Continental, and Oceanic Rocks of Maryland's Eastern Piedmont: The Potomac Terrane, Baltimore Terrane, and Baltimore Mafic Complex. Trip leader; Rebecca Kavage Adams, Maryland Geological Survey, rebecca.adams@maryland.gov.

The Piedmont and K–12 Pedagogy: How Geology Works and Why It Matters. *Endorsed by National Association of Geoscience Teachers (NAGT) Teacher Education Division (TED).* Trip leader: L. Lynn Marquez, Millersville University of Pennsylvania, Lynn.Marquez@millersville.edu.

Historical and Current Paleontological Collections at The Academy of Natural Sciences of Drexel University, Philadelphia. Trip leader: Ted Daeschler, Academy of Natural Sciences of Drexel University, ebd29@drexel.edu.

Geology along the York County Heritage Rail Trail. Trip leader: Jeri Jones, Jones Geological Services, jonesgeo@comcast.net.

SHORT COURSES

Short courses will run on Sat., 19 March. Short course registration opens in December. For additional information, please contact the short course organizer, Rob Sternberg, rob.sternberg@fandm.edu.

Geo-Philately—Earth Sciences on Postage Stamps. Online course. Convener: Rob Sternberg, Franklin & Marshall College, rob.sternberg@fandm.edu.

Contaminant Plume Modeling and Analysis for the Environmental Professional. Convener: Charles McLane, McLane Environmental LLC, cmclane@McLaneEnv.com.

Teaching and Learning Geoscience in a Changed and Changing World. *Endorsed by National Earth Science Teachers Association; National Association of Geoscience Teachers (NAGT) Teacher Education Division (TED).* Convener: Missy Holzer, National Earth Science Teachers Association, missy.holzer@gmail.com.

The Digital Geologic Map Schema (GeMS). Online course. Convener: David Soller, U.S. Geological Survey, drsoller@usgs.gov.

How to Create Your Own 3D Video-Game–Style Geologic Field Trip and Host it Online: Accessible, Immersive Data Visualization for Education and Research. Convener: Mattathias (Max) D. Needle, University of Washington, mneedle@uw.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.

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

Student Volunteers

Take advantage of work opportunities to earn free registration. Students interested in helping with the various aspects of the meeting should contact Emily Wilson, Franklin and Marshall College, emily.wilson@fandm.edu.

PROFESSIONALS

If you like to share your interest, enthusiasm, and experience in applied geology, consider being a GSA mentor at the meeting. 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.

CORPORATE SPONSORSHIP

Whenever possible, we like to reach out to industry representatives to mentor students and early career professionals (ECPs). Students and ECPs really enjoy talking to these individuals who can describe their career paths and what opportunities there are in their industries and companies. If there are possibilities to engage sponsors for the mentor programs, please contact Debbie Marcinkowski, Executive Director of the GSA Foundation, dmarcinkowski@geosociety.org. Sponsors enjoy meeting geology

students and ECPs as potential employees, so we will work with you to bring these two groups together.

REGISTRATION

Early registration deadline: 14 February
Cancellation deadline: 22 February

Registration opens in December. For further information or if you need special accommodations, please contact the general chairs, Andy de Wet, andy.dewet@fandm.edu, or Chris Williams, chris.williams@fandm.edu.

ACCOMMODATIONS

Hotel registration deadline: 5 p.m., Friday, 25 February.

A block of rooms has been reserved at the Lancaster Marriott at Penn Square. The meeting rate is US$159 per night plus tax. Reservations should be made by calling the Lancaster Marriott at Penn Square at +1-888-850-6146 (toll free) or +1-717-239-1600 (local). Please be sure to mention that you are attending the GSA meeting. The Lancaster Marriott at Penn Square is ADA compliant. Mobility accessible rooms may be requested at time of booking.

LOCAL COMMITTEE

Organizing Co-Chairs: Andy deWet, adewet@fandm.edu; Chris Williams, cwillia2@fandm.edu
Technical Program Co-Chairs: David Sunderlin, sunderld@lafayette.edu; LeeAnn Srogi, lsrogi@wcupa.edu; Gale Blackmer, gblackmer@pa.gov; Gail Ashley, gmashley@eps.rutgers.edu
Field Trip Chair: Jaime Tomlinson, jaimet@udel.edu
Sponsorships Co-Chairs: Tim Bechtel, timothy.bechtel@fandm.edu; Talor Walsh, talor.walsh@millersville.edu
Short Course Chair: Rob Sternberg, rob.sternberg@fandm.edu
K–12 Teacher Education Program Co-Chairs: Lynn Marquez, lynn.marquez@millersville.edu; Christopher Roemmele, CROEMMELE@wcupa.edu
Student Volunteer Chair: Emily Wilson, emily.wilson@fandm.edu
Coordination/Communications Chair: Melissa Betrone, mbetrone@fandm.edu

THE GEOLOGICAL SOCIETY OF AMERICA®
Penrose CONFERENCE

PRF2022—Progressive Failure of Brittle Rocks

Flat Rock, North Carolina, USA | Highland Lake Inn and Resort
20–24 June 2022

CONVENERS

Dr. Matthew Brain, Dept. of Geography, Durham University, matthew.brain@durham.ac.uk
Prof. Martha-Cary (Missy) Eppes, Dept. of Geography & Earth Sciences, University of North Carolina at Charlotte, meppes@uncc.edu
Dr. Kerry Leith, GNS Science, New Zealand, kerryleith@gmail.com
Dr. Alex Rinehart, Earth and Environmental Science, New Mexico Tech, Alex.Rinehart@nmt.edu

Endorsed by GSA Quaternary Geology and Geomorphology Division; GSA Environmental and Engineering Geology Division; GSA Soil and Soil Processes Division; GSA Planetary Geology Division. Additional funding provided by the National Science Foundation award #2134366.

OVERVIEW

What: A five-day conference with diverse keynote speakers, talks, posters, discussions, mentoring, and a one-day field trip.
Why: To foster a more robust and multidisciplinary understanding of the interdependencies of rock fracture and surface processes, hazards, infrastructure decay, weathering, and climate change.
Who: Geomorphologists, rock physicists, stone heritage preservationists, geotechnical engineers, critical zone scientists, and planetary geologists.
Where: Self-contained in a picturesque mountain retreat located in the Blue Ridge Mountains of west-central North Carolina, USA. Comfortable indoor and outdoor seating areas, walking trails, canoes, and swimming facilities will be available.

MOTIVATION

The progressive growth of fractures in rock directly impacts virtually all natural earth-surface systems and components of the built environment that involve rock. As rocks fracture in response to environmental, tectonic, and topographic forces and factors, that crack growth itself changes rock strength, porosity, and permeability. In turn, these changes impact natural processes and society. For example, the stability of slopes, excavations, tunnels, and boreholes are all intimately linked to these changes, as is the management of aging infrastructure, the conservation of our archaeological heritage, and the assessment of hazard risks related to phenomena like landslides and rockfalls. Crack growth also impacts the overall evolution of the critical zone, governing rates and modes of earth-surface processes ranging from CO_2 cycling to regolith production and hillslope sediment supply to bedrock channel incision.

Thus, there is substantial societal and scientific motivation for understanding rock fracture, the role it plays across a range of time and space scales, and for identifying key controls on its morphology, mechanisms, rates, and processes. However, the factors (e.g., climate, material properties, stresses, and water availability and chemistry) that drive or limit fracture growth itself—as well its manifestation and impacts over time—remain poorly characterized across a broad array of disciplines.

We hope this Penrose Conference, which we are calling PRF2022, can illustrate a pathway forward for filling the many knowledge gaps related to rock fracture overall, but particularly with respect to progressive rock failure (PRF). There is a burgeoning appreciation that crack growth in the natural and built environment is non-linear, most commonly progressing as slow, climate-dependent, *subcritical* deformation (i.e., PRF; Eppes and Keanini, 2017), which at times accelerates toward rapid and hazardous *critical* failure without obvious forewarning. Yet, the potentially central role that PRF may play in all fracture-related systems has been largely unrecognized or misconceived across both surface-process and engineering applications. Geomorphologists studying natural rock fracture have largely overlooked the knowledge and concepts to be derived from rock physics and engineering research on PRF, and engineers and rock physicists have remained largely unaware of the potential applications and validations that might be possible via the study of PRF in natural landscapes. PRF2022 seeks to bring together these communities for lively discussions and data analysis centered around testing and considering the assertion that virtually all natural rock fracture is dominated by—or at least predicated on—PRF.

CONFERENCE GOALS

This conference aims to transcend traditional disciplinary divides in the study of rock fracture—and its impacts—in both natural and applied research. We hope PRF2022 will enable attendees to understand and catalogue the applicability of PRF to fracture problems within their own disciplines by addressing the following types of questions:

- If mechanical weathering, critical zone fracture, infrastructure decay, and hazards are at least partially occurring via PRF, what are the implications? How can we quantify the extent to which PRF is, or is not, a dominant process in natural landscapes and built-stone infrastructure?
- If environment controls both stress *and* crack-tip PRF processes, what are the ramifications for the study of how past and ongoing climate change impacts rock fracture and any processes impacted by rock fracture processes?
- What is the impact of varying surface chemistry, moisture, and temperature conditions on the presence, rates, and morphological manifestation of PRF and thus the processes that it influences?


Left: Table Rock, South Carolina, USA: A typical granite "bald" and Blue Ridge escarpment landscape of the conference location, located just over the state line from Flat Rock, North Carolina, USA. Photo by JJ Fowler, vanzeppelin.com. Right: The pier at Highland Lake Inn and Resort, Flat Rock, North Carolina, USA. Photo by Jim Crotty.

- What does it mean for mechanical weathering and "erodibility" if only the smallest of stresses are needed to grow fractures? What are the relative roles of constant low-level stress generators versus infrequent large-stress generators?
- How do relationships between crack growth rates and fracture spacing (density/intensity) under PRF differ from relationships between fracture spacing and critical failure strength?
- How might experimental studies of microcrack growth be relevant over geologic time scales where material properties change as rocks are exposed under different—and changing—climatic regimes?

Specifically, by encouraging attendance by practitioners from a range of disciplines, PRF2022 will:

- Provide a platform to identify complementary data/observations/approaches (e.g., experimental vs. field, short time vs. deep time, modeling, etc.);
- Identify new scientific and commercial funding opportunities through new collaborations (e.g., bringing geomorphology and stone heritage investigators into engineering or mechanics studies and vice versa);
- Reveal key datasets (e.g., long-term data that can validate experiments or vice versa); and
- Lay out a framework for the future evaluation of PRF in the context of a full range of both academic and applied questions.

PRELIMINARY AGENDA

We plan to kick off this Penrose Conference with a "PRF primer and Q&A" that will ensure all attendees are on the same page with respect to the basic concepts and vocabulary of PRF; this will also free up time normally used for "background" for all presentations. Primer topics will be determined with input from attendees. It is expected that most attendees will be novices with respect to some aspects of the conference (e.g., PRF, fracture mechanics, surface processes, engineering, etc.). The underlying commonality will be that rock fracture is of interest.

We will organize daily talks, posters, and discussions around:

1. Monitoring;
2. Laboratory simulations;
3. Numerical modeling;
4. Fracture in a changing climate;
5. Scale linkages; and
6. Applications: From landscapes to hazard management.

Throughout the conference, we will schedule smaller discussions particularly aimed at early-career researchers and attendees from groups underrepresented in the geosciences. These discussions will be facilitated by an allocated mentor (conference convenor and/or a keynote speaker), allowing discussion of key themes in a friendly, supportive setting.

The mid-conference field excursion will consider both natural-system and applied aspects of PRF evident in the landscape and how the resultant hazards are managed, focusing on mass wasting features in the Hickory Nut Gorge, cutting into the impressive Blue Ridge Escarpment of western North Carolina. We hope the field trip will contextualize concepts discussed during the conference, demonstrating the significance and challenges of understanding the role that PRF plays in infrastructure degradation, hazards, and landscape evolution.

Field-Trip Leaders

Rick Wooten, P.G., North Carolina Geological Survey (retired)
Bart Cattanach, P.G., North Carolina Geological Survey
David Korte, Ph.D., P.G., North Carolina Geological Survey
Jennifer Bauer, P.G., Appalachian Landslide Consultants
Philip Prince, Ph.D., Appalachian Landslide Consultants
Cheryl Waters-Tormey, Ph.D., Western Carolina University
Karl Wegmann, Ph.D, L.G., L.E.G., North Carolina State University

INTERNATIONAL ADVISORY BOARD AND KEYNOTE SPEAKERS

These scientists are aiding the Penrose Conference conveners in identifying diverse attendees, providing keynote addresses, and acting as mentors.

Professor Erik Eberhardt, University of British Colombia. Recipient of the Canadian Geotechnical Society's 2013 John A. Franklin Award for outstanding technical contributions to rock mechanics and the 2017 Thomas Roy Award for outstanding contributions to engineering geology.

Dr. Stephen Laubach, University of Texas at Austin. Distinguished lecturer for the American Association of Petroleum Geologists (2010–2011) and Society of Petroleum Engineers (2003–2004) and GSA Fellow (2016).

Dr. Jill Marshall, University of Arkansas. Winner of the 2018 American Geophysical Union (AGU) Luna B. Leopold Young Scientist Award for significant and outstanding contributions that advance knowledge about earth- and planetary-surface processes.

Professor Phil Meredith, University College London. Winner of the 2016 European Geophysical Union Louis Néel Medal for his contributions to rock physics and geomechanics and for his role in stimulating international collaboration and interdisciplinary research.

Dr. Seulgi Moon, University of California Los Angeles. Recipient of the Gabilan Stanford Graduate Fellowship at Stanford University, and holder of an NSF Career Award for her work on fractures and landslides.

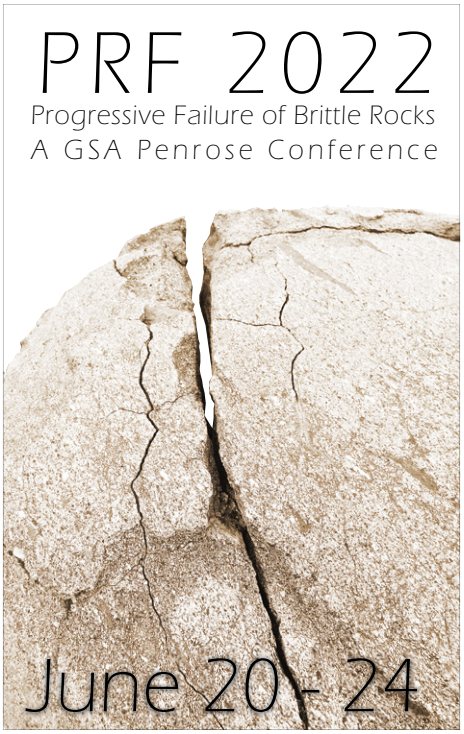
Professor Laura Pyrak-Nolte, Purdue University. President of the International Society of Porous Media (InterPore; 2019–2021); president of the American Rock Mechanics Association (2017–2019); recipient of the Society of Exploration Geophysicists 2020 Reginald Fessenden Award; fellow of the American Association for Advancement of Science, AGU, and American Rock Mechanics Association.

Professor Heather Viles, University of Oxford. Co-director of the Engineering and Physical Sciences Research Council Centre for Doctoral Training in Science and Engineering in Art, Heritage and Archaeology; honorary professor at the Institute of Sustainable Heritage, University College London; leader of the Oxford University Heritage Network.

LOGISTICS

This Penrose Conference plans to host ~75 in-person participants. Attendees will make their own travel arrangements. The anticipated registration fee (~US$1000, but possibly less depending on additional sponsorship) will cover all meals and lodging (nights of 19–23 June) and pre-arranged transportation from (19 June) and to Charlotte (24 June).

An application form link will be available via the GSA Penrose Conference website (https://www.geosociety.org/penrose) and the meeting website (www.prf2022.org) starting in October 2021.



Design by Ken Lambla, Marek Ranis, Missy Eppes—an art-science collaboration funded in part by NSF EAR#1839148.

Applications will require a provisional presentation/poster title and/or a brief summary of research interests and work related to the conference themes. Attendees are not required make a presentation to participate. Successful applicants will be notified 15 Feb. 2022, and registration—which will require an abstract if presenting—will close 15 Mar. 2022.

A key goal the conference is to maximize inclusion and diversity. We encourage participation from, and will provide some financial support for, a range of international, gender, BIPOC, LGBTQIA, early-career stage, and other underrepresented groups. To further foster a sense of belonging and a welcoming and inclusive atmosphere, we will be implementing a mentoring scheme for any attendee who wants a mentor. An artist in residence will also attend the conference, and resultant artwork will provide a key communication tool with the public and among scientists. All participants will be expected to observe the GSA Code of Ethics and the Events Code of Conduct throughout the meeting.

REFERENCE CITED

Eppes, M-C., and Keanini, R., 2017, Mechanical weathering and rock erosion by climate-dependent subcritical cracking: Reviews of Geophysics, v. 55, no. 2, p. 470–508.

Large Meteorite Impacts and Planetary Evolution VI

Edited by Wolf Uwe Reimold and Christian Koeberl

This volume represents the proceedings of the homonymous international conference on all aspects of impact cratering and planetary science, which was held in October 2019 in Brasília, Brazil. The volume contains a sizable suite of contributions dealing with regional impact records (Australia, Sweden), impact craters and impactites, early Archean impacts and geophysical characteristics of impact structures, shock metamorphic investigations, post-impact hydrothermalism, and structural geology and morphometry of impact structures—on Earth and Mars. Many contributions report results from state-of-the-art investigations, for example, several that are based on electron backscatter diffraction studies, and deal with new potential chronometers and shock barometers (e.g., apatite). Established impact cratering workers and newcomers to the field will appreciate this multifaceted, multidisciplinary collection of impact cratering studies.

SPE550, 642 p., ISBN 9780813725505

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POSITIONS OPEN

Assistant Professor in Applied GIS, Department of Environmental and Ocean Sciences, University of San Diego

The Environmental and Ocean Sciences Department at USD invites applications for a scholar who uses geospatial analysis (GIS) within the field of environmental or ocean sciences with a program of scholarship that is connected to one of the following cluster hire themes: (1) Climate Change and Environmental Justice, (2) Borders and Social Justice, or (3) Technology & the Human Experiences https://www.sandiego.edu/cas/about/diversity-equity-inclusion/hiring.php. For further details and to apply go to https://jobs.sandiego.edu/cw/en-us/job/494597/assistant-professor-in-applied-gis. (Priority deadline: 10/10/21).

Division Director, Division of Ocean Sciences, National Science Foundation (NSF), Alexandria, Virginia

The National Science Foundation, Directorate for Geosciences (GEO) seeks candidates for the position of Division Director in the Division of Ocean Sciences (OCE). The mission of the Division of Ocean Sciences is to enable fundamental research in most areas of the infrastructure, and education to advance understanding of all aspects of the global oceans and ocean basins, including their interactions with people and the integrated ocean system. These activities provide knowledge critical to addressing many of our nation's most pressing challenges involving ocean processes. OCE supports and promotes collaboration and facilitates the development of a diverse scientific and educational community, including international efforts. The Division works with the U.S. Ocean sciences academic community to direct funding towards advancing the frontiers of knowledge, developing the next generation of researchers, and enhancing the public's understanding of ocean sciences. Additional information about the Division's activities may be found https://www.nsf.gov/div/index.jsp?div=OCE.

The Division Director provides leadership and management to the Division's programs and assists the GEO Assistant Director in carrying out Directorate-wide responsibilities such as the preparation of budget submission for Congress, oversight and management of Division budgets, and recruitment of scientific staff. The incumbent also supervises and provides leadership and guidance to administrative and support personnel within the Division. Externally, the Division Director represents OCE in a variety of NSF-wide and interagency activities related to research and education, and in interactions with the community.

Appointment to this position may be on a Senior Executive Service (SES) Career, SES limited-term appointment (1-3 years), or Intergovernmental Personnel Act (IPA) assignment. The salary range is $174,225 to $194,516.

Announcement GEO-EXEC-2021-0011, with position requirements and application procedures, is located at https://www.usajobs.gov/GetJob/ViewDetails/606683400. Applicants may also obtain the announcement by contacting David Smith, 703-292-2142. Hearing impaired individuals may call TDD 703-292-5090. Applications must be received by September 10, 2021.

NSF is an equal opportunity employer committed to employing a highly qualified staff reflecting the diversity of our nation.

Assistant Professor, Hydrosphere, Occidental College

The Department of Geology at Occidental College invites applications for a tenure-track faculty position at the rank of Assistant Professor beginning August 2022. We seek a colleague with expertise in the hydrosphere, broadly defined as including interactions between water (including snow and ice), climate, ecosystems, and surface processes. Preference will be given to candidates that apply innovative and quantitative approaches to investigate water systems across temporal and spatial scales, through some combination of fieldwork, computational modeling, remote sensing, large datasets, and controlled experiments. The successful candidate will have teaching and research interests that complement those existing in the department and that can strengthen departmental connections with other science programs across campus and at institutes in the greater Los Angeles region. The successful candidate will engage with motivated undergraduate students as both a teacher and mentor, teach courses related to their specialty and introductory geology, and engage undergraduates in research projects in the earth and environmental sciences.

Applications should include statements of research interests in the context of a liberal arts college and teaching philosophy that includes a discussion of demonstrated commitment to, past evidence of, and future plans for creating equitable opportunities for learning and mentoring especially for underrepresented students. Appointment at the rank of Associate Professor or Advanced Assistant Professor may be considered for candidates with particularly advanced experience and a demonstrable ability to contribute to the College's mission as it relates to diversity, inclusion, equity, and justice. Candidates should specifically address their ability to (1) teach in a socioeconomically, ethnically and culturally diverse environment, and (2) engage students in an innovative and externally funded research program. Submit cover letter, research and teaching statements, curriculum vitae, 1-3 representative publications, and arrange for the confidential submission of three referees to Christopher Oze, the Search Committee Chair, at geosearch1@oxy.edu. A Ph.D. is required. Review of applications will begin October 10, 2021, and will continue until the search closes on December 20, 2021. Search committee members will meet interested candidates at the GSA and AGU meetings or virtually if needed.

Occidental is a nationally ranked liberal arts college recognized for its diverse student body and outstanding undergraduate research program. The mission of Occidental College is to provide a gifted and diverse group of students with a total educational experience of the highest quality—one that prepares them for leadership in an increasingly complex, interdependent and pluralistic world.

Occidental is an EEO employer and does not unlawfully discriminate against employees or applicants on the basis of race, color, religion, sex, sexual orientation, gender identity, gender expression, pregnancy, breastfeeding or related medical condition, national origin, ancestry, citizenship, age, marital status, physical disability, mental disability, medical condition, genetic characteristic or information, military and veteran status, or any other characteristic protected by state or federal Law. Individuals advancing the College's strategic equity and justice goals and those from groups whose underrepresentation in the American professoriate has been severe and longstanding are particularly encouraged to apply.

A comprehensive benefits package is available (https://www.oxy.edu/offices-services/human-resources/benefits-information). All qualified applicants will be considered, including those with criminal histories, consistent with applicable state and local laws, including the City of Los Angeles' FCIHO. If you need a reasonable accommodation because of a disability for any part of the application or employment process, contact hr@oxy.edu.

Faculty Position in Paleontology, University of Michigan

The Museum of Paleontology and the Department of Earth and Environmental Sciences at the University of Michigan are searching for a full-time tenure-track faculty candidate in the field of Paleontology at the assistant professor/assistant curator level. This is a university year appointment with an expected start date of August 29, 2022. The Museum of Paleontology has recently relocated its internationally significant collections of plant, invertebrate, and vertebrate fossils to the new Research Museums Center [https://lsa.umich.edu/rmc]. Paleontology faculty labs and offices are in the newly completed Biological Sciences Building, [https://lsa.umich.edu/ummnh/about/biological-sciences-building.html], which houses biology units (Ecology and Evolutionary Biology [https://lsa.umich.edu/eeb]; Molecular, Cellular, and Developmental Biology) [https://lsa.umich.edu/mcdb]; and the Museum of Natural History [https://lsa.umich.edu/ummnh].

We seek applicants who have broad research and teaching interests within developing areas of evolutionary or environmental paleontology. The Museum and Department invite applicants in fields including, but not restricted to macroevolution, interactions between developmental biology and evolution, extinction dynamics, paleoecology, organismal paleobiology, and biotic responses to global change. We will consider outstanding applicants in any of these areas, and are particularly

interested in candidates whose work bridges subdisciplines within paleontology and Earth sciences. Taxonomic expertise is expected, with preference for areas that add new curatorial strength.

The successful candidate is expected to establish an externally funded research program and contribute to excellence in undergraduate and graduate teaching. Applicants must have a Ph.D. at the time of appointment and should submit: (1) cover letter; (2) CV; (3) statement of current and future research plans; (4) statement of teaching philosophy and experience; (5) evidence of teaching excellence (e.g., evaluations, awards), if available; (6) a statement of activities contributing to diversity, equity, and inclusion in academia; (7) up to four publications; and (8) names and contact information for at least four references.

Information about the Museum and Department can be found at www.lsa.umich.edu/paleontology and www.lsa.umich.edu/earth. To apply please go to https://sites.lsa.umich.edu/faculty-position-paleo/ complete the online form, and upload the required application documents as a single PDF file. If you have any questions or comments, please send an email message to mfriedm@umich.edu.

The application deadline is October 1, 2021, for full consideration, but applications will continue to be reviewed until the position is filled. The University of Michigan is supportive of the needs of dual career couples and is an Affirmative Action/Equal Opportunity Employer. Women and members of minority groups are encouraged to apply.

Two Tenure-Track Assistant/Associate Professor Positions in Geology and Geophysics, Texas A&M University

The Department of Geology and Geophysics in the College of Geosciences at Texas A&M University is conducting a search to fill two tenure-track positions with 9-month academic appointments at the Assistant or Associate Professor rank. We seek creative faculty members who will lead vibrant, cutting edge research programs that can leverage the strengths of Texas A&M and the Department of Geology & Geophysics, while expanding our reach into national and international-scale initiatives. We particularly welcome applications from individuals with demonstrated commitment to diversity, equity and inclusion. This is an open-discipline search, and we seek applicants with backgrounds that strengthen or complement research within the Department of Geology and Geophysics. For more information, please refer to https://geogeo.tamu.edu/. This position has an anticipated start date of August 1, 2022.

The successful candidate will be expected to establish and maintain an independent and externally funded research program, contribute to transformative teaching and mentoring at the undergraduate and graduate levels, and participate in departmental and college activities.

The Department of Geology and Geophysics is part of the College of Geosciences, which also includes the Departments of Atmospheric Sciences, Geography, Oceanography, the interdisciplinary Environmental Programs and Water Management and Hydrologic Sciences degree programs, the International Ocean Discovery Program (IODP), and other interdisciplinary centers including the Berg-Hughes Center for Petroleum and Sedimentary Systems and the Center for Tectonophysics. Texas A&M University is a land-, sea-, and space-grant university, located at the center of the Bryan/College Station metro area with its dynamic and international community of over 270,000 people.

Texas A&M University is an Equal Opportunity/Affirmative Action/Veterans/Disability employer committed to building a culturally diverse educational environment for all visitors, students, faculty, and staff by promoting a culture that embraces inclusion, diversity, equity, and accountability. Diverse perspectives, talents, and identities are vital to accomplishing our mission and living our core values. The TAMU College of Geosciences Diversity and Inclusion Action Plan can be found at https://geosciences.tamu.edu/diversity-climate/action-plan/index.html. Applications from members of minoritized groups are strongly encouraged to apply and will be actively sought.

The University is aware that attracting and retaining exceptional faculty often depends on meeting the needs of two careers and therefore implements policies that contribute to work-life balance, including the Dual-Career Program (https://dof.tamu.edu/Faculty-Resources/DUAL-CAREER-PARTNER-PLACEMENT).

Applicants must have a Ph.D. in geology, geophysics or a related field at the time of appointment. Postdoctoral experience is desirable but is not required. Initial review of applications will begin on September 15, 2021 and continue until the position is filled.

To apply, please submit a cover letter, CV, statement of research vision, statement of teaching interests, a separate statement that demonstrates evidence of a commitment to diversity, equity, and inclusion, as well as names and contact information for at least three references to http://apply.interfolio.com/89462.

Informal inquiries or requests for more information may be sent via email directly to the Search Committee Chair: Dr. Mark E. Everett, Chair, Faculty Search Committee, Dept. of Geology and Geophysics, Texas A&M University, College Station, TX 77843-3115, email: everett@geo.tamu.edu.

Assistant Professor (Tenure Track) of Geological Science, California State University Long Beach

The Department of Geological Sciences, California State University Long Beach (CSULB) invites applications for a tenure-track Assistant Professor in Geophysics or in any other Geoscience discipline that substantially employs geophysical methods in research to start Fall 2022. A qualified candidate should be dedicated to teaching at the undergraduate and Masters level and committed to developing an externally funded research program that will involve students. As part of a campus that serves a very diverse community, the Department of Geological Sciences seeks candidates who, through previous experience supporting diverse students or their own lived experience, will be committed to the successful teaching and mentoring of all students.

Southern California abounds with world-class geologic exposures for teaching and research in the mountains, deserts, coast and ocean - most within a few-hour drive. CSULB is also located in the vibrant Los Angeles-Long Beach-Orange County metropolitan area, rich with universities and colleges, government agencies and local industry that provide many opportunities for collaboration.

Please follow this link [https://careers.pageuppeople.com/873/lb/en-us/job/501173/assistant-professor-of-geological-sciences-geoscience] for a detailed position description, list of required and preferred qualifications, and explanation of the application procedure. Review of applications will begin October 18, 2021.

Assistant Professor Position in Petrology/Geochemistry, Macalester College

The Macalester College Geology Department invites applications for a tenure track position in the broadly defined areas of petrology, geochemistry, volcanology, and/or planetary geology, to begin in Fall 2022. Candidates should hold a Ph.D. in Earth Sciences or a related field. The successful candidate will teach a course in mineralogy or "earth materials," and will be encouraged to develop additional introductory and advanced courses related to their interests and expertise that diversify and expand current curricular offerings. Existing strengths in the Macalester geology curriculum include structural geology and tectonics, surface processes and paleoclimate, paleobiology, and sedimentary geology. The successful candidate will be expected to maintain their scholarly work and conduct research with undergraduates. Demonstrated success in teaching and advising at the undergraduate level is desirable. The department is committed to increasing and supporting equity and diversity in the geosciences.

More information about the Macalester Geology Dept. can be found at www.macalester.edu/geology/. Macalester College is committed to student and faculty diversity, equity, and inclusion. As an Equal Opportunity employer supportive of affirmative efforts to achieve diversity among its faculty, Macalester College strongly encourages applications from women and members of underrepresented minority groups. Questions should be directed to Dr. Raymond Rogers, Chair, Geology Department (rogers@macalester.edu).

Applications will be considered beginning September 1, 2021. To apply and submit required documents, please visit: https://academicjobsonline.org/ajo/jobs/18851

Assistant Professor of Lithospheric Dynamics & Evolution, Utah State University

The Department of Geosciences at Utah State University (USU), Logan, invites applications for a 9-month tenure-track position in lithospheric dynamics and evolution. We seek candidates who combine geophysical, geochemical, and/or geological observations to conduct innovative, interdisciplinary, and quantitative investigation of solid-Earth system science. Research interests may include but are not limited to physics and physical-state properties of Earth materials, geophysical observation of

active lithospheric dynamics, and/or metamorphic/igneous petrology.

Successful candidates will demonstrate outstanding potential for excellence in research through development of a vibrant, externally funded research program; contribute to our core undergraduate curriculum and teach graduate courses; and advance diversity, equity, and inclusion within our department and university. This position will be one of four offered this coming year by USU's College of Science intended to strengthen a community of faculty with strong ties to underserved groups in the sciences.

For more information and to apply for this position, visit https://careers-usu.icims.com/jobs/3748/assistant-professor-in-lithospheric-evolution/job. Required materials include a cover letter; CV; statements of research, teaching, and DEI philosophies; contact information for 3 references; and one representative publication. Please visit our website (https://geo.usu.edu/) and contact Tony Lowry, Search Committee Chair, tony.lowry@usu.edu, with any inquiries. USU is an AA/EO employer. Review of applications begins on September 15, 2021.

Assistant Professor in Structural Geology, New Mexico Institute of Mining and Technology

The New Mexico Institute of Mining and Technology (NMT) invites applications for a tenure-track, assistant professor position in structural geology. We seek candidates with a strong track record of field-based research directed at the investigation of fundamental tectonic processes. Specific interests may include (but are not limited to) one or more of the following topics: active tectonics and hazards, remote sensing, seismogenic fault zone processes, ductile shear zone kinematics and petrology, thermochronology, surficial dating, thermo-kinematic or hazards modeling, and field method development. The successful candidate will be expected to develop a cutting-edge, externally funded research program and teach three classes per year.

Applicants should submit: (1) a cover letter, (2) curriculum vitae, (3) statement of research interests, (4) statement of teaching interests, (5) statement indicating how you would contribute to NMT's commitment to diversity, multiculturalism, and community, (6) one representative publication, and (7) names of three references, in a single pdf to Rosa.Jaramillo@nmt.edu and mark.person@nmt.edu. Inquiries should be directed to structural geology search committee chair, Mark Person (mark.person@nmt.edu). Review of application materials will begin on September 15, 2021. The search will remain open until the position is filled. New Mexico Tech, a Hispanic serving institution, is an equal opportunity/affirmative action employer.

Assistant Professor Position in Geophysics, New Mexico Institute of Mining and Technology

The Earth and Environmental Science Department at New Mexico Institute of Mining and Technology (NMT) invites applications for a tenure-track assistant professor in geophysics. We seek candidates whose interests would complement the department's strengths in understanding the Earth using geophysical techniques; applicants with interests in any field of observational, experimental, or computational geophysics are welcome. The successful candidate will be expected to develop a vigorous, independent, and externally funded research program supporting M.S. and Ph.D. students and teach three courses per year.

New Mexico Tech, located in the central Rio Grande valley community of Socorro, specializes in science and engineering education and research, and has an enrollment of approximately 2000 undergraduate and graduate students. The Earth and Environmental Science Department (www.nmt.edu/academics/ees) has undergraduate programs in Earth Science and Environmental Science, and M.S. and Ph.D. programs in Geophysics, Geology, Geochemistry, Geobiology, and Hydrology. The Department consists of 15 faculty and approximately 100 undergraduate and graduate students. Additional on-campus geoscience expertise includes the New Mexico Bureau of Geology and Mineral Resources (geoinfo.nmt.edu), Petroleum Recovery Research Center (www.prrc.nmt.edu), and IRIS-PASSCAL (www.passcal.nmt.edu).

Applicants should submit: (1) a cover letter, (2) curriculum vitae, (3) statement of research interests (2 pages), (4) statement of teaching interests (2 pages), (5) statement indicating how you would contribute to NMT's commitment to diversity, multiculturalism, and community (1 page), (6) one representative publication, and (7) names of three references, in a single pdf sent to nmtjobapps@npe.nmt.edu and glenn.spinelli@nmt.edu. Applicants must have a doctoral degree in Earth sciences or a related field. Inquiries should be directed to the geophysics search committee chair, Glenn Spinelli (glenn.spinelli@nmt.edu). Review of application material will begin on September 15, 2021. The search will remain open until the position is filled. New Mexico Tech, a Hispanic Serving Institution, is an equal opportunity/affirmative action employer.

How One Donor's Match Inspired Another's Added Challenge

Your Dollars, Doubled, to GSA's Greatest Needs Fund

A generous GSA donor put the power of a matching challenge to work in support of GSA's Greatest Needs, helping to raise $74,000—an unusually high amount for this important source of unrestricted funds for the Society.

The donor's offer compelled many of you to give, knowing your dollars would be doubled—but none of us anticipated that her action would also inspire another GSAF donor to add his own contribution to increase the match offer, encouraging even more of you to rise to the challenge. When the campaign wrapped up on 30 June, twice the challenged amount had been raised for the Greatest Needs Fund.

To every one of you who participated, we extend our sincere thanks. To the two donors who issued the matching challenges, we offer special thanks for inspiring others through your own generosity. The funds raised provide unrestricted support to GSA during a time of many changes, in great part due to circumstances around the pandemic, so the Society can apply the resources where they are most needed.

A friendly challenge from your fellow donors made a real impact. If you are interested in initiating this kind of challenge to inspire greater giving in the future, contact Cliff Cullen at ccullen@geosociety.org. Or take a moment to check with your employer—many offer matching gifts to your contributions and can receive recognition for participating. Contact Debbie Marcinkowski at dmarcinkowski@geosociety.org about employer matching gifts.

GSA Science Policy Fellows Ryan Haupt (2019–2020) and Laura Szymanski (2018–2019). GSA's policy work is one example of an area that can benefit from the Greatest Needs Fund.

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2022 GSA SECTION MEETINGS

SOUTH-CENTRAL SECTION

14–15 March
McAllen, Texas, USA
Meeting chairs: Juan González, juan.l.gonzalez@utrgv.edu; Chu-Lin Cheng, chulin.cheng@utrgv.edu
https://www.geosociety.org/sc-mtg

A resistant layer of the Roma sandstone is exposed crossing the Rio Grande. Photo by Juan González.

JOINT CORDILLERAN–ROCKY MOUNTAIN SECTION

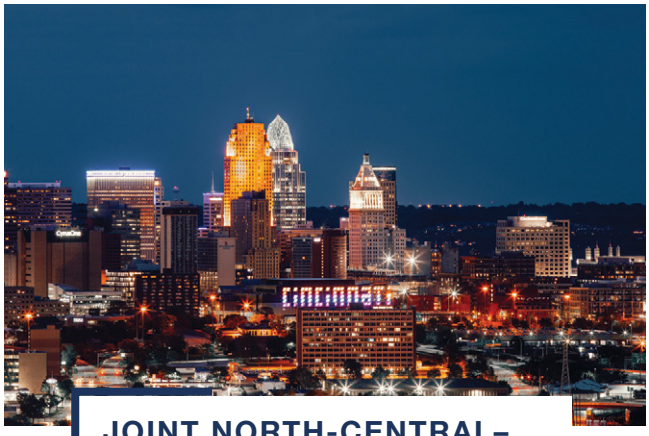
15–17 March
Las Vegas, Nevada, USA
Meeting chairs: Michael Wells, michael.wells@unlv.edu; Alexis Ault, alexis.ault@usu.edu
https://www.geosociety.org/cd-mtg

Red Rock Canyon, Nevada.
Photo by Daniel Halseth on Unsplash.

NORTHEASTERN SECTION

20–22 March
Lancaster, Pennsylvania, USA
Meeting chairs: Andy deWet, adewet@fandm.edu; Chris Williams, cwillia2@fandm.edu
https://www.geosociety.org/ne-mtg

Susquehanna River, southern Lancaster County.
Photo by Emily Wilson.



JOINT NORTH-CENTRAL–SOUTHEASTERN SECTION

7–8 April
Cincinnati, Ohio, USA
Meeting chairs: Craig Dietsch, dietscc@ucmail.uc.edu; Rebecca Freeman, rebecca.freeman@uky.edu
https://www.geosociety.org/nc-mtg

Cincinnati skyline at night.
Photo by Jake Blucker on Unsplash.

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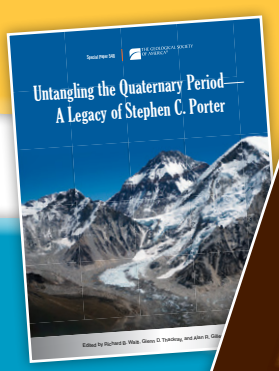

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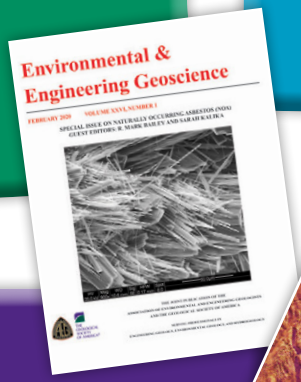

JOURNAL	Impact Factor 2021	Impact Factor 5-YEAR	SUBMIT ONLINE
Geology	5.399	6.079	geology.msubmit.net
GSA Bulletin	4.799	5.197	gsabulletin.msubmit.net
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TAKING ON 21ST CENTURY CHALLENGES CREATING 21ST CENTURY LEADERS

From the Earth's core to outer space, research at The University of Texas at Austin's Jackson School of Geosciences is advancing the understanding of our world and beyond for the benefit of humankind.

PHOTO: NASA/JPL-CALTECH