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Curation and Analysis of Global Sedimentary Geochemical Data to Inform Earth History

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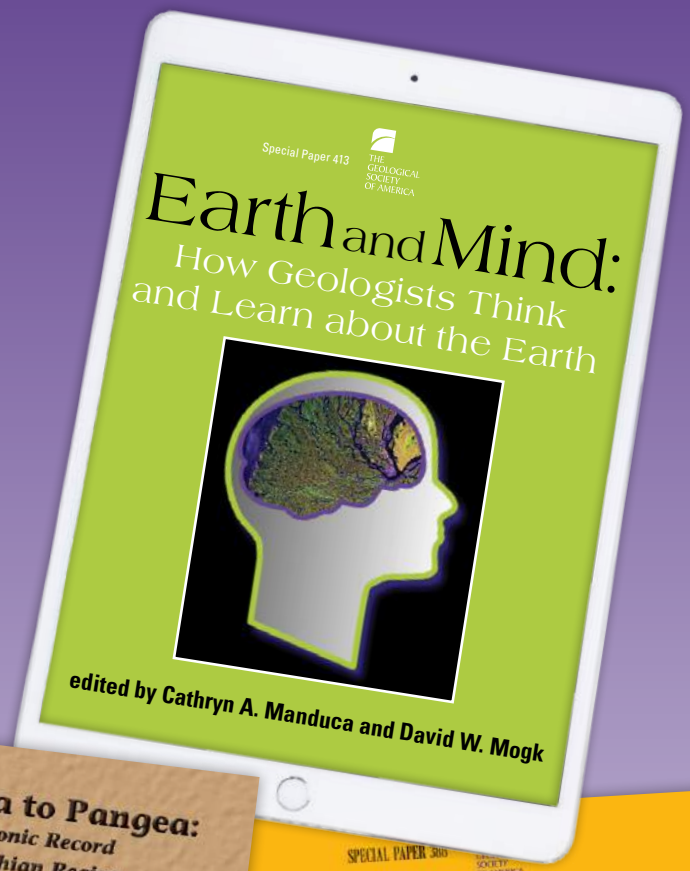

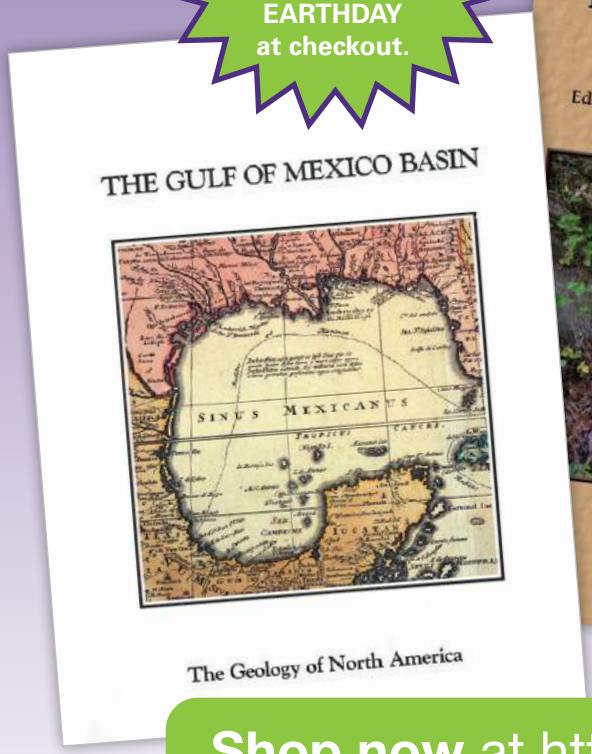

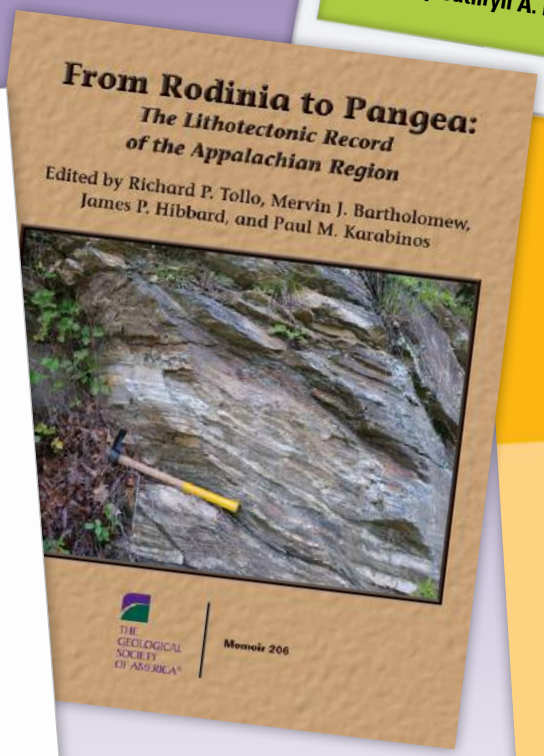

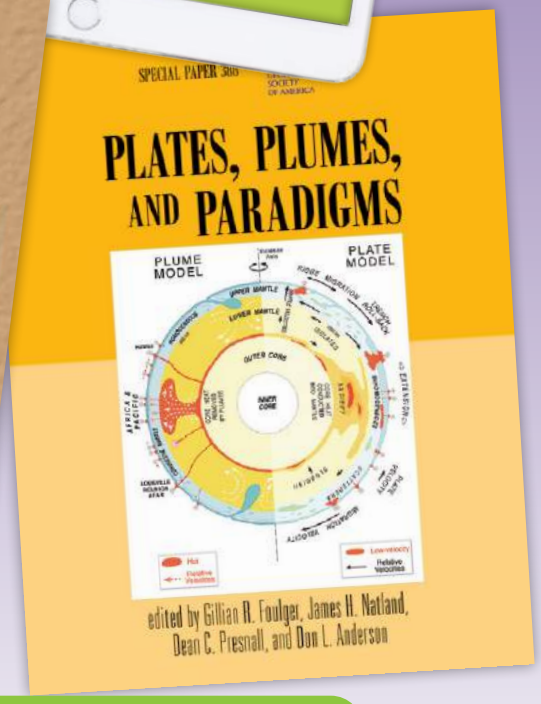

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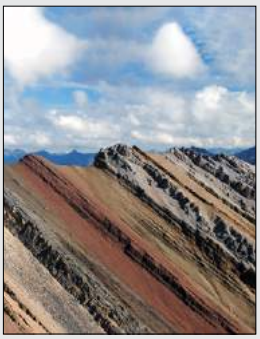

Cover: Upper Ediacaran and lower Cambrian sandstone, shale, and dolostone of the Risky and Sekwi formations in the headwaters of Goz Creek, Yukon, Canada. Credit: Justin Strauss. See related article, p. 4–10.

GSA CONNECTS 2021

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Corrigendum

Regarding: Muttoni, G., and D. Kent, 2016, A novel plate tectonic scenario for the genesis and sealing of some major Mesozoic oil fields: GSA Today, v. 26, no. 12, p. 4–10, https://www.geosociety.org/gsatoday/archive/26/12/abstract/i1052-5173-26-12-4.htm: Since its publication in 2016, two separate issues have emerged concerning some of the paleomagnetic data used in the publication. Muttoni and Kent have therefore crafted a **corrigendum** (online at https://www.geosociety.org/gsatoday/archive/26/12/pdf/muttoni-2016-corrigendum.pdf) that describes the issues and indicates the associated corrections.

Curation and Analysis of Global Sedimentary Geochemical Data to Inform Earth History

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ABSTRACT

Large datasets increasingly provide critical insights into crustal and surface processes on Earth. These data come in the form of published and contributed observations, which often include associated metadata. Even in the best-case scenario of a carefully curated dataset, it may be nontrivial to extract meaningful analyses from such compilations, and choices made with respect to filtering, resampling, and averaging can affect the resulting trends and any interpretation(s) thereof. As a result, a thorough understanding of how to digest, process, and analyze large data compilations is required. Here, we present a generalizable workflow developed using the Sedimentary Geochemistry and Paleoenvironments Project database. We demonstrate the effects of filtering and weighted resampling on Al_2O_3 and U contents, two representative geochemical components of interest in sedimentary geochemistry (one major and one trace element, respectively). Through our analyses, we highlight several methodological challenges in a "bigger data" approach to Earth science. We suggest that, with slight modifications to our workflow, researchers can confidently use large collections of observations to gain new insights into processes that have shaped Earth's crustal and surface environments.

INTRODUCTION

The study of Earth's past relies on a record that is spatially and temporally variable and, by some metrics, woefully undersampled. Through every geochemical analysis, fossil identification, and measured stratigraphic section, Earth scientists continuously add to this historical record. Compilations of such observations can illuminate global trends through time, providing researchers with crucial insights into our planet's geological and biological evolution. These compilations can vary in size and scope, from hundreds of manually curated entries in a spreadsheet to millions of records stored in software databases. The latter form is exemplified by

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databases such as The Paleobiology Database (PBDB; Peters and McClennen, 2016), Macrostrat (Peters et al., 2018), EarthChem (Walker et al., 2005), Georoc (Sarbas, 2008), and the Sedimentary Geochemistry and Paleoenvironments Project (SGP, this study).

Of course, large amounts of data are not new to the Earth sciences, and, with respect to volume, many Earth history and geochemistry compilations are small in comparison to the datasets used in other subdisciplines, including seismology (e.g., Nolet, 2012), climate science (e.g., Faghmous and Kumar, 2014), and hydrology (e.g., Chen and Wang, 2018). As a result, many Earth history compilations likely do not meet the criteria to be called "big data," which is a term that describes very large amounts of information that accumulate rapidly and which are heterogeneous and unstructured in form (Gandomi and Haider, 2015; or "if it fits in memory, it is small data"). That said, the tens of thousands to millions of entries present in such datasets do represent a new frontier for those interested in our planet's past. For many Earth historians, however, and especially for geochemists (where most of the field's efforts traditionally have focused on analytical measurements rather than data analysis; see Sperling et al., 2019), this frontier requires new outlooks and toolkits.

When using compilations to extract global trends through time, it is important to recognize that large datasets can have several inherent issues. Observations may be unevenly distributed temporally and/or spatially, with large stretches of time (e.g., parts of the Archean Eon) or space (e.g., much of Africa; Fig. S1[1]) lacking data. There may also be errors with entries—mislabeled values, transposition issues, and missing metadata can occur in even the most carefully curated compilations. Even if data are pristine, they may span decades of acquisition with evolving techniques, such that both analytical precision and measurement uncertainty are nonuniform across the dataset (Fig. S2 [see footnote 1]). Careful examination may demonstrate that contemporaneous and co-located observations do not agree. Additionally, data often are not targeted, such that not every entry may be necessary for (or even useful to) answering a particular question.

Luckily, these (and other) issues can be addressed through careful processing and analysis, using well-established statistical and computational techniques. Although such techniques have complications of their own (e.g., a high degree of comfort with programming often is required to run code efficiently), they do provide a way to extract meaningful trends from large datasets. No one lab can generate enough data to cover Earth's history densely enough (i.e., in time and space), but by leveraging compilations of accumulated knowledge, and using a well-developed computational pipeline, researchers can begin to ascertain a clearer picture of Earth's past.

A PROPOSED WORKFLOW

The process of transforming entries in a dataset into meaningful trends requires a series of steps, many with some degree of user decision making. Our proposed workflow is designed with the express intent of removing unfit data while appropriately propagating uncertainties. First, a compiled dataset is made or sourced (Fig. S3, i. [see footnote 1]). Next, a researcher chooses between in-database analysis and extracting data into another format, such as a text file (Fig. S3, ii.). This choice does nothing to the underlying data—its sole function is to recast information into a digital format that the researcher is most comfortable with. Then, a decision must be made about whether to remove entries that are not pertinent to the question at hand (Fig. S3, iii.). Using one or more metadata parameters (e.g., in the case of rocks, lithological descriptions), researchers can turn large compilations into targeted datasets, which then can be used to answer specific questions without the influence of irrelevant data. Following this gross filtering, researchers must decide between removing outliers or keeping them in the dataset (Fig. S3, iv.). Outliers have the potential to drastically skew results in misleading ways. Ascertaining which values are outliers is a non-trivial task, and all choices about outlier exclusion must be clearly described when presenting results. Finally, samples are drawn from the filtered dataset (i.e., "resampling") using a weighting scheme that seeks to address the spatial and temporal heterogeneities—as well as analytical uncertainties—of the data (Fig. S3, vi.). To calculate statistics from the data, multiple iterations of resampling are required.

CASE STUDY: THE SEDIMENTARY GEOCHEMISTRY AND PALEOENVIRONMENTS PROJECT

The SGP project seeks to compile sedimentary geochemical data, made up of various analytes (i.e., components that have been analyzed), from throughout geologic time. We applied our workflow to the SGP database[2] to extract coherent temporal trends in Al_2O_3 and U from siliciclastic mudstones. Al_2O_3 is relatively immobile and thus useful for constraining both the provenance and chemical weathering history of ancient sedimentary deposits (Young and Nesbitt, 1998). Conversely, U is highly sensitive to redox processes. In marine mudstones, U serves as both a local proxy for reducing conditions in the overlying water column (i.e., authigenic U enrichments only occur under low-oxygen or anoxic conditions and/or very low sedimentation rates; see Algeo and Li, 2020) and a global proxy for the areal extent of reducing conditions (i.e., the magnitude of authigenic enrichments scales in part with the global redox landscape; see Partin et al., 2013).

SGP data are stored in a PostgreSQL relational database that currently comprises a total of 82,579 samples (Fig. 1). The SGP database was created by merging sample data and geological context information from three separate sources, each with different foci and methods for obtaining the "best guess" age of a sample (i.e., the interpreted age as well as potential maximum and minimum ages). The first source is direct entry by SGP team members, which focuses primarily on Neoproterozoic–Paleozoic shale samples and has global coverage. Due to the direct involvement of researchers intimately familiar with their sample sets, these data have the most precise (Fig. 1A)—and likely also most accurate—age constraints. Second, the SGP database has incorporated sedimentary geochemical data from the United States Geological Survey (USGS) National Geochemical Database (NGDB), comprising samples from projects completed between the 1960s and 1990s. These samples, which

[1]Supplemental Material: table of valid lithologies; map depicting sample locations; crossplot illustrating analytical uncertainty; flowchart of the proposed workflow; histograms showing the effects of progressive filtering, the distribution of spatial and age scales, and proximity and probability values; and results of sensitivity tests. Go to https://doi.org/10.1130/GSAT.S.14179976 to access the supplemental material; contact editing@geosociety.org with any questions.

[2]All code used in this study is located at https://github.com/akshaymehra/dataCompilationWorkflow.

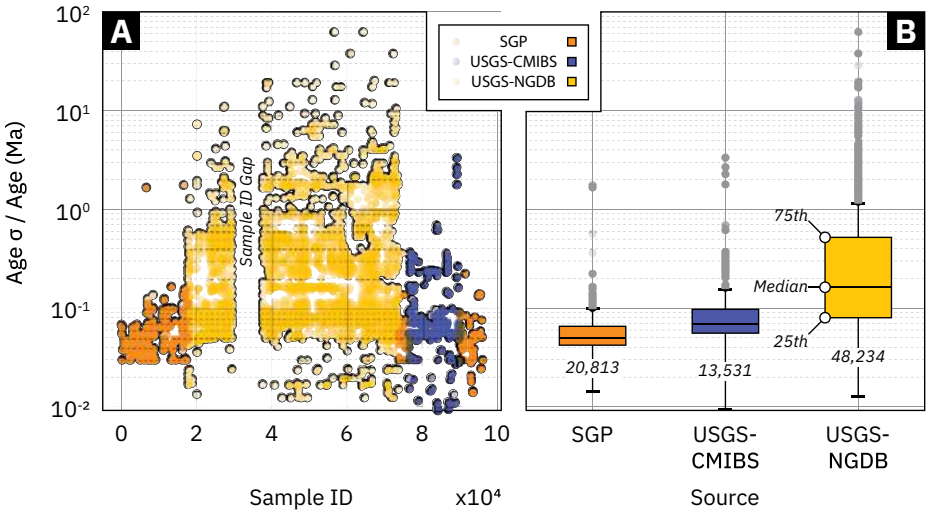

Figure 1. Visualizations of data in the Sedimentary Geochemistry and Paleoenvironments Project (SGP) database. (A) Relative age uncertainty (i.e., the reported age σ divided by the reported interpreted age) versus Sample ID. The large gap in Sample ID values resulted from the deletion of entries during the initial database compilation and has no impact on analyses. (B) Box plot showing the distributions of relative ages with respect to the sources of data. CMIBS—Critical Metals in Black Shales; NGDB—National Geochemical Database.

cover all lithologies and are almost entirely from Phanerozoic sedimentary deposits of the United States, are associated with the continuous-time age model from Macrostrat (Peters et al., 2018). Finally, the SGP database includes data from the USGS Global Geochemical Database for Critical Metals in Black Shales project (CMIBS; Granitto et al., 2017), culled to remove ore-deposit related samples. The CMIBS samples predominantly are shales, have global coverage, and span the entirety of Earth's sedimentary record. When possible, the CMIBS data are associated with Macrostrat continuous-time age models; otherwise, the data are assigned age information by SGP team members (albeit without detailed knowledge of regional geology or geologic units).

Cleaning and Filtering

We exported SGP data into a comma-separated values (.csv) text file, using a custom structured query language (SQL) query. In the case of geochemical analytes, this query included unit conversions from both weight percent (wt%) and parts per billion (ppb) to parts per million (ppm). After export, we parsed the .csv file and screened the data through a series of steps. First, if multiple values were reported for an analyte in a sample, we calculated and stored the mean (or weighted mean, if there were enough values) and standard deviation of the analyte. Then, we redefined empty values—which are the result of abundance being above or below detection—as "not a number" (NaN, a special value defined by Institute of Electrical and Electronics Engineers [IEEE] floating-point number standard that always returns false on comparison; see IEEE, 2019). Next, we converted major elements (e.g., those that together comprise >95% of Earth's crust or individually >1 wt% of a sample) into their corresponding oxides; if an oxide field did not already exist, or if there was no measurement for a given oxide, the converted value was inserted into the data structure. Then, we assigned both age and measurement uncertainties to the parsed data. In the case of the parsed SGP data, 5,935 samples (i.e., 7.1% of the original dataset) lacked an interpreted age and so no uncertainty could be assigned. For the remainder, we calculated an initial absolute age uncertainty by either using the reported maximum and minimum ages:

$$\sigma = \frac{\left|\text{age}_{maximum} - \text{age}_{minimum}\right|}{2},$$

or, if there were no maximum and minimum age values available, by defaulting to a two-sigma value of 6% of the interpreted age:

$$\sigma = 0.03 * \text{age}_{interpreted}.$$

The choice of a 6% default value was based on a conservative estimate of the precision of common in situ dating techniques (see, for example, Schoene, 2014). Additionally, we enforced a minimum σ of 25 million years:

$$\sigma = max(\sigma, 25).$$

Effectively, each datum can be thought of as a Gaussian distribution along the time axis with a σ of at least 25 million years (the minimum value of which may be thought of as a kernel bandwidth, rather than an analytical uncertainty). The selection of this σ value should correspond to an estimate of the processes that are being investigated (e.g., tectonic changes in provenance). We did not impose a minimum relative age uncertainty.

With respect to measurement uncertainties, we assigned an absolute uncertainty to every analyte that lacked one by multiplying the reported analyte value by a relative error. In future database projects, there is considerable scope to go beyond this coarse uncertainty quantification strategy. For example, given the detailed metadata associated with each sample in the SGP database, it would be straightforward to develop correction factors or uncertainty estimates for different geochemical methodologies (e.g., inductively coupled plasma–mass spectrometry [ICP-MS] versus inductively coupled plasma–optical emission spectrometry [ICP-OES], benchtop versus handheld X-ray fluorescence spectrometry [XRF], etc.). Correcting data for biases introduced during measurement is common in large Earth science datasets (Chan et al., 2019). However, such corrections previously have not been attempted in sedimentary geochemistry datasets.

Next, we processed the data through a simple lithology filter because, in the general case of rock-based datasets, only lithologies relevant to the question(s) at hand provide meaningful information. The choice of valid lithologies (or, for that matter, any other filterable metadata) are dependent on the researchers' question(s). As highlighted in the Discussion section, lithology filtering has significant implications for redox-sensitive and/or mobile/immobile elements. In this case study, our aim was to only sample data generated from siliciclastic mudstones. To decide which values to screen by, we manually examined a list made up of all unique lithologies in the dataset. We excluded samples that did not match our list of chosen lithologies (removing ~63.5% of the data; Table S1; Fig. S4 [see footnote 1]). Our strategy ensured that we only included mudstones sensu lato (see Potter et al., 2005, for a general description) where the lithology was coded. Alternative methods—such as choosing samples based on an Al cutoff value (e.g., Reinhard et al., 2017)—likely would result in a set comprising both mudstone and non-mudstone coded lithologies. In the future,

improved machine learning algorithms, designed to classify unknown samples based on their elemental composition, may provide a more sophisticated means by which to generate the largest possible dataset of lithology-appropriate samples.

We then completed a preliminary screening of the lithology filtered samples by checking if extant analyte values were outside of physically possible bounds (e.g., individual oxides with wt% less than 0 or greater than 100), and, if so, setting them to NaN. Next, to reduce the number of mudstone samples with detrital or authigenic carbonate and phosphatic mineral phases, we excluded samples with greater than 10 wt% Ca and/or more than 1 wt% P_2O_5 (removing ~66.9% of the remaining data; Fig. S4 [see footnote 1]). Additionally, in order to ensure that our mudstone samples were not subject to secondary enrichment processes, such as ore mineralization, we queried the USGS NGDB to extract the recorded characteristics of every sample with an associated USGS NGDB identifier. We examined these characteristics for the presence of selected strings (i.e., "mineralized," "mineralization present," "unknown mineralization," and "radioactive") and excluded any sample exhibiting one or more strings. Finally, as there were still several apparent outliers in the dataset, we manually examined the log histograms of each element and oxide of interest. On each histogram, we demarcated the 0.5th and 99.5th percentile bounds of the data, then visually studied those histograms to exclude "outlier populations," or samples located both well outside those percentile bounds and not part of a continuum of values (removing ~5.7% of the remaining data; Fig. S4). Following these filtering steps, we saved the data in a .csv text file.

Data Resampling

We implemented resampling based on inverse distance weighting (after Keller and Schoene, 2012), in which samples closer together—that is, with respect to a metric such as age or spatial distance—are considered to be more alike than samples that are further apart. The inverse weighting of an individual point, x, is based on the basic form:

$$y(x) = \frac{1}{d(x,x_i)^p},$$

where d is a distance function, x_i is a second sample, and p, which is greater than 0, is a power parameter. In the case of the SGP data, we used two distance functions, spatial (s) and temporal (t):

$$s = \frac{arcdistance(x,x_i)}{scale_{spatial}},$$

$$t = \frac{|age(x - x_i)|}{scale_{age}},$$

where *arcdistance* refers to the distance between two points on a sphere, $scale_{spatial}$ refers to a preselected arc distance value (in degrees; Fig. S5, inset [see footnote 1]), and $scale_{age}$ is a preselected age value (in million years, Ma). In this case study, we chose a $scale_{spatial}$ of 0.5 degrees and a $scale_{age}$ of 10 Ma (see below for a discussion about parameter values).

For n samples, the proximity value w assigned to each sample x is:

$$w(x) = \sum_{i=1}^{i=n} \frac{1}{(s^2+1)} + \frac{1}{(t^2+1)}.$$

Essentially, the proximity value is a summation of the reciprocals of the distance measures made for each pair of the sample and a single other datum from the dataset. Accordingly, samples that are closer to other data in both time and space will have larger w values than those that are farther away. Note that the additive term of 1 in the denominator establishes a maximum value of 1 for each reciprocal distance measure.

We normalized the generated proximity values (Fig. S6 [see footnote 1]) to produce a probability value P. This normalization was done such that the median proximity value corresponded to a P of ~0.20 (i.e., a 1 in 5 chance of being chosen):

$$P(x) = \frac{1}{\left(w(x) * median\left(\frac{0.20}{w}\right)\right) + 1}.$$

This normalization results in an "inverse proximity weighting," such that samples that are closer to other data (which have large w values) end up with a smaller P value than those that are far away from other samples. Next, we assigned both analytical and temporal uncertainties to each analyte to be resampled. Then, we culled the dataset into an m by n matrix, where each row corresponded to a sample and each column to an analyte. We resampled this culled dataset 10,000 times using a three-step process: (1) we drew samples, using calculated P values, with replacement (i.e., each draw considered all available samples, regardless of whether a sample had already been drawn); (2) we multiplied the assigned uncertainties discussed above by a random draw from a normal distribution ($\mu = 0$; $\sigma = 1$) to produce an error value; and (3) we added these newly calculated errors to the drawn temporal and analytical values. Finally, we binned and plotted the resampled data.

Naturally, the reader may ask how we chose the values for $scale_{age}$ and $scale_{temporal}$ and what, if any, impact those choices had on the final results? Nominally, the values of $scale_{age}$ and $scale_{temporal}$ are controlled by the size and age, respectively, of the features that are being sampled. So, in the case of sedimentary rocks, those values should reflect the length scale and duration of a typical sedimentary basin, such that many samples from the same "spatiotemporal" basin have lower P values than few samples from distinct basins. Of course, it is debatable what "typical" means in the context of sedimentary basins, as both size and age can vary over orders of magnitude (Woodcock, 2004). Given this uncertainty, we subjected the SGP data to a series of sensitivity tests, where we varied both $scale_{age}$ and $scale_{temporal}$, using logarithmically spaced values of each (Fig. S5 [see footnote 1]). While the uncertainty associated with results varied based on the choice of the two parameters, the overall mean values were not appreciably different (Fig. S7 [see footnote 1]).

RESULTS

To study the impact of our methodology, we present results for two geochemical components, U and Al_2O_3 (Fig. 2). Contents-wise, the U and Al_2O_3 data in the SGP database contain extreme outliers. Many of these outliers were removed using the lithology and Ca or P_2O_5 screening (Figs. 2A and 2C); the final outlier filtering strategy discussed above handled any remaining values of concern. In the case of U, our multi-step filtering reduced the range of concentrations by three orders of magnitude, from 0–500,000 ppm to 0–500 ppm.

DISCUSSION

The illustrative examples we have presented have implications for understanding Earth's history. Al_2O_3 contents of ancient mudstones appear relatively stable over the

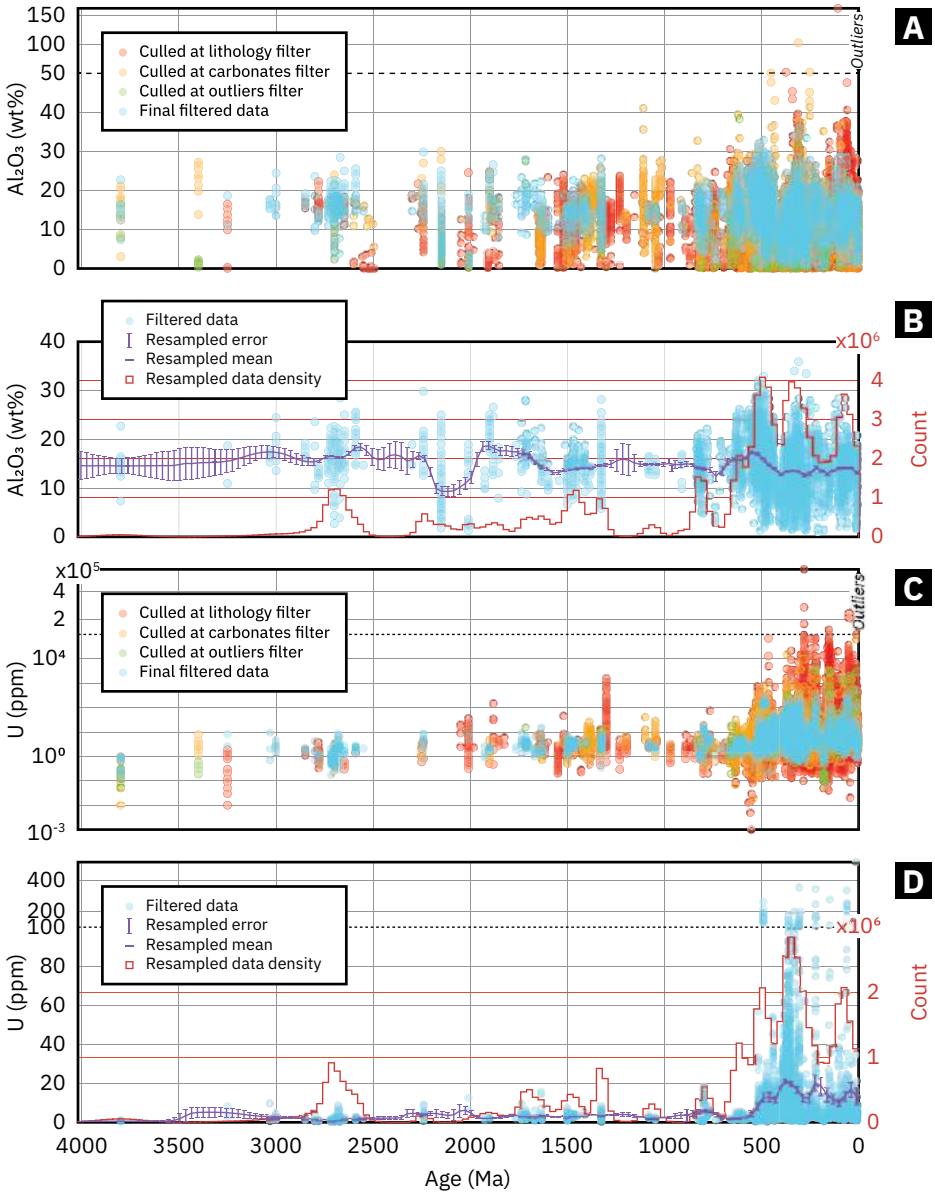

Figure 2. Filtering and resampling of Al_2O_3 and U. (A) and (C). Al_2O_3 and U data through time, respectively. Each datum is color coded by the filtering step at which it was separated from the dataset. In blue is the final filtered data, which was used to generate the resampled trends in (B) and (D). (B) and (D). Plots depicting Al_2O_3 and U filtered data, along with a histogram of resampled data density and the resulting resampled mean and 2σ error. Note the log-scale y axis in (C).

past ca. 1500 Ma (the time interval for which appreciable data exist in our dataset), suggesting little first-order change in Al_2O_3 delivery to sedimentary basins over time. The U contents of mudstones shows a substantial increase between the Proterozoic and Phanerozoic. Although we have not accounted for the redox state of the overlying water column, these results broadly recapitulate the trends seen in a previous much smaller (and non-weighted) dataset (Partin et al., 2013) and generally may indicate oxygenation of the oceans within the Phanerozoic.

Moving forward, there is no reason to believe that the compilation and collection of published data, whether in a semi-automated (e.g., SGP) or automated (e.g., GeoDeepDive; Peters et al., 2014) manner, will slow and/or stop (Bai et al., 2017). Those interested in Earth's history—as collected in large compilations—should understand how to extract meaningful trends from these ever-evolving datasets. By presenting a workflow that is purposefully general and must be adapted before use, we hope to elucidate the various aspects that must be considered when processing large volumes of data.

Foremost to any interpretation of a quantitative dataset is an assessment of uncertainty. In truth, a datum representing a physical quantity is not a single scalar point, but rather, an entire distribution. In many cases, such as in our workflow, this distribution is implicitly assumed to be Gaussian, an assumption that may or may not be accurate (Rock et al., 1987)—although a simplified distribution certainly is better than none. The quantification of uncertainty in Earth sciences especially is critical when averaging and binning by a selected independent variable, since neglecting the uncertainty of the independent variable will lead to interpretational failures that may not be mitigated by adding more data. As time perhaps is the most common independent variable (and one with a unique relationship to the assessment of causality), incorporating its uncertainty especially is critical for the purposes of Earth history studies (Ogg et al., 2016). An age without an uncertainty is not a meaningful datum. Indeed, such a value is even worse than an absence of data, for it is actively misleading. Consequently, assessment of age uncertainty is one of the most important, yet underappreciated, components of building accurate temporal trends from large datasets.

Of course, age is not the only uncertain aspect of samples in compiled datasets, and researchers should seek to account for as many inherent uncertainties as possible. Here, we propagate uncertainty by using a resampling methodology that incorporates information about space, time, and measurement error. Our chosen methodology—which is by no means the only option available to researchers studying large datasets—has the benefit of preventing one location or time range from dominating the resulting trend. For example, although the Archean records of Al_2O_3 and U especially are sparse (Fig. 2), resampling prevents the appearance of artificial "steps" when transitioning from times with little data to instances of (relatively) robust sampling (e.g., see the resampled record of Al_2O_3 between 4000 and 3000 Ma). Therefore, researchers should examine their selected methodologies to ensure that: (1) uncertainties are accounted for, and (2) that spatiotemporal heterogeneities are addressed appropriately.

Even with careful uncertainty propagation, datasets must also be filtered to keep outliers from affecting the results. It is important to note that the act of filtering does not mean that the filtered data are necessarily "bad," just that they do not meaningfully contribute to the question at hand. For example, while

our lithology and outlier filtering methods removed most U data because they were inappropriate for reconstructing trends in mudstone geochemistry through time, that same data would be especially useful for other questions, such as determining the variability of heat production within shales. This sort of filtering is a fixture of scientific research—e.g., geochemists will consider whether samples are diagenetically altered when measuring them for isotopic data—and, likewise, should be viewed as a necessary step in the analysis of large datasets.

As our workflow demonstrates, filtering often requires multiple steps, some automatic (e.g., cutoffs that exclude vast amounts of data in one fell swoop or algorithms to determine the "outlierness" of data; see Ptáček et al., 2020) and others manual (e.g., examining source literature to determine whether an anomalous value is, in fact, meaningful). Each procedure, along with any assumptions and/or justifications, must be documented clearly (and code included and/or stored in a publicly accessible repository) by researchers so that others may reproduce their results and/or build upon their conclusions with increasingly larger datasets.

Along with documentation of data processing, filtering, and sampling, it is important for researchers also to leverage sensitivity analyses to understand how parameter choices may impact resulting trends. Here, through the analysis of various spatial and temporal parameter values, we demonstrate that, while the spread of data varies based on the prescribed values of $scale_{spatial}$ and $scale_{temporal}$, the averaged resampled trend does not (Fig. S7 [see footnote 1]). At the same time, we see that trends are directly influenced by the use (or lack thereof) of Ca and P_2O_5 and outlier filtering. For example, the record of U in mudstones becomes overprinted by anomalously large values when carbonate samples are not excluded (Fig. S7B).

CONCLUSIONS

Large datasets can provide increasingly valuable insights into the ancient Earth system. However, to extract meaningful trends, these datasets must be cultivated, curated, and processed with an emphasis on data quality, uncertainty propagation, and transparency. Charles Darwin once noted that the "natural geological record [is] a history of the world imperfectly kept" (Darwin, 1859, p. 310), a reality that is the result of both geological and sociological causes. But while the data are biased, they also are tractable. As we have demonstrated here, the challenges of dealing with this imperfect record—and, by extension, the large datasets that document it—certainly are surmountable.

ACKNOWLEDGMENTS

We thank everyone who contributed to the SGP database, including T. Frasier (YGS). BGS authors (JE, PW) publish with permission of the Executive Director of the British Geological Survey, UKRI. We would like to thank the editor and one anonymous reviewer for their helpful feedback.

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THE GEOLOGICAL SOCIETY OF AMERICA®

CONNECTS 2021

10–13 October
Portland, Oregon, USA

Greetings!

We're excited to welcome you to Portland for GSA Connects 2021, 10–13 October. So much has changed since we hosted in 2009, which means there's even more to see and do. Portland and its surrounds offer a broad and spectacular range of accessible geology: two hours' drive can take you into the Cascades, the Columbia Gorge, the Oregon Coast, and the rolling hills and thick sediments of the Willamette Valley. Our landforms reflect flood basalts, violent earthquakes and volcanic eruptions, glacial floods, and part of the world's largest temperate rain forest.

We'd love to guarantee an in-person meeting, and will do everything to make that possible, but whether in the newly renovated Oregon Convention Center, on a field trip, or by online participation, we can still share science and each other's company.

Speaking of science, we're offering 177 topical sessions, 37 short courses, 24 field trips, and five Pardee Symposia, all conducted under GSA's Respectful Inclusive Scientific Events umbrella.

Oh—and of course we'll have the networking, mentoring, and other community events that you want, and you'll be able to make your own spontaneous connections. We're the hosts—it's your conference!

Want to take a break? Enjoy diverse restaurant and food-cart offerings, our surrounding wine country, performing and visual arts, public gardens, and more than 10,000 acres of public parks just within the city limits—and a populace that actually shows up for public science presentations! The same light-rail system that serves our conference venue stretches across three counties from award-winning Portland International Airport to the suburbs.

See you in October!

Jeff Rubin and **Ian Madin,**
Local Organizing Committee
General Co-Chairs

IMPORTANT DATES

Mid-May: Space-request system opens (non-technical, social, and business meeting room requests)

Early June: Abstract form, registration, and travel grant applications open

Mid-June: Housing opens

28 June: Space-request system deadline—fees increase after this date

20 July: Abstracts deadline

August: Student volunteer program opens

7 September: Early registration deadline

7 September: GSA Sections travel grants deadline

13 September: Registration and student volunteer cancelation deadline

15 September: Housing deadline for discounted hotel rates

Oregon Convention Center. Credit: Travel Portland.

NON-TECH REQUEST SYSTEM

Deadline for first consideration: 28 June

Please let us know about your non-technical events via our online request system. Meeting space at the official GSA event locations is reserved on a first-come, first-served basis. The form will include options for in-person, hybrid, and online events. We look forward to including your business meetings, town halls, luncheons, workshops, and receptions.

OFFICIAL GSA EVENT LOCATIONS

Oregon Convention Center (OCC)
Hyatt Regency Portland at the OCC (Headquarter Hotel)
DoubleTree by Hilton Portland (Co-Headquarter Hotel)

Call for Papers

Abstracts deadline: 20 July

SUBMITTING AN ABSTRACT

Abstracts form opens: 1 June
Submission deadline: Tues., 20 July

- **Abstract non-refundable submission fee:**
  GSA MEMBERS: professionals: US$60; students: US$25;
  NON-MEMBERS: professionals: US$80; students: US$50;
- To begin your submission, go to **https://community.geosociety.org/gsa2021/program/technical**;
- For detailed guidelines on preparing your submission, please go to **https://gsa.confex.com/gsa/2021AM/categorypreparation.cgi.**

TWO-ABSTRACT RULE

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

POSTER PRESENTERS

- You will be provided with one horizontal, free-standing 8-ft-wide by 4-ft-high display board and Velcro for hanging your display at no charge.
- Each poster booth will share a 6-ft-long by 30-inch-wide table.
- Electricity is available for a fee.
- Morning Session: Posters will be displayed 9 a.m.–1 p.m., with presenters present 11 a.m.–1 p.m.
- Afternoon Session: Posters will be displayed 2:30–6:30 p.m., with presenters present 4–6 p.m.

ORAL PRESENTERS

The normal length of an oral presentation is 12 minutes plus three minutes for questions and answers. You *must* visit the Speaker Ready Room at least 24 hours before your scheduled presentation. All technical session rooms will be equipped with a PC Windows 10/MS Office 2016. Presentations should be prepared using a 16:9 screen ratio.

HYBRID EVENTS

This year, GSA is offering an online component where we will be streaming live from 10 session rooms, in addition to the GSA Presidential Address, Pardee Keynote Symposia, and the GSA Noontime Lectures.

ABSTRACT SUBMISSIONS: EXPECTED BEHAVIOR

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

Contents

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.

P4. **Planetary Habitability: 2020 Randolph W. "Bill" and Cecile T. Bromery Awardee**

Endorsers: *GSA Planetary Geology Division; GSA Geobiology and Geomicrobiology Division; Geochemical Society; GSA Marine and Coastal Geosciences Division; GSA Limnogeology Division*
Disciplines: Planetary Geology, Geomicrobiology
Convenor: Martha Gilmore

What are the conditions that create and maintain a habitable planet? Are Mars, Europa, Titan, Venus, and scores of exoplanets habitable now or in the past? This Pardee Symposium consists of talks and a panel discussion that highlight the state of our understanding of the conditions of planetary habitability as we prepare for new missions to examine potentially habitable worlds. We hope that this will offer an opportunity for all to see how geoscientists, including perhaps their own work, might be important to advance our knowledge in this critical area.

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.

Discipline Sessions

In addition to topical sessions, GSA offers vibrant discipline sessions. Discipline sessions are an essential addition to the fulfillment of the overall meeting. We will have technical sessions that relate to recent advances in:

- Continental Scientific Drilling
- Economic Geology
- Energy Geology
- Engineering Geology
- Environmental Geoscience
- Geoarchaeology
- Geochemistry
- Geochronology
- Geoinformatics
- Geology and Health
- Geomicrobiology
- Geomorphology
- Geophysics/Geodynamics
- Geoscience Education
- Geoscience Information/Communication
- Geoscience and Public Policy
- History and Philosophy of Geology
- Hydrogeology
- Karst
- Limnogeology
- Marine/Coastal Science
- Mineralogy/Crystallography
- Paleoclimatology/Paleoceanography
- Paleontology, Biogeography/Biostratigraphy
- Paleontology, Diversity, Extinction, Origination
- Paleontology, Paleoecology/Taphonomy
- Paleontology, Phylogenetic/Morphological Patterns
- Petrology, Igneous
- Petrology, Metamorphic
- Planetary Geology
- Precambrian Geology
- Quaternary Geology
- Sediments, Carbonates
- Sediments, Clastic
- Soils
- Stratigraphy
- Structural Geology
- Tectonics/Tectonophysics
- Volcanology

Topical Sessions

TECTONICS/TECTONOPHYSICS

T1. **Cascadia Subduction Zone Earthquakes: Geologic, Geophysical, and Modeling Constraints on Rupture Timing and Process**

Endorsers: *GSA Structural Geology and Tectonics Division; GSA Quaternary Geology and Geomorphology Division; GSA Geophysics and Geodynamics Division; GSA Marine and Coastal Geoscience Division; GSA Geoinformatics and Data Science Division*
Disciplines: Tectonics/Tectonophysics, Marine/Coastal Science, Geophysics/Geodynamics
Advocates: Lydia Staisch; Chris Goldfinger; Nora Nieminski; Maureen Walton; Sean Richard LaHusen

For this session, we solicit a diverse range of research presentations on the Cascadia megathrust earthquake chronology and variability in rupture parameters.

T2. **Cenozoic Tectonism, Magmatism, Sedimentation, and Landscape Evolution in the Intermountain West**

Endorsers: *GSA Structural Geology and Tectonics Division; GSA Sedimentary Geology Division; GSA Geochronology Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; Geochemical Society*
Disciplines: Tectonics/Tectonophysics, Structural Geology, Stratigraphy
Advocates: Theresa M. Schwartz; Amy K. Gilmer; Jens-Erik Lund Snee

We welcome abstracts focused on the Cenozoic tectonic, magmatic, sedimentary, and landscape evolution of the Intermountain West. Studies using a broad range of methods to investigate events on any time scale are welcome.

T3. **Evolution, Structure, and Landscapes of the North Atlantic–Arctic Realm**

Endorsers: *GSA Geophysics and Geodynamics Division; GSA Quaternary Geology and Geomorphology Division; GSA Marine and Coastal Geoscience Division; GSA Geoinformatics and Data Science Division; GSA Geochronology Division*
Disciplines: Tectonics/Tectonophysics, Geophysics/Geodynamics, Geomorphology
Advocates: Christian Schiffer; Jane Lund Andersen; Pauline Jeanneret; Scott Jess; Alexander Peace

In this session, we will review our knowledge of the solid-Earth system in the North Atlantic realm. We welcome contributions from all relevant disciplines, studying structure and processes at all depths and of all ages.

T4. **Feedbacks between Upper-Plate Deformation and Plate Boundary Processes in Subduction Systems**

Endorsers: *GSA Geophysics and Geodynamics Division; GSA Structural Geology and Tectonics Division*
Disciplines: Tectonics/Tectonophysics, Geomorphology, Geophysics/Geodynamics
Advocates: Christine Regalla; Kirsty Mckenzie; Kristin Morell

This session focuses on geologic, geomorphic, and geodynamic processes of strain accumulation and topographic growth in subduction forearcs, and their relationships to the subduction plate boundary interface.

T5. **Geologic and Geomorphic Evolution of the Columbia River Basin**

Endorsers: *GSA Structural Geology and Tectonics Division; GSA Quaternary Geology and Geomorphology Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division*
Disciplines: Tectonics/Tectonophysics, Volcanology, Quaternary Geology
Advocates: Lydia Staisch; Scott Bennett; Jim E. O'Connor

The Columbia River system uniquely drains to an active convergent margin, energetically interacting with volcanic, tectonic, and anthropogenic processes. We welcome contributions broadly exploring the geologic and geomorphic record of the river and its basin.

T6. **Hot Rocks: High-Temperature Microstructures from Mantle to Surface**

Endorsers: *GSA Structural Geology and Tectonics Division; GSA Geochronology Division; GSA Geophysics and Geodynamics Division*
Disciplines: Tectonics/Tectonophysics
Advocates: Morgan Monz; Hannah Blatchford; Zachary D. Michels

This session highlights research on high-homologous-temperature microstructures, with diverse applications including reconstructing lithospheric viscous flow, glacier and ice sheet dynamics, and recrystallization of mineral chronometers. We seek contributions based on field, experimental, and modeling approaches.

T7. **Initiation and Evolution of Arc-Forearc Systems in Cascadia and Beyond**

Endorsers: *GSA Structural Geology and Tectonics Division; GSA Sedimentary Geology Division; GSA Geophysics and*

INDUSTRY TRACKS

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

Economic Geology | Energy | Engineering | Hydrogeology and Environmental Geology

Geodynamics Division; GSA Marine and Coastal Geoscience Division
Disciplines: Tectonics/Tectonophysics, Stratigraphy, Volcanology
Advocates: Michael Darin; Kristin McDougall-Reid; James Jackson; Paul Umhoefer

This session explores the tectonic, magmatic, sedimentary, and paleogeographic evolution of the Cascadia arc and forearc system from the early Eocene through the Miocene. Examples from analogous modern or ancient subduction margins are also encouraged.

T8. **Intracontinental Tectonics and Orogeny: The Deformation, Fabric Evolution, and Mechanism**

Endorser: *GSA Geophysics and Geodynamics Division*
Disciplines: Tectonics/Tectonophysics, Structural Geology, Geochronology
Advocate: Yu Wang

Intracontinental tectonics and orogeny have been important processes in Earth's evolution and directly related to environmental changes of human beings at present and in the future, which need to be studied fundamentally.

T9. **Late Cretaceous–Eocene (pre-Cascadia) Tectonics from the Greater Pacific Northwest Margin to the Rocky Mountains**

Endorsers: *GSA Geochronology Division; GSA Sedimentary Geology Division; GSA Structural Geology and Tectonics Division; GSA Geophysics and Geodynamics Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division*
Disciplines: Tectonics/Tectonophysics, Petrology, Igneous, Stratigraphy
Advocates: Paul Umhoefer; Robert B. Miller; Stacia M. Gordon; Thomas J. Kalakay

This session explores the tectonic, magmatic, metamorphic, sedimentary, and paleogeographic evolution of the greater Pacific Northwest from the Late Cretaceous to early Eocene, a period of large uncertainty about the regional plate-tectonic setting.

T10. **Northern Andes Mountain Building: From Proterozoic to Quaternary**

Disciplines: Tectonics/Tectonophysics
Advocates: Jorge Gomez Tapias; Ana Maria Patiño Acevedo

This session aims to present any contribution related to the geological framework of the northern Andes, the Caribbean plate, and the Panamá–Chocó Block, from Proterozoic to Quaternary.

T11. **Recent to Long-Term Slip Histories of Active Faults and Folds in Cascadia**

Endorsers: *GSA Structural Geology and Tectonics Division; GSA Structural Geology and Tectonics Division; GSA Geophysics and Geodynamics Division; GSA Quaternary Geology and Geomorphology Division; GSA Geoinformatics and Data Science Division*
Disciplines: Tectonics/Tectonophysics, Quaternary Geology, Geophysics/Geodynamics
Advocates: Scott Bennett; Elizabeth R. Schermer; Andrew Meigs

Active faults and folds in the upper plate of the Cascadia subduction zone have protracted histories. This session explores geological and geophysical evidence for Eocene to Holocene history of structures from the Cascadia forearc to backarc.

$ T12. **Sutures and Suture Zones in the Phanerozoic and Precambrian Orogenic Belts**

Endorsers: *GSA Structural Geology and Tectonics Division; GSA Geophysics and Geodynamics Division; GSA Geochronology Division; GSA Sedimentary Geology Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; Geological Society of London*
Disciplines: Tectonics/Tectonophysics
Advocates: Yildirim Dilek; Andrea Festa

We welcome case studies of sutures–suture zones in Phanerozoic and Precambrian orogenic belts toward refining the geological, geophysical, and geochemical criteria for their recognition, and better delineating the sites and polarities of ancient convergent plate boundaries.

T13. **Tectonics, Climate, and Life: Continental Drift, Large Igneous Provinces, and Global Change**

Endorsers: *GSA Marine and Coastal Geoscience Division; Paleontological Society; GSA Structural Geology and Tectonics Division; GSA Sedimentary Geology Division*
Disciplines: Tectonics/Tectonophysics
Advocates: Ross Mitchell; Zheng Gong; Richard E. Ernst

The boundary conditions of Earth's climate constantly change and influence biotic evolution. Two tectonic controls on long-term climate are continental drift and large igneous provinces that can affect life directly or indirectly through climate change.

T14. **Tectonometamorphic Evolution of the Mediterranean from the End of the Variscan Orogeny to Present**

Endorsers: *GSA Geophysics and Geodynamics Division; GSA Geochronology Division*
Disciplines: Tectonics/Tectonophysics, Petrology, Metamorphic, Geochronology
Advocates: Megan Flansburg; Eirini M. Poulaki; Romain Augier

The Mediterranean region has remained tectonically complex since the late Paleozoic. This session aims to highlight novel applications of various structural, geophysical, geochemical, and geochronological methods to answer long-standing tectonic questions throughout the Mediterranean.

T15. **The 100-Ma Event on the Western Margin of North America**

Endorser: *GSA Structural Geology and Tectonics Division*
Disciplines: Tectonics/Tectonophysics, Structural Geology, Petrology, Igneous
Advocates: Basil Tikoff; Michael L. Wells; Sarah Trevino

There is increasing evidence for a major tectonic event at ca. 100 Ma on the western edge of North America. This session will investigate the timing, kinematics, causes, and effects of this orogenic event.

T16. **The Rise of the Andes and the Development of the South American Monsoon: New Perspectives on Neogene Hydroclimate, Topography, and Ecology from Proxies and Models**

Endorser: *GSA Geophysics and Geodynamics Division*
Disciplines: Tectonics/Tectonophysics, Paleoclimatology/Paleoceanography, Stratigraphy
Advocates: Ethan Hyland; Jennifer M. Cotton; Nadja Insel

This session brings together proxy and model research into the complex development of Andean topography and impacts on changing hydroclimate and environments, to evaluate current knowledge on the establishment of the South American Monsoon system.

VOLCANOLOGY

T17. **Mapping the West: Honoring the Contributions of David Sherrod to Understanding of the Geologic History of Volcanic Terranes (Posters)**

Endorser: *Geochemical Society*
Disciplines: Volcanology, Quaternary Geology, Hydrogeology
Advocates: Jim O'Connor; Kenneth E. Lite Jr.

In recognition of the contributions of David Sherrod, this session aims to assemble presentations on recent geologic mapping and advances in geologic history and processes, and their interdisciplinary applications, with a focus on volcanic terranes of western North America.

T18. **The Dynamics and Hazards of Hydrovolcanic Systems (Posters)**

Endorsers: *IAVCEI Volcano–Ice Interaction Commission; GSA Marine and Coastal Geoscience Division; Geochemical Society*
Disciplines: Volcanology, Hydrogeology, Energy Geology
Advocates: Erin Fitch; Alison Graettinger; Ryan Cahalan

This multidisciplinary session brings together studies on the breadth of interactions between volcanoes and water, including phreatomagmatism, phreatic eruptions, hydro- and geothermal systems, volcanic lakes, volcanic floods and debris flows, submarine eruptions, and glaciovolcanism.

STRUCTURAL GEOLOGY

T19. **Best Student Geologic Map Competition (Posters)**

Endorsers: *U.S. Geological Survey National Cooperative Geologic Mapping Program; Geological Society of America; GSA Foundation; GSA Structural Geology and Tectonics Division*
Discipline: Structural Geology
Advocate: Michael Marketti

Students will present their research through geologic mapping projects that have a significant field component that addresses scientific or societal issues. The top three geologic maps will be awarded.

T20. **Structural Geology and Tectonics Division 40th Anniversary Symposium: Drivers of Orogenesis**

Endorsers: *GSA Structural Geology and Tectonics Division; GSA Geophysics and Geodynamics Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Quaternary Geology and Geomorphology Division*
Discipline: Structural Geology
Advocates: Juliet Crider; Nancye Dawers; Eric Cowgill; J Ramón Arrowsmith; Paul J. Umhoefer

How do we conceptualize and evaluate the energy budgets of orogenic events? Posters are encouraged to accompany three talks addressing this question and observational constraints from the lower crust to Earth's surface.

PETROLOGY, IGNEOUS

T21. **From the Afar Rift to Alaskan Arcs (and the Oregon Plateau in between): Honoring the Career and Contributions of William K. Hart**

Endorsers: *GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; Geochemical Society*
Disciplines: Petrology, Igneous, Volcanology, Tectonics/Tectonophysics
Advocates: Matthew Brueseke; Kurt Shoemaker

Bill Hart's research-mentoring has improved our understanding of the evolution of northwestern U.S. basalt provinces, southern Alaska, and the Afar Depression. We welcome studies from these regions focused on magmatism, especially building on Bill's work.

T22. **Rhyolites, Take a Bow! Examining the Production of Rhyolite Magma in Continental Arc Settings**

Endorsers: *Geochemical Society; GSA Geochronology Division*
Disciplines: Petrology, Igneous, Volcanology, Geochronology
Advocates: Erik Klemetti; Hannah Shamloo; Adam J.R. Kent

Rhyolite should be a common composition across continental arcs. However, they are not as ubiquitous as it seems. What connections can be made between arcs? We encourage submissions on the explosive topic of rhyolite magmatism and volcanism in continental arcs.

T23. **The How, When, Where, and Why of Open-System Magma Processes**

Endorsers: *GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Planetary Geology Division; GSA Geochronology Division; Geochemical Society*
Disciplines: Petrology, Igneous, Geochemistry, Geochronology
Advocates: Jenna V. Adams; Valerie Strasser; Wendy A. Bohrson; Frank J. Spera

Open-system magma processes rule! We seek contributions that provide insight into the how, when, and where of these processes, as well as why the spatio-temporal records of open-system processes are distinct among magmatic systems.

T24. **The Life and Times of Arc Volcanoes from Bottom to Top**

Endorsers: *GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; Geochemical Society*
Disciplines: Petrology, Igneous, Volcanology, Geophysics/Geodynamics
Advocates: Anita Grunder; Thomas W. Sisson; Kellie T. Wall

The diverse nature of arc volcanoes and intrusions invites examination of the mantle fluxes, crustal feedbacks, magma origin and storage, structural controls, and geophysical and tectonic contexts that lead to variability.

PETROLOGY, METAMORPHIC

T25. **Metamorphism into the 21st Century—A Celebration of the Career of Mike Brown**

Endorsers: *GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; Mineralogical Society of America; Geochemical Society*

Disciplines: Petrology, Metamorphic, Petrology, Igneous, Precambrian Geology
Advocates: Chris Yakymchuk; Julia A. Baldwin; Mark J. Caddick

We welcome contributions from the broad field of metamorphic geology ranging from the micro- to macroscale, from low- to high-grade and from field- to modeling-based to reflect Mike's multidisciplinary research contributions to metamorphic geology and understanding secular change.

GEOCHEMISTRY

T26. **Environmental Geochemistry and Health**

Endorsers: *GSA Geology and Health Division; GSA Environmental and Engineering Geology Division; GSA Hydrogeology Division; GSA Geology and Society Division; GSA Soils and Soil Processes Division*
Disciplines: Geochemistry, Environmental Geoscience, Geology and Health
Advocates: Jean M. Morrison; Ann Ojeda; Sarah Hayes; Nico Perdrial

We encourage presentations on the environmental fate of contaminants and their impact on human and environmental health. Transdisciplinary contributions, those examining the rock-soil-water-human nexus at all scales having strong public outreach or societal impact, are welcome.

T27. **Evolution of Earth's Surface: Honoring Xiao-Ming Liu, Recipient of the 2021 Mineralogy, Geochemistry, Petrology, and Volcanology Division's Early Geological Career Award**

Endorsers: *GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; Geochemical Society*
Disciplines: Geochemistry, Precambrian Geology, Sediments, Carbonates
Advocates: Roberta L. Rudnick; Timothy W. Lyons; Fang-Zhen Teng

How, when, and why has Earth's surface evolved over geologic time? Secular changes in atmosphere, oceans, and crust have all been documented or proposed. The session will explore the record and causes of these changes.

T28. **Groundwater–Surface Water Interactions in Streams, Lakes, and Wetlands**

Endorsers: *GSA Hydrogeology Division; GSA Karst Division; GSA Soils and Soil Processes Division*
Disciplines: Geochemistry, Geophysics/Geodynamics, Limnogeology
Advocates: Zeno Levy; Masaki Hayashi

This session encourages contributions that cover research on groundwater–surface water interactions in a broad range of aquatic environments using a variety of methods including hydrological field measurements, aqueous geochemistry, hydrogeophysics, and mathematical modeling.

T29. **Metamorphic Geochemistry without Borders: To Honor 2020 Dana Medalist Daniela Rubatto**

Endorsers: *Mineralogical Society of America; GSA Structural Geology and Tectonics Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division*
Discipline: Geochemistry
Advocates: Suzanne Baldwin; Sumit Chakraborty; Matthew J. Kohn; Clare Warren

We seek contributions that shed light on metamorphic processes through the integration of petrology, geochemistry, and geo- and thermochronology using isotopes, trace elements, mineral equilibria, and kinetics.

T30. **Using Hydrochemistry to Conceptualize Relations between Recharge and Discharge in Karst Aquifers**

Endorsers: *GSA Hydrogeology Division; GSA Karst Division*
Discipline: Geochemistry
Advocates: Rebecca R. Nunu; MaryLynn Musgrove

We welcome submittals that discuss the use of hydrogeochemical analyses in karst terrains to investigate: location of spring recharge areas; time of transport to discharge; source, timing, and nature of recharge; water-rock interaction in spring catchment areas; and flow pathways.

GEOCHRONOLOGY

T31. **Assessing Causes, Consequences, and Time Scales of Miocene Climate and Environmental Change**

Endorser: *GSA Geochronology Division*
Disciplines: Geochronology, Paleoclimatology/Paleoceanography, Paleontology, Biogeography/Biostratigraphy
Advocates: Jennifer J. Kasbohm; Alexander J. Lowe

Inviting contributions exploring terrestrial and marine records and/or modeling of Miocene environmental change and its possible causes, preferably in the context of well-resolved geochronological frameworks, to assess time scales of the earth system response to perturbations.

T32. **Magnets in the Time of Geology: The Many Roles of Paleomagnetism in Telling Geological Time**

Endorsers: *GSA Geochronology Division; GSA Structural Geology and Tectonics Division; GSA Geophysics and Geodynamics Division*
Disciplines: Geochronology, Structural Geology, Geophysics/Geodynamics
Advocates: Anthony Pivarunas; Joseph G. Meert; Courtney Sprain

Knowing "when," "for how long," or "at what rate" something occurred is fundamental to geology. Paleomagnetism is used in varied ways, in concert with varied disciplines, to address such questions throughout all of Earth's history.

ECONOMIC GEOLOGY

T33. **Magnetite Apatite (MtAp) Deposits in Space and Time**

Endorsers: *Mineralogical Society of America; Society of Economic Geologists*
Discipline: Economic Geology
Advocates: John M. Hanchar; Jeffrey Chiarenzelli; Marian Lupulescu; Fernando Tornos

Magnetite apatite (MtAp) ore deposits, sometimes referred to as iron oxide-apatite (IOA) deposits, are one of the most debated types of mineralization, are an important source of iron, and are a potential resource for rare earth elements.

T34. **Metals for the Future: Geology of Critical and Basic Minerals for the Green Economy**

Endorsers: *GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; Society of Economic Geologists; Geochemical Society; Mineralogical Society of America; GSA Geology and Society Division; GSA Energy Geology Division*
Disciplines: Economic Geology, Geochemistry, Tectonics/Tectonophysics
Advocates: Douglas C. Kreiner; Zhaoshan Chang; Simone Runyon; John Dilles

Critical (e.g., Li, rare earth element, Co, Te) and basic (Cu, Au, Ni) minerals are essential for efficient green energy technologies and transportation. The session will embrace geological, tectonic, geophysical, and petrochemical studies of deposit occurrences, environmental aspects, and global economic outlooks.

T35. **Rare Earth Elements and Other Critical Minerals in Phanerozoic Paleosols**

Endorsers: *GSA Soils and Soil Processes Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; Geochemical Society; Mineralogical Society of America; Society of Economic Geologists*
Disciplines: Economic Geology, Geochemistry, Soils
Advocates: William Andrews Jr.; Sarah R. Brown; Cortland F. Eble

An exploration of recent research into the geochemistry and geologic context of rare earth elements and other critical minerals in paleosols.

ENERGY GEOLOGY

T36. **Exploration of Helium in Sedimentary Basins: The New "Gold" Rush?**

Endorsers: *Geochemical Society; GSA Energy Geology Division*
Discipline: Energy Geology
Advocates: Daniele Pinti; Oliver Warr; Barbara Sherwood Lollar

This session addresses the mechanisms controlling the migration and accumulation of helium in sedimentary basins at exploitable concentrations, through a multidisciplinary approach involving all working parties, from noble gas specialists to petroleum geologists.

T37. **Geologic Energy Research**

Endorser: *GSA Energy Geology Division*
Discipline: Energy Geology
Advocates: Laura S. Ruhl; Travis McLing; Richard Esposito Jr.

This is the general session of the Energy Geology Division and highlights research into geologic based energy resources. Topics include coal geology, petroleum geology, geothermal, uranium, and the environmental impacts from energy utilization.

T38. **Geologic Research at the Cascade Volcanoes: Ideal Natural Laboratories for Cutting-Edge Research with Implications for Life Safety and Infrastructure Protection in the Pacific Northwest**

Endorsers: *GSA Quaternary Geology and Geomorphology Division; U.S. National Park Service; Geochemical Society*
Disciplines: Energy Geology, Geomorphology, Quaternary Geology
Advocates: Scott Beason; Claire Todd; Robert P. Jost; Taylor R. Kenyon

Volcanoes in the Pacific Northwest present a suite of hazards to a wide area. This session explores results of research at these volcanoes and how such research can be applied to similar locations.

ENGINEERING GEOLOGY

T39. **Engineering Geology for the Betterment of Society: Honoring the Legacy of Jerome V. De Graff**

Endorser: *GSA Environmental and Engineering Geology Division*
Disciplines: Engineering Geology, Geomorphology, Environmental Geoscience
Advocates: Dennis M. Staley; Alan J. Gallegos

This session is intended to honor the career and legacy of Jerome De Graff, who passed away in March 2020. We seek presentations from a variety of subjects in environmental and engineering geology.

T40. **Environmental and Engineering Geology Division**

Endorser: *GSA Environmental and Engineering Geology Division*
Disciplines: Engineering Geology, Environmental Geoscience
Advocates: Robert Mitchell; Thomas Oommen; A. Nandi

The oral session for the Environmental and Engineering Geology Division gives an opportunity to the geosciences community to present their research, data, and work pertaining to environmental and engineering geology.

T41. **Environmental and Engineering Geology Division Student Research Competition (Posters)**

Endorser: *GSA Environmental and Engineering Geology Division*
Disciplines: Engineering Geology, Environmental Geoscience
Advocates: Robert J. Mitchell; Thomas Oommen; A. Nandi

We encourage graduate and undergraduate students to submit poster presentations on topics related to applied research in environmental and engineering geology. Monetary awards will be given to the top presenters at the Division awards ceremony.

T42. **Landslide Hazards: Inventories, Hazard Maps, Risk Analysis, and Warning Systems**

Endorsers: *GSA Environmental and Engineering Geology Division; GSA Environmental and Engineering Geology Division Landslide Committee*

INDUSTRY TRACKS

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

Economic Geology | Energy | Engineering | Hydrogeology and Environmental Geology

Disciplines: Engineering Geology, Geomorphology, Geoscience Information/Communication
Advocates: William Burns; Matthew Crawford; Anne Witt; Stephen Slaughter

This session is designed to highlight landslide hazards information especially as related to landslide inventories, hazard maps, risk analysis, and warning systems

T43. **Modern Geoscience: Hazard and Risk Analysis and Communication**

Disciplines: Engineering Geology, Geomorphology, Geoscience Information/Communication
Advocates: William Burns; Nancy Calhoun; Christina A. Appleby

The focus of this session is new techniques in hazards mapping and modeling, risk analysis, and risk communication.

GEOPHYSICS/GEODYNAMICS

T44. **Geophysical Applications to Investigate Mineral, Energy, and Groundwater Resources**

Endorsers: *GSA Geophysics and Geodynamics Division; GSA Hydrogeology Division; Society of Economic Geologists; GSA Karst Division*
Disciplines: Geophysics/Geodynamics, Economic Geology, Energy Geology
Advocate: Kevin Mickus

Abstracts are requested that use geophysics to explore and develop mineral, energy, and groundwater resources.

T45. **Recent Studies in Near Surface Geophysics to Solve Geological Problems**

Endorsers: *GSA Geophysics and Geodynamics Division; GSA Hydrogeology Division; GSA Geoarchaeology Division; GSA Environmental and Engineering Geology Division; GSA Soils and Soil Processes Division; GSA Karst Division*
Disciplines: Geophysics/Geodynamics, Environmental Geoscience, Engineering Geology
Advocate: Kevin Mickus

Presentations are requested that use geophysics to aid in helping geological investigations, including environmental, archaeology, engineering, karst, geomorphology, hydrology, and near-surface geology.

T46. **Rifts, Rifted Margins, Backarcs, and Spreading Ridges: Understanding Extensional Processes across Tectonic Settings and Time Scales**

Endorsers: *GSA Geophysics and Geodynamics Division; GSA Energy Geology Division*
Disciplines: Geophysics/Geodynamics, Structural Geology, Geochemistry
Advocates: Patricia Persaud; Jolante van Wijk; Abah Omale; Jackson Stone Borchardt

This cross-disciplinary session on extensional systems welcomes presentations on structure, geochemistry, geophysics, geomorphology, hazards, and modeling that aim to understand linkages and feedbacks between processes and hazards in the solid Earth, hydrosphere, and atmosphere.

HYDROGEOLOGY

T47. **A Showcase of Undergraduate Research in Hydrogeology (Posters)**

Endorsers: *GSA Hydrogeology Division; GSA Karst Division; Council on Undergraduate Research Geosciences Division*
Discipline: Hydrogeology
Advocates: Miguel Valencia; Jacob Clyne; Samuel Smidt; Tyler V. King; Laura Rademacher

This session is designed for undergraduates presenting research and senior theses in the field of hydrogeology. Prizes will be awarded for top presentations. Employers and graduate advisers are encouraged to attend.

T48. **Addressing Complex Problems in Hydrogeology with Big Data and Machine Learning**

Endorsers: *GSA Hydrogeology Division; GSA Karst Division; GSA Geoinformatics and Data Science Division*
Disciplines: Hydrogeology, Environmental Geoscience, Karst
Advocates: Paul E. Stackelberg; Kenneth Belitz; Mason Stahl; James J. Butler Jr.

Big data and machine learning can address complex problems in hydrogeology that previously were intractable due to computational and data limitations. Presentations will demonstrate the use of big data and machine learning in overcoming these constraints.

T49. **Advances in Understanding Processes at or Near the Groundwater–Surface Water Interface**

Endorser: *GSA Karst Division*
Discipline: Hydrogeology
Advocates: Corey D. Wallace; Mohamad Reza Soltanian; Bhavna Arora; Daniele Tonina

This session will convey new insights on processes at/near the interface between groundwater and surface water, including fluid, nutrient fluxes, and biogeochemical processes. Field and lab studies, analysis, and computational research will be included.

T50. **Arsenic, Fluoride, and Other Geogenic Contaminants in Groundwater Basins: Linking Advances in Natural Sciences and Applications of Artificial Intelligence and Data Science for Long-Term Risk Prediction and Policy Interventions**

Endorsers: *GSA Hydrogeology Division; GSA International; GSA Geology and Health Division; International Society of Groundwater for Sustainable Development (ISGSD); International Water Association Specialist Group; Metals and Related Substances in Drinking Water (METRELS); Geochemical Society; GSA Environmental and Engineering Geology Division; GSA Geoinformatics and Data Science Division*
Disciplines: Hydrogeology, Geology and Health, Geoscience and Public Policy
Advocates: Prosun Bhattacharya; Abhijit Mukherjee; Arslan Ahmad; Saugata Datta; Joseline Tapia Zamora; Brady Ziegler

The growing trend of data aggregation in recent years enables us to consolidate our understandings through machine learning on the specificities of groundwater basins in terms of qualitative perspective for direct consumption and/or treatment for groundwater supplies.

T51. **Basic Data Innovations in Hydrogeological Investigations**

Endorsers: *GSA Hydrogeology Division; GSA Environmental and Engineering Geology Division; GSA Karst Division; GSA Geoinformatics and Data Science Division*
Disciplines: Hydrogeology, Environmental Geoscience, Karst
Advocates: Abraham E. Springer; William Cunningham

In a hydrogeological work world increasingly dominated by models, basic data are still required to understand and constrain the framework of hydrogeologic systems. Presentations showcasing innovations in basic hydrogeological data measurement and collection are encouraged.

T52. **Coastal and Marine Hydrogeology in an Age of Rising Seas: From the Shore to the Oceanic Ridge**

Endorsers: *GSA Hydrogeology Division; GSA Environmental and Engineering Geology Division; GSA Geobiology and Geomicrobiology Division; GSA Geoinformatics and Data Science Division; GSA Marine and Coastal Geoscience Division; GSA Geophysics and Geodynamics Division; GSA Geology and Society Division; GSA Karst Division; GSA Quaternary Geology and Geomorphology Division; GSA Soils and Soil Processes Division; National Ground Water Association; Soil Science Society of America; International Association of Hydrogeologists; Consortium of Universities for the Advancement of Hydrologic Science Inc. (CUAHSI); American Geophysical Union–Hydrology Division*
Disciplines: Hydrogeology, Marine/Coastal Science, Engineering Geology
Advocates: Michael C. Sukop; Christopher Russoniello; Kevin M. Befus; Martina Rogers; Barret Kurylyk; Shellie Habel

As sea levels rise, coastal and marine hydrogeology are crucial. Seawater intrusion can impact water supplies, and water-table rise affects flooding and infrastructure. The focus in this session will be on climate change, submarine groundwater discharge, benthic exchange, and biogeochemistry.

T53. **Geochemical Approaches in Advanced Water Purification and Desalination**

Endorsers: *GSA Hydrogeology Division; GSA Environmental and Engineering Geology Division; GSA Karst Division; Geochemical Society*
Disciplines: Hydrogeology, Geochemistry, Geomicrobiology
Advocates: Harshad Kulkarni; Drew Johnson; Keisuke Ikehata; Mohammad Alauddin; Saugata Datta

This session will enhance our understanding of geochemical processes involved in the treatment (advanced purification and desalination) of relatively untapped water resources such as ocean water, wastewater, and brackish and saline groundwater.

T54. **Geology, Hydrogeology, and Hydrochemistry of Non-Traditional Basin Resources**

Endorsers: *GSA Hydrogeology Division; GSA Energy Geology Division; Geochemical Society*
Disciplines: Hydrogeology, Geochemistry, Energy Geology
Advocates: Benjamin Rostron; Gavin Jensen; Leslie J. Robbins

We welcome presentations on non-traditional resources in basins: geothermal energy; economic minerals; helium; carbon capture, utilization, and storage; water source/disposal; or others. Talks could include theoretical or case studies on origin, mapping, evaluation, and utilization of the subsurface.

T55. **Hydrological Modeling in Complex Geology**

Endorser: *GSA Hydrogeology Division*
Disciplines: Hydrogeology, Environmental Geoscience
Advocates: Stephen B. Gingerich; Tracie Jackson; Joseph Kennedy

This session will address the application of computational methods to predict groundwater movement through complex geological frameworks.

T56. **Potential Impacts of Oil and Gas Exploration, Development, and Transport on Groundwater Resources**

Endorser: *GSA Energy Geology Division*
Disciplines: Hydrogeology, Geochemistry, Environmental Geoscience
Advocate: Nicholas Utting

This session will explore potential impacts on groundwater resources from oil and gas exploration, development, and transport.

T57. **Secured Groundwater toward a Sustainable Earth**

Endorsers: *GSA Hydrogeology Division; GSA Geology and Society Division; GSA Environmental and Engineering Geology Division; GSA Geoinformatics and Data Science Division; GSA Geology and Health Division; GSA International; International Association of Hydrogeologists; International Society of Groundwater for Sustainable Development (ISGSD); Groundwater Solutions Initiative for Policy and Practice (GRIPP); GSA Karst Division*
Disciplines: Hydrogeology, Environmental Geoscience, Geoscience and Public Policy
Advocates: Abhijit Mukherjee; Alice Aureli; Prosun Bhattacharya; Karen Villholth; Alan MacDonald; Roger Sathre

We welcome interdisciplinary studies that bridge the knowledge of groundwater resources to solutions and sustainability, from science to policy, and from technology to clean water and food, through pathways of transforming groundwater knowledge to policy and governance

T58. **Water Storage and Transit in Bedrock and Implications for Critical Zone Evolution, Stream Chemistry, Climate, and Ecosystems**

Endorsers: *GSA Quaternary Geology and Geomorphology Division; GSA Karst Division; GSA Geology and Society Division; GSA Soils and Soil Processes Division*
Disciplines: Hydrogeology, Geomorphology, Environmental Geoscience
Advocates: Jill Marshall; David Vinson; Daniella M. Rempe

Bedrock weathering creates a porous and permeable region for water exchange with the atmosphere, aquifers, and streams. This session welcomes studies across disciplines focused on linking bedrock weathering with water in the Critical Zone.

KARST

T59. **Effects of Carbonate Minerals on Critical Zone Characteristics and Processes**

Endorsers: *GSA Karst Division; GSA Hydrogeology Division; National Cave and Karst Research Institute; Karst Waters Institute*
Disciplines: Karst, Hydrogeology, Environmental Geoscience
Advocates: Jonathan B. Martin; Matthew D. Covington; Laura Toran; Pamela Sullivan; Jennifer L. Macalady

Distinct carbonate and silicate mineral properties (e.g., reaction rates, dissolution mechanisms) drive fundamental differences in critical zone characteristics and processes. This session aims to explore how mineralogical compositions affect critical zone processes.

T60. **Geoarchaeology of Underwater Caves**

Endorsers: *GSA Karst Division; GSA Geoarchaeology Division*
Disciplines: Karst, Geoarchaeology, Quaternary Geology
Advocates: Eduard G. Reinhardt; Matthew Peros

Karst cave deposits provide unique paleontological and archaeological evidence of prehistoric life and environment of the Quaternary. This session will highlight the latest paleo-environmental techniques for understanding site formation processes in the phreatic cave environment.

T61. **Karst Ecosystems and Biogeochemistry**

Endorsers: *GSA Karst Division; GSA Environmental and Engineering Geology Division; GSA Geobiology and Geomicrobiology Division; GSA Hydrogeology Division; National Cave and Karst Research Institute; Karst Waters Institute*
Disciplines: Karst, Geomicrobiology, Geochemistry
Advocates: Daniel Jones; Patricia N. Kambesis

This session seeks abstracts that deal with the study of cave and karst ecosystems, including the identification, quantification, and/or discussion of biota, flora, microbial, and related biogeochemical processes or environments in or near karst features.

T62. **Karst Hazards and Monitoring**

Endorsers: *GSA Karst Division; GSA Environmental and Engineering Geology Division; GSA Geophysics and Geodynamics Division; National Cave and Karst Research Institute; Karst Waters Institute; Geochemical Society*
Disciplines: Karst, Engineering Geology
Advocates: Daniel Jones; Patricia N. Kambesis

This session will cover hazards (sinkholes, groundwater pollution, radon, development, urbanization) and monitoring approaches (data collection, data logging, GIS applications, historical data analyses) in karst landscapes, including technical applications (e.g., LiDAR, 3D scanning, geodatabase development) and management implications (resource management, education, policy, regulation).

T63. **Karst Hydrology and Hydrogeology**

Endorsers: *GSA Karst Division; GSA Environmental and Engineering Geology Division; GSA Hydrogeology Division; National Cave and Karst Research Institute; Karst Waters Institute; Geochemical Society*
Disciplines: Karst, Hydrogeology
Advocates: Daniel Jones; Patricia N. Kambesis

This session will include abstracts themed around the fundamental aspects of fluid-rock interactions within karst landscapes, including geologic, hydrogeologic, and hydrologic investigations. Appropriate topics range from dye tracing and aquifer processes to surface-subsurface hydrologic interactions and quantitative modeling.

T64. **Karst Processes and Speleology**

Endorsers: *GSA Karst Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Quaternary Geology and Geomorphology Division; National Cave and Karst Research Institute; Karst Waters Institute; Geochemical Society*
Disciplines: Karst, Geomorphology, Geochemistry
Advocates: Daniel Jones; Patricia N. Kambesis

This session covers the myriad of cave and karst forming processes, geomorphic evolution of karst landscapes, and cave-system development, including geochemical, morphological, and cave survey studies. Carbonate weathering, diagenesis, hypogene processes, carbonate mineralogy, structural controls, and other related topics are included.

T65. **Karst Sedimentary, Paleoclimate, and Historical Records**

Endorsers: *GSA Karst Division; GSA Geochronology Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Quaternary Geology and Geomorphology Division; National Cave and Karst Research Institute; Karst Waters Institute; Geochemical Society*
Disciplines: Karst, Stratigraphy, Paleoclimatology/Paleoceanography
Advocates: Daniel Jones; Patricia N. Kambesis

Cave deposits (sediments, speleothems, tufa, etc.), karst environmental records (sedimentary, underwater deposits, carbonate stratigraphy, etc.), and geoarchaeological and historical investigations to reconstruct or interpret past climates, landscapes, extreme events, land-use histories, and similar phenomena and model or predict future changes.

T66. **New Frontiers in Cave and Karst Research: In Honor of the International Year of Caves and Karst**

Endorsers: *GSA Karst Division; GSA Geochronology Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Quaternary Geology and Geomorphology Division; GSA Hydrogeology Division; GSA Environmental and Engineering Geology Division; GSA Geophysics and Geodynamics Division; GSA Geobiology and Geomicrobiology Division; National Cave and Karst Research Institute; Karst Waters Institute*
Disciplines: Karst, Hydrogeology, Environmental Geoscience
Advocates: Daniel Jones; Rachel Bosch; Ellen K. Herman; Patricia N. Kambesis; Lewis Land; Andrew Luhmann; Jason Polk; Benjamin W. Tobin

We encourage submissions in any field of cave and karst science, with special emphasis on novel techniques, interdisciplinary approaches, and contributions from diverse early-career researchers (students, postdocs, and faculty).

T67. **Pseudo-Karst Processes and Features**

Endorsers: *GSA Karst Division; GSA Quaternary Geology and Geomorphology Division; National Cave and Karst Research Institute; Karst Waters Institute*
Disciplines: Karst, Geomorphology

Advocates: Daniel Jones; Patricia N. Kambesis

This session addresses origin, development, depositional processes, biogeology, and management of landscapes and features that morphologically or in other ways resemble karst; examples include caves formed by wave action, fracturing, gravitation movement, melting or cooling of materials, and exotic chemistries.

LIMNOGEOLOGY

T68. **Lacustrine Systems around the World**

Endorsers: *GSA Limnogeology Division; GSA Geobiology and Geomicrobiology Division; GSA Continental Scientific Drilling Division; GSA Geochronology Division; GSA Marine and Coastal Geoscience Division; GSA Quaternary Geology and Geomorphology Division; American Quaternary Association; International Association of Limnogeology; SEPM (Society for Sedimentary Geology); Paleontological Society; GSA Sedimentary Geology Division*

Disciplines: Limnogeology, Paleoclimatology/Paleoceanography, Stratigraphy

Advocates: Scott Starratt; Bailee N. Hodelka

Lakes contain important historical records as their sediments are archives of climate change, local human impact, and ecological succession. This session explores lacustrine research across the globe.

T69. **Out of This World Lakes**

Endorsers: *GSA Limnogeology Division; GSA Planetary Geology Division; GSA Quaternary Geology and Geomorphology Division; SEPM (Society for Sedimentary Geology); Geochemical Society; GSA Geobiology and Geomicrobiology Division*

Discipline: Limnogeology

Advocates: Kathleen C. Benison; Brenda B. Bowen; Johan C. Varekamp

This session seeks current studies of the sedimentology, mineralogy, geochemistry, and/or habitability of lakes on Mars and other planets and moons in the Solar System, as well as extreme terrestrial lakes that serve as analogs for extraterrestrial lakes.

T70. **The Diversity of Cenozoic Western North American Lakes**

Endorsers: *GSA Limnogeology Division; GSA Geobiology and Geomicrobiology Division; GSA Continental Scientific Drilling Division; GSA Geochronology Division; GSA Marine and Coastal Geoscience Division; GSA Quaternary Geology and Geomorphology Division; American Quaternary Association; International Association of Limnogeology; SEPM (Society for Sedimentary Geology); Paleontological Society; GSA Sedimentary Geology Division*

Disciplines: Limnogeology, Stratigraphy, Continental Scientific Drilling

Advocates: Scott Starratt; Michael R. Rosen

Lakes have played an important role in the economic and cultural history of western North America. This session will bring together geological, biological, and modeling research on modern lakes and lacustrine deposits across the region.

MARINE/COASTAL SCIENCE

T71. **Advances and New Voices in Marine and Coastal Geoscience**

Endorsers: *GSA Marine and Coastal Geoscience Division; GSA Geology and Society Division*

Disciplines: Marine/Coastal Science

Advocates: Rónadh Cox; Deirdre Ryan; Stephen C. Phillips

Marine and coastal geoscience embraces many topics. We are seeking abstracts on physical oceanography, marine geology, geomorphology, sediment transport, marine geophysics, tectonic processes, glaciology, climate change, marine paleobiology, or any aspect of the oceans and coasts.

T72. **Coastal Geoscience: Working Together to Understand Coastal Impact of Climate Change**

Endorsers: *GSA Marine and Coastal Geoscience Division; GSA Geology and Society Division*

Disciplines: Marine/Coastal Science, Geoscience and Public Policy, Environmental Geoscience

Advocates: Robert Weiss; Rónadh Cox

Understanding climate-change impacts in coastal zones requires interdisciplinary understanding of the human-natural system. We welcome abstracts covering geoscience, engineering, and/or the social/political sciences to provide perspectives on coastal complexity and increasing coastal resilience.

T73. **Coastal Storm Impacts in Times of Changing Climate and Sea Levels: Geological Records, Historic Perspectives, and Forecasting**

Endorsers: *GSA Marine and Coastal Geoscience Division; GSA Quaternary Geology and Geomorphology Division; Eastern Section of the Society for Sedimentary Geology (ES-SEPM); GSA Geology and Society Division; GSA Sedimentary Geology Division; GSA Environmental and Engineering Geology Division*

Disciplines: Marine/Coastal Science

Advocates: Bosiljka Glumac; Michael Savarese

Storm impacts on coastal areas globally will be addressed in relation to climate and sea-level trends, along with exploring usefulness of multiple perspectives from the geologic record

INDUSTRY TRACKS

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

Economic Geology | Energy | Engineering | Hydrogeology and Environmental Geology

and storm-activity observations for refining predictive models and informing mitigation and adaptation efforts.

T74. **Geoscience Approaches to Interpreting Coastal Records of Earthquakes, Tsunamis, and Storms**

Endorsers: *GSA Quaternary Geology and Geomorphology Division; GSA Marine and Coastal Geoscience Division; GSA Structural Geology and Tectonics Division*
Disciplines: Marine/Coastal Science, Geomorphology, Tectonics/Tectonophysics
Advocates: Isabel Hong; Tina Dura; Frances R. Griswold; Breanyn MacInnes

The session highlights advancements across a range of methods aimed at identifying and characterizing event deposits, including earthquakes, tsunamis, and storms, in coastal environments.

T75. **Methane in Marine and Coastal Geological Systems**

Endorsers: *GSA Marine and Coastal Geoscience Division; GSA Sedimentary Geology Division; GSA Geobiology and Geomicrobiology Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Geophysics and Geodynamics Division; GSA Energy Geology Division*
Disciplines: Marine/Coastal Science, Geochemistry, Geophysics/Geodynamics
Advocates: Stephen C. Phillips; Jeanine Ash; Joel E. Johnson; Kehua You

Methane is an important molecule in Earth's biogeochemical and climate cycles. We welcome submissions related to methane generation, migration, phase transitions (hydrates), and consumption in modern or paleo-marine sedimentary or crustal environments, nearshore or offshore.

T76. **Sea-Level Indicators: New Interpretations and Constraints for Future Projections**

Endorsers: *GSA Marine and Coastal Geoscience Division; GSA Quaternary Geology and Geomorphology Division; GSA Environmental and Engineering Geology Division; GSA Geology and Society Division; GSA Sedimentary Geology Division*
Disciplines: Marine/Coastal Science, Geomorphology, Sediments, Carbonates
Advocates: Deirdre Ryan; Nicole Khan; Erica Ashe; Jessica Creveling

Well-constrained sea-level indicators are critical to understand past, present, and future global and regional sea-level variability. This session showcases state-of-the-art methods describing and constraining sea-level indicators, and their value for improving sea-level modeling and projections.

T77. **Subduction Top to Bottom (ST2B-2), Histories and Processes at Modern and Ancient Convergent Margins**

Endorser: *GSA Marine and Coastal Geoscience Division*
Disciplines: Marine/Coastal Science
Advocates: David Scholl; Gray E. Bebout; Robert Stern

The Subduction Top to Bottom (ST2B) session is intended to provide a forum for the presentation of oral papers and posters addressing multi-thematic issues in subduction zone processes and histories.

PALEOCLIMATOLOGY/PALEOCEANOGRAPHY

T78. **Co-Evolution of Earth's Surface Environment and Eukaryotic Life after the Great Oxidation Event**

Disciplines: Paleoclimatology/Paleoceanography, Paleontology, Diversity, Extinction, Origination, Geochemistry
Advocates: Alexandra Kunert; Xinze Lu

This session will focus on multidisciplinary (e.g., organic and inorganic geochemistry, sedimentology, paleontology, numerical modeling) approaches of reconstructing the co-evolutionary path of Earth's environment and eukaryotic life following the Great Oxidation Event.

T79. **Comings and Goings of Proterozoic Global Glaciations**

Endorser: *Geochemical Society*
Disciplines: Paleoclimatology/Paleoceanography, Paleontology, Diversity, Extinction, Origination, Geochemistry
Advocates: Bing Shen; Maoyan Zhu; Xianguo Lang

This session focuses on global glaciations and geology-geobiology in the Proterozoic.

T80. **Foraminiferal Signals of Major Events in Mesozoic–Cenozoic Earth History**

Endorsers: *Cushman Foundation; Paleontological Society; Paleontological Research Institution; GSA Marine and Coastal Geoscience Division; Geochemical Society; GSA Sedimentary Geology Division*
Disciplines: Paleoclimatology/Paleoceanography, Paleontology, Diversity, Extinction, Origination, Paleontology, Phylogenetic/Morphological Patterns
Advocates: Kenneth Miller; Miriam E. Katz; Megan Fung

Benthic and planktonic foraminiferal indicators of major milestones in Mesozoic–Cenozoic Earth history: biostratigraphic, paleoecologic, and geochemical evidence (Cushman Foundation for Foraminiferal Research Symposium).

T81. **Impacts of Volcanism on Global Climate and Oceans—Drivers of Mass Extinctions through the Phanerozoic**

Endorsers: *GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Geobiology and Geomicrobiology Division; GSA Marine and Coastal Geoscience Division; U.S. Paleontology and Sedimentology; Geochemical Society; Paleontological Society*
Disciplines: Paleoclimatology/Paleoceanography
Advocates: Stephen E. Grasby; Gerta Keller; David Bond; Thierry Adatte

This session examines how major volcanic eruptions impact global environments and biogeochemical cycles, driving mass extinction and ocean anoxic events throughout the Phanerozoic, and examines the fingerprints such eruptions leave in the sedimentary record.

T82. **Integrative Approaches to Understanding Mesozoic Environmental and Biologic Perturbations**

Endorser: *GSA Geobiology and Geomicrobiology Division*
Disciplines: Paleoclimatology/Paleoceanography
Advocates: Selva M. Marroquin; Benjamin C. Gill

This session highlights integrative approaches to understanding Mesozoic biotic, environmental, and climatic change. The goal is to foster interactions between specialists to provide a more holistic understanding of outstanding questions about Mesozoic Earth system dynamics.

PALEONTOLOGY

T83. **Future Leaders in Paleontology**

Endorser: *Paleontological Society*
Disciplines: Paleontology, Biogeography/Biostratigraphy, Paleontology, Diversity, Extinction, Origination, Paleontology, Paleoecology/Taphonomy
Advocate: Matthew Clapham

This session will showcase outstanding research by student members of the Paleontological Society, spanning all disciplines of paleontology.

T84. **Cephalopods Present and Past: Evolution, Paleoecology, and Links to Paleoenvironmental Change**

Endorsers: *Paleontological Society; Paleontological Research Institution; GSA Geobiology and Geomicrobiology Division*
Disciplines: Paleontology, Diversity, Extinction, Origination, Paleontology, Paleoecology/Taphonomy, Paleontology, Biogeography/Biostratigraphy
Advocates: Christopher D. Whalen; Corinne Myers; James Witts

This session will feature the latest research on fossil and modern cephalopods, including cephalopod paleobiology, evolution, and the use of cephalopods in paleoenvironmental reconstruction.

T85. **In Memory of Joanne Kluessendorf: The Winifred Goldring Award and the Promise of Women in Paleontology**

Endorsers: *Association for Women Geoscientists; Paleontological Society; Paleontological Research Institution*
Disciplines: Paleontology, Diversity, Extinction, Origination
Advocates: Patricia Kelley; René A. Shroat-Lewis

Joanne Kluessendorf encouraged female participation in the geosciences, founding the Winifred Goldring Award for promising women paleontology students. This session in her memory highlights women's current (and anticipated) contributions to paleontology, especially by Goldring recipients.

T86. **New Insights on Arthropod Paleobiology**

Endorser: *Paleontological Society*
Disciplines: Paleontology, Diversity, Extinction, Origination
Advocates: Matthew Witte; Rhiannon LaVine; Julien Kimmig; James C. Lamsdell

For more than 540 million years, arthropods have remained an important and diverse group of marine invertebrates, whose abundance in the fossil record have shaped our modern understanding the processes of evolution, diversification, morphology, and more.

T87. **New Perspectives on Phanerozoic Mass Extinctions and Environmental Perturbations**

Endorsers: *GSA Geobiology and Geomicrobiology Division; Paleontological Research Institution; Paleontological Society; GSA Marine and Coastal Geoscience Division*
Disciplines: Paleontology, Diversity, Extinction, Origination, Paleontology, Paleoecology/Taphonomy, Paleoclimatology/Paleoceanography
Advocates: Ekaterina Larina; Bethany J. Allen; James D. Witts; Rowan Whittle

This session will highlight research employing a multidisciplinary approach to better understand patterns, drivers, and biological response behind mass extinction events and other major environmental perturbation events across the Phanerozoic.

T88. **Putting the Clocks Forward: Latest Advances in Heterochrony and Developmental Bias in Deep Time**

Disciplines: Paleontology, Diversity, Extinction, Origination, Paleontology, Phylogenetic/Morphological Patterns
Advocates: Anieke Brombacher; Katie Collins

Developmental processes are hypothesized to be a major driver of evolutionary innovation, but empirical data remain scarce. This session will bring together the latest advances in our understanding of developmental processes in deep time.

T89. **The Evolution of Early Phanerozoic Oceans: A Geobiological Perspective**

Endorsers: *Paleontological Society; GSA Geobiology and Geomicrobiology Division; GSA Marine and Coastal Geoscience Division; Geochemical Society*
Disciplines: Paleontology, Diversity, Extinction, Origination
Advocates: Pedro Monarrez; Joshua Zimmt; Richard Stockey

This session will highlight recent advancements among a diverse set of disciplines (e.g., paleobiology, ecophysiology, geochemistry, paleoceanography) that seek to understand the various factors influencing early animal evolution spanning the latest Neoproterozoic to the Ordovician.

T90. **Biotic Interactions through Time**

Endorsers: *Paleontological Society; German Research Foundation (DFG); GSA Marine and Coastal Geoscience Division*
Disciplines: Paleontology, Paleoecology/Taphonomy, Paleontology, Diversity, Extinction, Origination, Paleontology, Phylogenetic/Morphological Patterns
Advocates: Tobias Grun; Elizabeth Petsios

This session is dedicated to any aspects of evolutionary history of biotic interactions. We aim to promote an interdisciplinary exchange of data, methods, and knowledge pertaining to interactions between organisms over evolutionary time scales.

T91. **Community Ecology and the Fossil Record: Diversity, Ecological Structure, and Paleoenvironmental Responses**

Endorser: *Paleontological Society*
Disciplines: Paleontology, Paleoecology/Taphonomy
Advocates: Karma Nanglu; Thomas M. Cullen

This session reports on new research relating to the structure and dynamics of paleo-communities and how data from these systems informs on a broad array of ecological and evolutionary mechanisms and questions.

T92. **From the Burgess Shale to the Manis Mastodon: 500 Million Years of Environmental & Evolutionary Change in the Great Northwest**
Endorsers: *Paleontological Society; GSA Geochronology Division*
Disciplines: Paleontology, Paleoecology/Taphonomy, Paleontology, Biogeography/Biostratigraphy, Paleoclimatology/Paleoceanography
Advocates: John D. Orcutt; Lindsay A. MacKenzie; Caroline A.E. Stromberg

This session will explore the natural paleobiological laboratory that is northwestern North America. We welcome submissions focused on northwest fossils and localities, the paleoecological and geological framework that augments our understanding of them, and their educational use.

T93. **Stratigraphy, Stasis, and Shales: A Celebration of the Careers of Carlton Brett and Gordon Baird**
Endorsers: *Paleontological Society; GSA Energy Geology Division*
Disciplines: Paleontology, Paleoecology/Taphonomy
Advocates: Alex J. Bartholomew; Jocelyn A. Sessa

This session spotlights the contributions of Carlton and Gordon to stratigraphy, taxonomy, taphonomy, paleoecology, and biofacies tracking, with an emphasis on field-intensive studies. Contributions on these topics are welcome to celebrate their outstanding careers.

T94. **The Neoproterozoic Earth-Life System**
Endorsers: *GSA Geobiology and Geomicrobiology Division; Paleontological Society; SEPM (Society for Sedimentary Geology)*
Disciplines: Paleontology, Paleoecology/Taphonomy, Paleoclimatology/Paleoceanography, Geochemistry
Advocates: Qing Tang; Morrison Nolan; Junyao Kang; Scott D. Evans

This session aims to boost discussions and interdisciplinary collaborations for a better understanding of the Neoproterozoic Earth and life co-evolution. We welcome inputs from paleontologists, geochemists, sedimentologists, earth-system modelers, and more.

T95. **Advances in Virtual Paleontology: Applications, Digitization, and Dissemination**
Endorsers: *Paleontological Society; GSA Geoinformatics and Data Science Division*
Disciplines: Paleontology, Phylogenetic/Morphological Patterns, Paleontology, Paleoecology/Taphonomy, Geoscience Education
Advocates: Sarah M. Jacquet; Tara Selly; James Schiffbauer

This session will showcase research employing advanced imaging techniques (tomographic and surface-based) that further our understanding of palaeobiological behavior, structure, and function; taphonomy; evolutionary biology; and virtual collections management.

T96. **Phylogenetic Paleobiology: Combining Evolutionary Trees and Fossils to Understand the Evolution of Life**
Endorsers: *Paleontological Society; Paleontological Research Institution; GSA Geobiology and Geomicrobiology Division; GSA Geoinformatics and Data Science Division*
Disciplines: Paleontology, Phylogenetic/Morphological Patterns
Advocates: William Gearty; Curtis R. Congreve; James C. Lamsdell

This session will highlight recent advances integrating phylogenetics with fossil data to address evolutionary and ecological questions through deep time. Topics include, but are not limited to, macroevolutionary trends, diversification dynamics, trait evolution, and paleobiogeography.

SEDIMENTS, CARBONATES

$ T97. **Toward Unravelling the Dolomite Problem: New Approaches and Novel Perspectives**
Endorsers: *Mineralogical Society of America; GSA Karst Division*
Disciplines: Sediments, Carbonates, Geochemistry, Geomicrobiology
Advocates: Bing Shen; Meng Ning; Ruimin Wang

This session provides a platform to communicate progress in dolomite studies with applications of diverse sedimentological, geochemical, numerical modeling, and experimental approaches and to share novel ideas toward understanding the dolomite problem.

SEDIMENTS, CLASTIC

$ T98. **Applying Integrated Sedimentology and Ichnology to Refine Paleoenvironmental Interpretations, Identify Paleosalinities, and Reveal Key Sequence Stratigraphic Surfaces along Complex Coastlines**
Endorser: *GSA Marine and Coastal Geoscience Division*
Disciplines: Sediments, Clastic, Paleontology, Diversity, Extinction, Origination, Stratigraphy
Advocates: Peter Flaig; Murray Gingras; Janok P. Bhattacharya

We showcase innovative, integrative sedimentologic, ichnologic, and stratigraphic research that seeks to refine paleoenviromental interpretations, clarify paleosalinity trends, groundwater profile reconstructions, or develop an improved sequence stratigraphic framework.

T99. **Insights into Cordilleran Tectonics and Magmatism from the Sedimentary Record**
Endorsers: *GSA Structural Geology and Tectonics Division; GSA Sedimentary Geology Division; Geochemical Society*
Disciplines: Sediments, Clastic
Advocates: Richard M. Gaschnig; Kathleen Surpless

This session aims to highlight new insights into the development and evolution of the North American Cordillera from the study of the sedimentary record, with particular emphasis on provenance.

STRATIGRAPHY

T100. **The Inception, Heyday, and Demise of Forearc Basins in Nature and Models across Spatio-Temporal Scales**
Endorsers: *GSA Continental Scientific Drilling Division; GSA Geochronology Division; GSA Marine and Coastal Geoscience Division; GSA Structural Geology and Tectonics Division; GSA Geoinformatics and Data Science Division; GSA Sedimentary Geology Division*
Disciplines: Sediments, Clastic, Tectonics/Tectonophysics, Continental Scientific Drilling
Advocates: Megan Mueller; Devon Orme; Harold Tobin

This session highlights the sedimentary evolution of forearc regions. We welcome research that characterizes long-term forearc basin processes using field observations, stratigraphy, subsurface and seismic data, geo-thermochronologic analyses, and numerical and analogue modeling.

T101. **Broken Paradigms: Shallow-Water Deposition of Organic-Rich Facies through Earth History**

Endorsers: *GSA Marine and Coastal Geoscience Division; GSA Geobiology and Geomicrobiology Division; Geochemical Society; GSA Sedimentary Geology Division; GSA Energy Geology Division*
Discipline: Stratigraphy
Advocates: Ed Landing; Langhorne B. Smith; Brian R. Pratt

New work is supplanting traditional deep marine (preservational, Black Sea) and upwelling (productivity) models for black shale/organic-rich facies. More commonly, these facies show shallow, restricted marine, low-oxygen epeiric sea deposition through Earth's history.

T102. **Correlation of Global Stages, Series, and Systems into North American Stratigraphic Successions**

Endorsers: *SEPM (Society for Sedimentary Geology); North American Commission on Stratigraphic Nomenclature (NACSN); International Commission on Stratigraphy (ICS)*
Discipline: Stratigraphy
Advocates: Richard Fluegeman; Stanley C. Finney; David A.T. Harper; Carlton E. Brett

Eighty-eight percent of global stratotype section and points (GSSPs) are in stratigraphic successions outside of North America. The proposed session will demonstrate the system-by-system correlation of the GSSPs and the units they define into the stratigraphic successions of North America.

T103. **Sedimentary Geology Division/SEPM Student Research Poster Competition: Dynamics of Stratigraphy and Sedimentation (Posters)**

Endorsers: *GSA Sedimentary Geology Division; SEPM (Society for Sedimentary Geology); GSA Energy Geology Division*
Disciplines: Stratigraphy, Sediments, Clastic, Sediments, Carbonates
Advocates: Brian Hampton; Amy L. Weislogel

Students (at any level) may present posters of original research on any topics within sedimentary geology: carbonates, clastics, chemical sediments, ancient and/or modern systems. Posters are judged for monetary awards distributed at the "Seds and Suds" reception.

CONTINENTAL SCIENTIFIC DRILLING

T104. **Neogene and Quaternary Environmental Change in the Tropics: Recent Advances and Future Opportunities**

Endorsers: *GSA Continental Scientific Drilling Division; GSA Limnogeology Division; GSA Quaternary Geology and Geomorphology Division; GSA Geobiology and Geomicrobiology Division; Geochemical Society*
Disciplines: Continental Scientific Drilling, Paleoclimatology/Paleoceanography, Quaternary Geology
Advocates: Paul Baker; James M. Russell

This session explores the Neogene and Quaternary history of tropical Africa, South America, Asia, Australia, and the surrounding oceans to evaluate patterns and mechanisms of tropical environmental change.

T105. **Reading the Record of Volcanic Tephra and Tuff in Geoarchaeological Site Studies and Drill Core Records**

Endorsers: *GSA Geoarchaeology Division; GSA Mineralogy, Geochemistry, Petrology and Volcanology Division*
Disciplines: Continental Scientific Drilling, Geoarchaeology, Volcanology
Advocates: Jayde Hirniak; Marie D. Jackson

This session involves investigations of tephra and tuff in drill cores, sediment cores, and outcrops and their applicability to geoarchaeological studies, specifically, in archaeological materials, tephrochronology, paleoanthropology, and the synchronization of paleoenvironmental records.

MINERALOGY/CRYSTALLOGRAPHY

T106. **Gemological Research in the 21st Century—Gem Minerals and Localities**

Endorsers: *Gemological Institute of America; Mineralogical Society of America; Society of Economic Geologists*
Disciplines: Mineralogy/Crystallography, Economic Geology, Geoscience Information/Communication
Advocates: James Shigley; Wuyi Wang; Barbara Dutrow; John W. Valley; Caroline Nelms

Gemstones are among the most recognized of all minerals. This session focuses on diverse aspects of gems including exploration, deposits and their formation, and identification, as well as mineral inclusions in gems and their geological implications.

T107. **Volatile Cycles from Earth's Surface to the Core: In Honor of 2020 Mineralogical Society of America Medalist Jin Liu**

Endorsers: *Mineralogical Society of America; High Pressure Science & Technology Advanced Research (HPSTAR); GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; Geochemical Society*
Disciplines: Mineralogy/Crystallography
Advocate: Ho-kwang Mao

Recent advances in mineral physics have revealed a number of unexpected transitions and phenomena, such as super-oxidation

INDUSTRY TRACKS

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

Economic Geology | Energy | Engineering | Hydrogeology and Environmental Geology

and super-ionization in volatile-bearing minerals that lead to paradigm change in our understanding of volatile cycles.

T108. **Young Investigators in Mineralogy and Crystallography**

Endorsers: *Mineralogical Society of America; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division*
Disciplines: Mineralogy/Crystallography
Advocates: Tyler L. Spano; Si Athena Chen

This session provides a platform for early-career mineralogists and crystallographers to share research. Early-career, postdoctoral, and student researchers are encouraged to submit abstracts and provide fresh perspectives, new ideas, and creative answers to mineralogical problems.

PRECAMBRIAN GEOLOGY

T109. **Life's Innovations from the Early Earth to the Search on Modern Mars: Honoring the Career of Andrew H. Knoll**

Endorsers: *Paleontological Society; GSA Geobiology and Geomicrobiology Division; GSA Planetary Geology Division; GSA Sedimentary Geology Division; SEPM (Society for Sedimentary Geology); Geochemical Society*
Discipline: Precambrian Geology
Advocates: Julie K. Bartley; C. Kevin Boyce; Linda C. Kah; Alan J. Kaufman; Shuhai Xiao

The modern sweep of geobiology will be covered, from the emergence of Precambrian microbial metabolisms through eukaryotic evolution and the Cambrian Explosion to the influence of the Phanerozoic biota on global cycles to martian exploration.

PLANETARY GEOLOGY

T110. **Best Practices and Exciting Discoveries in Identifying, Mapping, and Analyzing Planetary Landforms and Terrestrial Analogues**

Endorser: *GSA Planetary Geology Division*
Disciplines: Planetary Geology, Geoscience Education
Advocate: Kelsey Crane

We welcome abstracts that investigate the methodology of planetary and terrestrial landform analysis or that explore these methodologies as a means of achieving insight into the evolution of those landforms.

T111. **Exploring Small Bodies throughout the Solar System**

Endorser: *GSA Planetary Geology Division*
Disciplines: Planetary Geology, Geomorphology, Structural Geology
Advocates: Jennifer E.C. Scully; Kynan H.G. Hughson; Debra Buczkowski

We welcome abstracts about the geological, geophysical, and/or geochemical analysis of rocky and icy small worlds through the use of spacecraft data, telescopic observations, modeling studies, laboratory studies, astromaterial studies, comparative studies, and/or future exploration.

T112. **Exploring the Solar System in the Thermal Infrared: A Memorial Session in Remembrance of Joshua L. Bandfield**

Endorser: *GSA Planetary Geology Division*
Discipline: Planetary Geology
Advocates: Timothy D. Glotch; Christopher S. Edwards

This session solicits talks that describe the use of thermal infrared remote sensing observations to study the mineralogy, thermophysics, and atmospheric properties of solar system bodies. In memory of Joshua L. Bandfield.

T113. **Friends of Hoth: Episode V—Small, Icy, and Ocean Worlds**

Endorser: *GSA Planetary Geology Division*
Discipline: Planetary Geology
Advocates: Erin Leonard; Emily Martin; D. Alex Patthoff

We seek abstracts relating to surface, structural, and tectonic processes; interior and thermal evolution; and planetary analogs as they pertain to icy satellites in the outer solar system. This includes experimental, observational, and theoretical approaches.

T114. **From the Guajira Desert to the Apennines, and from the Sardinia/Corsica Microplate to the Killer Asteroid: Honoring the Career of Walter Alvarez on the Occasion of His 80th Birthday**

Endorsers: *GSA Planetary Geology Division; GSA Structural Geology and Tectonics Division; GSA History and Philosophy of Geology Division; GSA Geophysics and Geodynamics Division*
Discipline: Planetary Geology
Advocates: Christian Koeberl; Philippe Claeys

This session covers the career and scientific accomplishments of Walter Alvarez by welcoming presentations related to the many topics he covered in the last 60 years, from tectonics to the K-T impact event.

T115. **Geomorphology and Landscape Evolution of Mars**

Endorsers: *GSA Quaternary Geology and Geomorphology Division; GSA Karst Division*
Disciplines: Planetary Geology, Geomorphology, Hydrogeology
Advocates: Sharon Wilson; Marisa Jasper; Elena Favaro

This session focuses on fluvial, lacustrine, aeolian, and crater degradation processes to investigate the geomorphology, geology, and climate history of Mars. We welcome abstracts using orbital and rover data as well as Earth analogues.

T116. **Impact Cratering in the Solar System: Remembering Nadine Barlow and H. Jay Melosh**

Endorsers: *GSA Planetary Geology Division; GSA Continental Scientific Drilling Division; GSA Geophysics and Geodynamics Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Quaternary Geology and Geomorphology Division; GSA Structural Geology and Tectonics Division*
Disciplines: Planetary Geology, Petrology, Metamorphic, Geophysics/Geodynamics
Advocates: Christian Koeberl; Jeffrey B. Plescia

Impact cratering is an important geological process throughout the solar system. The session, remembering Nadine Barlow and

H. Jay Melosh, seeks contributions on all aspects of impact cratering on Earth and the Solar System.

T117. **Perseverance at Jezero Crater—Characterizing an Ancient Crater Lake Basin on Mars**

Endorser: *GSA Planetary Geology Division*
Disciplines: Planetary Geology, Sediments, Clastic
Advocates: Kathryn M. Stack; Briony Horgan; Patrick Russell

This session will cover scientific results from the first eight months of NASA's Mars 2020 Perseverance rover operations and exploration in Jezero crater on Mars.

T118. **Planetary Science Education: Strategies, Examples, and Best Practices for Teaching Astrogeology-Related Topics**

Endorsers: *GSA Planetary Geology Division; GSA Geoscience Education Division; GSA Geobiology and Geomicrobiology Division*
Disciplines: Planetary Geology, Geoscience Education, Geoscience Information/Communication
Advocates: Nicholas Lang; Jennifer L.B. Anderson

This session explores approaches used to teach planetary science to students at the K–12, college, and graduate levels. Approaches to successfully integrating all student levels into research will also be addressed, as will topics related to engaging the public.

T119. **The Cretaceous–Paleogene Boundary: From Impact Cratering Processes to Mass Extinction Mechanisms**

Endorsers: *GSA Planetary Geology Division; Paleontological Society; GSA Marine and Coastal Geoscience Division*
Disciplines: Planetary Geology, Paleontology, Diversity, Extinction, Origination, Marine/Coastal Science
Advocates: Catherine Ross; Pim Kaskes

Cretaceous–Paleogene boundary records within and outside the Chicxulub impact crater reveal new insights into mass extinction mechanisms. We welcome contributions varying from K-Pg proxy records to modeling and settings ranging from crater to distal sites.

T120. **The G.K. Gilbert Award Session**

Endorser: *GSA Planetary Geology Division*
Discipline: Planetary Geology
Advocates: Debra Needham; Emily Martin; Nicholas P. Lang

This session will honor the 2021 winner of the Planetary Geology Division's G.K. Gilbert Award, highlighting recent contributions in the awardee's field of research.

T121. **The Interplay of Volcanism, Tectonism, and Impacts across the Solar System**

Endorsers: *GSA Planetary Geology Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division*
Discipline: Planetary Geology
Advocates: Paul K. Byrne; Mallory Kinczyk; Christian Klimczak

We solicit contributions that compare volcanic, tectonic, and impact landforms and processes on Solar System bodies, including how specific studies can help understand the complex interplay between these phenomena across the Solar System in general.

T122. **Venus: Second Rock from the Sun**

Endorsers: *GSA Planetary Geology Division; Geochemical Society*
Disciplines: Planetary Geology, Volcanology, Structural Geology
Advocates: Debra Buczkowski; Nicholas P. Lang

This session solicits abstracts on the geology of Venus, including volcanism, tectonism, impact cratering, and geologic mapping. It encompasses surface geology, interior evolution, and comparative planetary studies with observational, experimental, or theoretical approaches.

GEOMICROBIOLOGY

T123. **Co-Evolution of Earth and Life**

Endorser: *GSA Geobiology and Geomicrobiology Division*
Disciplines: Geomicrobiology, Geochemistry, Paleontology, Diversity, Extinction, Origination
Advocates: Trinity Hamilton; Heather V. Graham; Christen Grettenberger

Focused on the evolution of metabolisms on early Earth and throughout transitions in Earth's history, this session highlights research focused on the co-evolution of Earth and life and how metabolisms shaped Earth's geochemical environment.

T124. **New Advances in Geobiology**

Endorsers: *GSA Geobiology and Geomicrobiology Division; Geochemical Society*
Disciplines: Geomicrobiology, Paleontology, Paleoecology/Taphonomy, Paleontology, Diversity, Extinction, Origination
Advocates: Trinity Hamilton; Victoria A. Petryshyn; David Gold; Emily F. Smith; Zoë Havlena; Alison Cribb; Rowan C. Martindale; Andrew Putt; Brandt Gibson

This session will focus on new research at the intersection between geologic and biologic processes with special emphasis on novel materials and methods, new field sites, and advances at the intersections of scientific fields.

T125. **New Voices in Geobiology**

Endorsers: *GSA Geobiology and Geomicrobiology Division; Geochemical Society*
Disciplines: Geomicrobiology, Paleontology, Paleoecology/Taphonomy, Paleontology, Diversity, Extinction, Origination
Advocates: Andrew Putt; Alison Cribb; Zoë Havlena; Trinity Hamilton; Victoria A. Petryshyn; David Gold; Emily F. Smith; Rowan C. Martindale; Brandt Gibson

This session will bring together new research focusing on the interplay between geologic and biologic processes with a special emphasis on work by early-career scientists exploring new questions and hypotheses.

T126. **Source, Fate, and Roles of Natural Organic Matter in Geochemical Cycling of Metals and Metalloids in Surface and Groundwater Systems**

Endorsers: *GSA Geology and Health Division; GSA Geobiology and Geomicrobiology Division; GSA Karst Division; Geochemical Society*
Disciplines: Geomicrobiology, Geochemistry, Hydrogeology
Advocates: Harshad Kulkarni; Thomas Varner; Mohammad Alauddin; Robert Finkelman; Karen Johannesson; Saugata Datta

This session will enhance our understanding of the roles of natural organic matter (NOM) in biogeochemical cycling of trace and redox sensitive elements of human health concerns in surface and groundwater systems.

GEOMORPHOLOGY

T127. **Advances in Geomorphology: Understanding How Interactions among Climatic, Tectonic, Fluvial, and Hillslope Processes Drive Topographic Change**

Endorsers: *GSA Soils and Soil Processes Division; GSA Quaternary Geology and Geomorphology Division*
Disciplines: Geomorphology, Quaternary Geology, Tectonics/Tectonophysics
Advocates: Adrian Bender; Sean Gallen; Karin Lehnigk; Charles Shobe

We solicit multidisciplinary contributions that advance understanding of how climate and tectonics drive interactions among bedrock river incision, landslide erosion, weathering, hydrology, and fluvial sediment transport that control topographic change across all spatiotemporal scales.

T128. **Biogeomorphic Responses to Wildfire in Fluvial Ecosystems**

Endorsers: *GSA Quaternary Geology and Geomorphology Division; GSA Geology and Society Division; GSA Soils and Soil Processes Division*
Disciplines: Geomorphology, Quaternary Geology, Environmental Geoscience
Advocates: Joan L. Florsheim; Alison P. O'Dowd; Anne Chin

Conceptualizing rivers as ecosystems acknowledges interconnected and complex interactions among geomorphic, ecological, biogeochemical, and human processes. This session gathers interdisciplinary researchers addressing wildfire as it changes riparian and in-stream communities and physical habitats within fluvial systems, including channels, hillslopes, and floodplains.

T129. **Dynamics of Huge Floods**

Disciplines: Geomorphology, Quaternary Geology, Sediments, Clastic
Advocates: Roger P. Denlinger; Richard Waitt

Decades of research, development, and fieldwork on huge floods worldwide define the character and substantial geomorphic impact of these remarkable phenomena. We now relate outcrops to flows over thousands of kilometers, with surprising results.

T130. **Military Geosciences: Past Lessons and Modern Challenges**

Endorsers: *GSA Quaternary Geology and Geomorphology Division; GSA Soils and Soil Processes Division; GSA Geology and Society Division; GSA Environmental and Engineering Geology Division*
Disciplines: Geomorphology
Advocates: Eric V. McDonald; Sally A. Shoop; Brad Sion; J. Bruce J. Harrison; Steven N. Bacon

The goal of this session is to bring together earth scientists who apply geomorphic, hydrologic, remote sensing, soil, infrastructure assessment, computational, and environmental methods to support a wide range of military activities.

T131. **Mountain Glaciation and Climate Change of the Past and Present**

Disciplines: Geomorphology, Quaternary Geology, Paleoclimatology/Paleoceanography
Advocates: Benjamin Laabs; Keith A. Brugger; Eric M. Leonard

Mountain glaciers and the Quaternary record of mountain glaciation can yield valuable insights into climatic change. This session brings together studies of modern and past mountain glaciation and their implications for reconstructing the dynamics of glacier change through time.

T132. **Sediment Residence Times and Thresholds for Sediment Transport in Fluvial Corridors**

Endorsers: *GSA Quaternary Geology and Geomorphology Division; GSA Sedimentary Geology Division; GSA Geoinformatics and Data Science Division; GSA Geochronology Division*
Disciplines: Geomorphology, Geochronology, Quaternary Geology
Advocates: Kristin Jaeger; Nicholas Sutfin

This session explores sediment residence times, transit times, and thresholds for transport in river channels and floodplains through field, modeling, and analysis of remotely sensed approaches.

T133. **Weathering and Soils: Advances in Understanding Rates, Mechanisms, Controlling Factors and Feedbacks**

Endorsers: *GSA Quaternary Geology and Geomorphology Division; GSA Soils and Soil Processes Division*
Disciplines: Geomorphology, Soils, Geochronology
Advocates: Brendon J. Quirk; Jennifer Aldred; Arjun M. Heimsath; Rachel C. Glade

We welcome studies seeking to understand and quantify processes and rates of weathering and soil formation and their feedbacks with surface processes—particularly in the context of the climatic-, environmental-, and material-properties that dictate their progression.

QUATERNARY GEOLOGY

T134. **Advances in Wildfire-Related Earth-Surface Processes**

Endorsers: *GSA Quaternary Geology and Geomorphology Division; GSA Environmental and Engineering Geology Division; GSA Geology and Society Division*
Disciplines: Quaternary Geology, Geomorphology, Environmental Geoscience
Advocates: Ann Youberg; Luke McGuire; Francis K. Rengers

We encourage researchers to present a broad range of topics related to wildfires and earth-surface processes, including field studies, hazard analyses, emerging trends, landscape evolution studies, and deep record geologic studies.

T135. **Dynamics of the Laurentide Ice Sheet**

Endorsers: *GSA Quaternary Geology and Geomorphology Division; GSA Marine and Coastal Geoscience Division*
Discipline: Quaternary Geology
Advocates: Timothy G. Fisher; Randall Schaetzl

We encourage papers and posters on the timing, extent, and dynamics of the Laurentide Ice Sheet. Presentations should focus on build up to the Last Glacial Maximum (LGM), LGM, and post-LGM events.

T136. **Eolian Processes, Landforms, and Chronologies**

Endorsers: *GSA Quaternary Geology and Geomorphology Division; GSA Environmental and Engineering Geology Division; GSA Soils and Soil Processes Division*
Disciplines: Quaternary Geology, Geomorphology, Soils
Advocates: Randall J. Schaetzl; Nick Lancaster; Phillip Kerr

We encourage papers on all topics related to eolian systems, processes, landforms, and chronologies. Papers on loess and sand dune systems are particularly welcomed.

T137. **From the Caspian to Mediterranean: Environmental Change and Human Response during the Quaternary (INQUA IFG POCAS, IGCP 610)**

Endorsers: *Avalon Institute of Applied Science, Canada; GSA Geoarchaeology Division; GSA Marine and Coastal Geoscience Division; GSA Quaternary Geology and Geomorphology Division; GSA Soils and Soil Processes Division*
Disciplines: Quaternary Geology
Advocates: Valentina Yanko-Hombach; Tamara Yanina

The session provides cross-disciplinary and cross-regional correlation of geological, archaeological, environmental, and anthropological records to explore interrelationships between environmental change and human adaptation in the Caspian–Black Sea–Mediterranean Corridors during the Quaternary.

T138. **Glacial Hydrology: Processes Operating within, beneath, and along the Margins of Glaciers and Ice Sheets**

Endorsers: *GSA Quaternary Geology and Geomorphology Division; GSA Karst Division*
Discipline: Quaternary Geology
Advocates: Richard Dunn; Stephen F. Wright

This session focuses on glacial hydrology processes including, but not restricted to, the evolution of glacial drainage, the influence of hydrology on ice movement, and erosional and depositional processes beneath and adjacent to glaciers.

T139. **Hyperthermals of Western North America: Cenozoic Lessons for the Future**

Endorsers: *GSA Quaternary Geology and Geomorphology Division; GSA Marine and Coastal Geoscience Division*
Disciplines: Quaternary Geology, Limnogeology, Marine/Coastal Science
Advocates: Jason Addison; Kristin McDougall-Reid; Miriam C. Jones; Ana Christina Ravelo

Many times throughout the Cenozoic, temperatures were greatly elevated. What causes these hyperthermals, and what are their impacts on Earth systems? This session will explore the geological signatures of these environments as an analog for our future.

T140. **Paleoclimate, Paleoenvironments, and Paleoceanography of Northwestern North America**

Endorsers: *GSA Quaternary Geology and Geomorphology Division; GSA Continental Scientific Drilling Division; GSA Marine and Coastal Geoscience Division; GSA Limnogeology Division; GSA Geoarchaeology Division; American Quaternary Association; Geochemical Society*
Disciplines: Quaternary Geology, Limnogeology, Paleoclimatology/Paleoceanography
Advocates: Beth Caissie; Lesleigh Anderson; Alan C. Mix; Summer Praetorius

From offshore in the Pacific to the Cordilleran and Beringia, we encourage presentations of new techniques, study locations, and insights of past climate, ecosystems, landscape/sea-surface change and human dispersal during the Neogene and Quaternary.

T141. **Reconstruction of Quaternary Paleoenvironments at Regional and Global Scales: A Tribute to Eric C. Grimm (1951–2020)**

Endorsers: *GSA Quaternary Geology and Geomorphology Division; GSA Geobiology and Geomicrobiology Division; GSA Geochronology Division; GSA Geoinformatics and Data Science Division; GSA Geoarchaeology Division; American Quaternary Association; GSA Sedimentary Geology Division; GSA Karst Division*
Disciplines: Quaternary Geology, Geoinformatics, Paleoclimatology/Paleoceanography
Advocates: Rolfe Mandel; Julie Brigham-Grette; Cathy Whitlock

Quaternary scientists mourn the loss of Eric Grimm, renowned for his studies of Quaternary paleoecology and paleoclimatology. This session highlights how Eric's studies and development of databases and models influenced multiproxy reconstructions of Quaternary paleoenvironments at regional and global scales.

T142. **The Status of the Laurentide Ice Sheet during MIS-3**

Endorsers: *GSA Quaternary Geology and Geomorphology Division; GSA Marine and Coastal Geoscience Division*
Disciplines: Quaternary Geology, Paleoclimatology/Paleoceanography, Marine/Coastal Science
Advocates: Gifford H Miller; Michel Lamothe; Michel Parent; Martin Roy

The configuration and volume of the Laurentide Ice Sheet during MIS-3 remain debated, with strong implications for sea level and the status of the Antarctic Ice Sheet. We encourage contributions that help resolves these uncertainties.

INDUSTRY TRACKS

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

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

T143. **Wildfire as an Earth System Process—Ancient and Modern**

Endorsers: *GSA Quaternary Geology and Geomorphology Division; GSA Sedimentary Geology Division; GSA Geology and Society Division; GSA Environmental and Engineering Geology Division; GSA Soils and Soil Processes Division*
Discipline: Quaternary Geology
Advocates: Andrew C. Scott; Ian J. Glasspool; Sarah J. Baker

The impact of fire on the biosphere and the role that mankind is playing in altering the nature of fire systems as well as that fire is an essential element of how the Earth works will be addressed.

ENVIRONMENTAL GEOSCIENCE

T144. **Intersections of Sustainability and Geosciences**

Endorsers: *GSA Karst Division; GSA Soils and Soil Processes Division*
Disciplines: Environmental Geoscience, Geoscience Education, Geoscience and Public Policy
Advocates: Leslie North; Robert Brinkmann

The session seeks to highlight works that combine the fields of sustainability and geoscience to examine or educate about environmental and/or societal problems. Topics such as water management, pollution, and climate change will be explored.

T145. **Sigma Gamma Epsilon Student Research Exhibition (Posters)**

Endorsers: *Sigma Gamma Epsilon; GSA Limnogeology Division*
Disciplines: Environmental Geoscience, Structural Geology, Geochemistry
Advocates: Diane Burns; James Walters

All Sigma Gamma Epsilon student members are encouraged to submit their research to this poster session to showcase endeavors as well as compete for awards. All geological investigations, from archaeological geology to volcanology, are encouraged to be entered.

T146. **Site Characterization and Monitoring Techniques for Geologic Disposal of Nuclear Waste**

Endorsers: *GSA Environmental and Engineering Geology Division; GSA Hydrogeology Division; GSA Continental Scientific Drilling Division; GSA Geoinformatics and Data Science Division; GSA Geology and Society Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Energy Geology Division*
Discipline: Environmental Geoscience
Advocates: Bret W. Leslie; Ismo S. Aaltonen

The multi-decadal process to site, construct, and operate a geologic repository requires many characterization and monitoring techniques. Both specific surface-based and underground characterization and monitoring studies and national approaches to siting are sought.

GEOLOGY AND HEALTH

T147. **Energy Resources, Environment, and Health**

Endorsers: *GSA Geology and Health Division; GSA Energy Geology Division*
Disciplines: Geology and Health, Energy Geology, Environmental Geoscience
Advocates: Laura S. Ruhl; Marc L. Buursink; Jenna L. Shelton

Energy resources are essential to society but have environmental and health risks. This session will explore research related to environmental and health issues associated with energy, including exploration, extraction, waste disposal, and greenhouse gas emissions.

T148. **Head, Shoulders, Knees, and Toes: Delineating Biogeochemical and Metabolic Pathways Linking Environmental Exposures and Human Health**

Endorsers: *GSA Geology and Health Division; GSA Soils and Soil Processes Division; GSA Geology and Society Division; GSA Geobiology and Geomicrobiology Division; GSA Environmental and Engineering Geology Division; International Society of Exposure Science; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; International Medical Geology Association*
Disciplines: Geology and Health, Environmental Geoscience, Soils
Advocates: Malcolm Siegel; Reto Gieré; Laura S. Ruhl; Ann Ojeda

This session seeks contributions on the use of geoscience methods in exposure science, environmental epidemiology, environmental toxicology, and monitoring in understanding the biogeochemical and metabolic pathways during interaction between humans and environment.

GEOSCIENCE AND PUBLIC POLICY

T149. **Building the Workforce of the 21st Century: Understanding Diversity, Intersectionality, Ethics, and Inclusivity in the Geosciences and Implementing Transformative Change in Our Culture**

Endorsers: *GSA Geoscience Education Division; GSA Geology and Society Division; GSA Marine and Coastal Geoscience Division; International Association for Geoscience Diversity; National Association of Geoscience Teachers (NAGT); GSA Soils and Soil Processes Division*
Disciplines: Geoscience and Public Policy
Advocates: Elena A. Miranda; Aradhna Tripati; Gabriela Mora-Klepeis; Catherine Flowers

We focus on identifying existing challenges and innovative solutions to (1) recruiting and retaining a diverse workforce; (2) establishing an accessible and inclusive workplace; and (3) eradicating discrimination, harassment, bullying, and retaliation.

T150. **Geoscience and Hydrology of Your Public Lands: STEM Internships, Research, Science, Mapping, Resource Management, and Education**

Endorsers: *National Park Service; U.S. Forest Service; U.S. Bureau of Land Management; GSA Environmental and Engineering Geology Division; GSA Karst Division; GSA Geology and Society Division; GSA Soils and Soil Processes Division*
Disciplines: Geoscience and Public Policy, Geoscience Information/Communication, Geoscience Education
Advocates: Jason P. Kenworthy; Matthew Dawson; Limaris Soto; Kiersten Jarvis; Brent H. Breithaupt; F. Edwin Harvey

An interdisciplinary forum for geoscientists, land managers, Geoscientists in the Parks, Scientists in Parks, and GeoCorps™ America participants or sponsors, as well as educators, to present their work and describe its relevance to the public and land managers.

T151. **That Signpost up Ahead: At the Crossroads of Geoscience and Society—A Public Policy Perspective**

Endorsers: *GSA Geology and Society Division; Geology and Public Policy Committee; GSA Environmental and Engineering Geology Division; GSA Energy Geology Division; GSA Geology and Health Division; GSA Hydrogeology Division; GSA Soils and Soil Processes Division*
Disciplines: Geoscience and Public Policy, Geoscience Information/Communication
Advocates: James Heller; Beth Bartel; Susan G. Stover

This session encourages presentations that illuminate the interface between the Earth sciences and society and the importance of science policy. Topics related to climate change, environment, resource management, natural hazards, and infrastructure will be discussed.

GEOSCIENCE EDUCATION

T152. **Advances in Undergraduate Research and Education, Colorado Geology, and Igneous Petrology: Celebrating the 55-Year Career of Reinhard "Bud" Wobus**

Endorsers: *National Association of Geoscience Teachers (NAGT); GSA Geoscience Education Division; Council on Undergraduate Research Geosciences Division*
Disciplines: Geoscience Education
Advocates: K. Brock Riedell; Rachel Beane; Cathryn Manduca

To celebrate the 55-year career of Reinhard "Bud" Wobus at Williams College, this session focuses on the impact of his dedication to undergraduate research and education, southern Rocky Mountain geology, and plutonic-volcanic studies.

T153. **Application of Student Research Projects, A Way to Solve Water-Related Problems—Issues in Developing Nations**

Endorser: *GSA Geology and Society Division*
Disciplines: Geoscience Education, Hydrogeology, Environmental Geoscience
Advocates: Solomon A. Isiorho; Duke U. Ophori; Isaac I. Akinwumi

Water-related issues and problems are pervasive in most parts of the world, especially in developing nations; however, there are not enough personnel or resources to examine all issues. Student transdisciplinary research projects could provide solutions.

T154. **Best Practices in Place-Based Education**

Endorsers: *National Association of Geoscience Teachers (NAGT); GSA Geoscience Education Division*
Disciplines: Geoscience Education, Environmental Geoscience, Geoscience and Public Policy
Advocates: Michael A. Phillips; Steven Semken; Sarah Fortner

Place-based programs make learning, science, environmental communication, and sustainability meaningful because participants can apply concepts to, and connect with, familiar places. We encourage place-based educators from all levels (formal and informal) to share successful ideas.

T155. **Bringing Inquiry into Geoscience Labs for Students, Teaching Assistants, and Faculty**

Endorsers: *National Association of Geoscience Teachers (NAGT); National Association of Geoscience Teachers (NAGT) Geo2YC Division; GSA Geoscience Education Division; National Association of Geoscience Teachers (NAGT) Geoscience Education Research (GER) Division; National Association of Geoscience Teachers (NAGT) Teacher Education Division (TED); GSA Geoscience Education Division*
Disciplines: Geoscience Education, Geoscience Information/Communication
Advocates: Katherine Ryker; Rachel Teasdale; Kelsey S. Bitting

Inquiry-based learning engages students in "doing science" in geoscience labs. Presenters will share their experiences creating and testing inquiry-based labs, data on their efficacy, and strategies for supporting other instructors (e.g., graduate teaching assistants).

T156. **Building Trust Using Science Communication and Education within Diverse Communities**

Endorsers: *GSA Geology and Society Division; GSA Geoscience Education Division; GSA Diversity in the Geosciences Committee; GSA Karst Division; GSA Soils and Soil Processes Division*
Disciplines: Geoscience Education, Geoscience Information/Communication, Geoscience and Public Policy
Advocates: Leila Joyce; Darryl Reano; Angel Garcia Jr.; Michael Buck

This session will answer calls for more authentic collaborations between geoscientists and historically marginalized communities.

T157. **Celebrating Innovative and Effective Approaches to Implementing the Next Generation Science Standards in Earth and Space Science Education (NGSS-ESS)**

Endorsers: *National Association of Geoscience Teachers (NAGT); American Geophysical Union; American Geosciences Institute; National Earth Science Teachers Association; GSA Geoscience Education Division; GSA Karst Division; GSA Geology and Society Division*
Discipline: Geoscience Education
Advocates: Aida Awad; Margaret Holzer; Edward Robeck

The NGSS-ESS presents challenges and opportunities for teaching, learning, assessment, and professional development in K–16 education. This session presents resources that highlight approaches to the challenges of implementing the NGSS-ESS while demonstrating where opportunities exist for continuing these efforts.

T158. **Geoscience and Society: Action and Interdisciplinary Engagement on Local and Global Scales (Posters)**

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, University of Texas–El Paso*

Disciplines: Geoscience Education, Geoscience Information/Communication, Geoscience and Public Policy
Advocates: Gregory R. Wessel; Rudy Schuster; Chloe Hill; Nina Burkhardt

Through grassroots case studies, this session will show how geoscientists can facilitate engagement and re-development to benefit society and enhance resilience. It is a partner to the Pardee Symposium of the same name.

T159. **Hands-On Teaching Demonstrations that Combine Geoscience and Societal Issues: Audience Participation Requested!**

Endorsers: *GSA Geoscience Education Division; National Association of Geoscience Teachers (NAGT); GSA Structural Geology and Tectonics Division; GSA Marine and Coastal Geoscience Division; GSA Soils and Soil Processes Division*
Discipline: Geoscience Education
Advocates: Elizabeth A. Nagy; Tiffany A. Rivera

This is a geoscience education session that practices what it preaches. Authors present micro-demonstrations of effective teaching activities that integrate geoscience content with societal concerns. Presentations include audience participation, assessment results, and reflections on effectiveness.

T160. **How Has the COVID-19 Pandemic Transformed K9–16 Students' Ability to Engage in Multi-Faceted Research in the Geosciences Using a Virtual Platform? (Posters)**

Endorsers: *GSA Environmental and Engineering Geology Division; GSA Quaternary Geology and Geomorphology Division; GSA Geology and Society Division; GSA Geoscience Education Division*
Disciplines: Geoscience Education, Geoscience Information/Communication, Geoscience and Public Policy
Advocates: Nazrul I. Khandaker; Arif Sikder

K9–16 students engaged in research on topics related to natural hazards, extreme weather-related events, coastal erosion, geomorphology, fluvial processes, and geoscience education outreach are encouraged to submit posters providing examples or experiences with creative use of virtual platforms.

T161. **Institutional and Grassroots Efforts Promoting Diversity, Equity, and Inclusion in the Scientific Workplace**

Endorsers: *GSA Geophysics and Geodynamics Division; GSA Geoscience Education Division*
Disciplines: Geoscience Education, Geoscience Information/Communication, Geoscience and Public Policy
Advocates: Jenna L. Shelton; Tina Roberts-Ashby; Jennifer Malpass

The session will be focused on unique efforts that individuals (i.e., grassroots) and institutions are developing or implementing to promote diversity, equity, and inclusion in the geoscience workplace.

T162. **Lessons Learned from URGE 2021: Unlearning Racism in the Geosciences**

Endorsers: *GSA Geoscience Education Division; GSA Geology and Society Division*
Disciplines: Geoscience Education, Geoscience and Public Policy, Geoscience Information/Communication
Advocates: Gabriel Duran; Phoebe Cohen

Unlearning Racism in Geoscience (URGE) is a community-wide reading and action group that began in January of 2021. In this session, we encourage those who participated in URGE to share their department/institutions/groups' specific actions toward making the geosciences anti-racist.

T163. **Long-Term Changes to the Geoscience Enterprise from COVID-19**

Endorsers: *GSA Geoscience Education Division; GSA Geology and Society Division*
Disciplines: Geoscience Education, Geoscience and Public Policy
Advocates: Leila M. Gonzales; Christopher Keane

This session explores the impacts that COVID-19–related changes to geoscience workplace environments have on recent geoscience graduates and professionals as well as the impacts on the workforce preparation of students.

T164. **Making Sense of Methodologies and Theoretical Frameworks in Geoscience Education Research**

Endorsers: *GSA Geoscience Education Division; National Association of Geoscience Teachers (NAGT) Geoscience Education Research (GER) Division*
Disciplines: Geoscience Education, Geoscience Information/Communication
Advocates: Kelsey S. Bitting; Emily Ward; Leilani Arthurs; Lauren Neitzke Adamo; Cory Forbes; Bailey Kreager; Peggy McNeal

Methods and theoretical frameworks can come from within and outside of geoscience education research to shape of our field. Presenters are encouraged to highlight decision-making processes in research studies that advance the field. New approaches and applications of established methods/frameworks are welcome.

T165. **Measuring Learning in Geoscience Education**

Endorsers: *National Association of Geoscience Teachers (NAGT); National Association of Geoscience Teachers (NAGT) Geoscience Education Research (GER) Division; GSA Geoscience Education Division*
Disciplines: Geoscience Education
Advocates: Virginia Isava; Argenta Price

This session aims to highlight assessments in K–12 and higher-education classroom environments. We welcome presentations on assessment theory (deciding what to assess, benchmarks, timing, etc.), as well as innovative measurements and tools for learning.

T166. **The Intersection of Physical and Social Science Research: How Critical Theories Can Be Used to Improve Geoscience Education Research and Pedagogy**

Endorsers: *GSA Geoscience Education Division; GSA Diversity in the Geosciences Committee; International Association for Geoscience Diversity*
Disciplines: Geoscience Education, Geoscience Information/Communication
Advocates: Ivan Carabajal; Akilah K. Alwan; Darryl Reano

This session will share how critical theories are applied in geoscience education research to analyze data, design research projects, and inform other higher-education experiences to create more inclusive, diverse, equitable, and just educational environments.

T167. **The Lasting Effects of the 2020–2021 COVID-19 Crisis on Geoscience Education: Insights, Problems, and Unanticipated Benefits**

Endorsers: *GSA Geoscience Education Division; National Association of Geoscience Teachers (NAGT); National Association of Geoscience Teachers (NAGT) Geoscience Education Research (GER) Division; GSA Geoinformatics and Data Science Division; GSA Geology and Society Division*
Discipline: Geoscience Education
Advocates: Mark Abolins; Catherine Riihimaki

Contributions will explore the effects of the COVID-19 crisis on geoscience teaching, outreach, and academic administration. Presentations about geoscience-education research conducted during the crisis are especially welcome.

T168. **Undergraduate Research Posters by 2YC and 4YCU Geoscience Students (Posters)**

Endorsers: *National Association of Geoscience Teachers (NAGT); National Association of Geoscience Teachers (NAGT) Geo2YC Division; International Association for Geoscience Diversity; National Association of Geoscience Teachers (NAGT) Geoscience Education Research (GER) Division; GSA Geoscience Education Division; GSA Karst Division; Council on Undergraduate Research Geosciences Division*
Discipline: Geoscience Education
Advocates: Adrianne Leinbach; Gretchen L. Miller; Stephanie Rollins

This session is designed for two-year college (2YC) and four-year college and university (4YCU) students presenting research posters in any subdiscipline of geoscience.

GEOSCIENCE INFORMATION/COMMUNICATION

T169. **Discovery and Preservation of Emerging Research Output Formats in the Geosciences (Posters)**

Endorser: *Geoscience Information Society*
Disciplines: Geoscience Information/Communication, Geoscience Education, Geoscience and Public Policy
Advocate: Elise Gowen

This poster session examines emerging forms of scholarly output in the geosciences and related challenges and opportunities. Posters highlighting innovative methods of preservation and access of formats for data, learning objects, software, multimedia, immersive experiences, and more, are welcome.

T170. **New and Emerging Research Output Formats in the Geosciences**

Endorser: *Geoscience Information Society*
Disciplines: Geoscience Information/Communication, Geoscience Education, Geoscience and Public Policy
Advocate: Elise Gowen

With the increasing diversity of mediums and formats used to access and disseminate research, the poster session discusses best practices for the management, preservation, and access of emerging forms of research outputs.

GEOINFORMATICS

T171. **Data-Driven Approaches Deciphering Water and Carbon Cycles in Earth-Surface Systems**

Endorsers: *GSA Karst Division; GSA Energy Geology Division; GSA Soils and Soil Processes Division*
Disciplines: Geoinformatics, Hydrogeology, Environmental Geoscience
Advocates: Tao Wen; Shuang Zhang; Mingsong Li

This session seeks abstracts ranging from the development of advanced data-analysis techniques and the application of data-driven methods to gain understanding of water and carbon cycling in coupled human-natural Earth surface systems.

T172. **Integrating Remote Sensing and In Situ Data for Understanding Surface and Subsurface Processes**

Endorsers: *GSA Geoinformatics and Data Science Division; GSA Structural Geology and Tectonics Division; GSA Quaternary Geology and Geomorphology Division; GSA Marine and Coastal Geoscience Division; GSA Soils and Soil Processes Division*
Discipline: Geoinformatics
Advocates: Esayas Gebremichael; Mohamed Ahmed

This session is aimed at promoting the numerous applications of geospatial science and technology techniques and datasets for monitoring, mapping, and quantifying surface and subsurface processes.

T173. **Machine Learning for Advancing Data Analysis Toolkit in Geoscience**

Endorser: *GSA Geoinformatics and Data Science Division*
Disciplines: Geoinformatics, Geoscience Education, Geoscience Information/Communication
Advocates: Ziheng Sun; Xiaogang Ma

This session will bring together community experiences on using artificial intelligence in the geosciences, identify the best practices, and share the knowledge. We welcome successful use cases of any step in the data life cycle.

INDUSTRY TRACKS

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

Economic Geology | Energy | Engineering | Hydrogeology and Environmental Geology

HISTORY AND PHILOSOPHY OF GEOLOGY

T174. **Great Geological Outcrops and Locales**

Endorsers: *GSA History and Philosophy of Geology Division; History of Earth Sciences Society*
Disciplines: History and Philosophy of Geology, Structural Geology, Geophysics/Geodynamics
Advocates: Renee Clary; Kathy Lohff; J. Bourgeois

We explore outcrops and localities that became cornerstones in geology, as well as resulting theories, both correct and incorrect, that were inspired by them. Inspirational outcrops and locales from all continents and centuries welcome, particularly those from the eighteenth through twentieth centuries.

GEOARCHAEOLOGY

T175. **Coastal Geoarchaeology: New Research above and below Sea Level**

Endorsers: *GSA Geoarchaeology Division; GSA Marine and Coastal Geoscience Division; GSA Karst Division*
Disciplines: Geoarchaeology, Marine/Coastal Science, Geomorphology
Advocates: Loren Davis; Laura Murphy; Leila Joyce

We welcome papers on coastal environments as they relate to the archaeological record, including approaches to locating and investigating underwater, submerged, and intertidal sites, and the monitoring and management of coastal erosion at archaeological sites.

T176. **Losing Cultural Heritage: Geoarchaeology and Climate Change Impacts**

Endorsers: *GSA Geoarchaeology Division; GSA Quaternary Geology and Geomorphology Division; GSA Geology and Society Division; GSA Soils and Soil Processes Division*
Discipline: Geoarchaeology
Advocates: Alice Kelley; Leslie Reeder-Myers

Climate change–related phenomena are threatening cultural resources. This session seeks presentations of case studies and contributions illustrating techniques and approaches developed to address climate-change impacts.

T177. **Solving Paleoenvironmental Problems with Isotopes: New Advances and Ongoing Challenges in Soils and Geoarchaeology**

Endorsers: *GSA Geoarchaeology Division; GSA Soils and Soil Processes Division; GSA Quaternary Geology and Geomorphology Division; GSA Energy Geology Division*
Disciplines: Geoarchaeology, Soils, Geochemistry
Advocates: Samantha Krause; Timothy Beach

This session brings together soil and geoarchaeological scholars who are solving problems using isotopic techniques. Presentations include soil carbon sequestration, isotopic composition of biomarkers, anthropogenic impacts on soil, studies of human diet, and paleoenvironmental change.

2021 Joint Technical Program Committee (JTPC)

Technical Program Chair: Amy Brock-Hon, amy-brock-hon@utc.edu
Technical Program Vice-Chair: Robinson Cecil, robinson.cecil@csun.edu
GSA Technical Program Manager: Nancy Wright, nwright@geosociety.org

JTPC CONTACT(S)	DISCIPLINE	REVIEW GROUP
Monica Easton	geoscience information/communication	Association of Earth Science Editors
Elizabeth A. Heise		Council on Undergraduate Research Geosciences Division
Marie D. Jackson	continental scientific drilling	GSA Continental Scientific Drilling Division
Jenna L. Shelton; Marc Buursink	energy geology	GSA Energy Geology Division
Thomas Oommen; Arpita Nandi; Richard V. Martin	engineering geology; environmental geoscience	GSA Environmental and Engineering Geology Division
Laura Murphy; Samantha Marie Krause	geoarchaeology	GSA Geoarchaeology Division
Lydia Schiavo Tackett; Brandt Gibson	geobiology; geomicrobiology	GSA Geobiology and Geomicrobiology Division
Eugene Szymanski	geochronology	GSA Geochronology Division
Frank Ramos	geochemistry	Geochemical Society
Matty Mookerjee; C. Brenhin Keller; Denise Hills	geoinformatics	GSA Geoinformatics and Data Science Division
Laura Suzanne Ruhl; G. Nelson Eby	geology and health	GSA Geology and Health Division
Beth Ann Bartel; John A. Chermak	geoscience and public policy	GSA Geology and Society Division
Ting Chen; Benjamin Drenth	geophysics/geodynamics	GSA Geophysics and Geodynamics Division
Charles D. Czajka; Meagan M. Gilbert	geoscience education	GSA Geoscience Education Division
Elise Gowen	geoscience information/communication	Geoscience Information Society
Mary Hubbard		GSA International
Kathleen Lohff; Renee Clary	History and Philosophy of Geology	GSA History and Philosophy of Geology Division
Andrea Brookfield; Ben Rostron; Don Rosenberry	hydrogeology	GSA Hydrogeology Division
Jason Polk; Daniel Jones	karst	GSA Karst Division
Scott Starratt; Jason R. Price	limnogeology	GSA Limnogeology Division
Deirdre D. Ryan	marine/coastal science	Marine/Coastal Geology
Dennis L. Newell; Rosemary C. Capo; Amanda B. Clarke	mineralogy/crystallography; geochemistry; petrology, volcanology	GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division
Philip Brown	mineralogy/crystallography; petrology, igneous; petrology, metamorphic; volcanology	Mineralogical Society of America
Margaret Crowder	geoscience education	National Association of Geoscience Teachers (NAGT)
Miriam E. Katz	paleoclimatology/paleoceanography	Paleoceanography/Paleoclimatology

(continued)

JTPC CONTACT(S)	DISCIPLINE	REVIEW GROUP
James Lamsdell; Matthew E. Clapham	paleontology, biogeography/biostratigraphy; paleontology, diversity, extinction, origination; paleontology, paleoecology/taphonomy; paleontology, phylogenetic/morphological patterns	Paleontological Society
Emily S. Martin; Nickolas P. Lang; Debra Buczkowski	planetary geology	GSA Planetary Geology Division
Gregory Dumond	Precambrian geology	Precambrian Geology
Julie Brigham-Grette; Karl W. Wegmann	geomorphology; Quaternary geology	GSA Quaternary Geology and Geomorphology Division
Will Jackson; Howard Harper	sediments, carbonates; sediments, clastic; stratigraphy	GSA Sedimentary Geology Division
Howard Harper	sediments, carbonates; sediments, clastic; stratigraphy	SEPM (Society for Sedimentary Geology)
Richard Goldfarb; John Dilles	economic geology	Society of Economic Geologists
Ashlee Dere; Tim Beach	soils	GSA Soils and Soil Processes Division
Juliet Crider; Rebecca Dorsey	structural geology; tectonics	GSA Structural Geology and Tectonics Division

GSA Partners with Our Associated Societies for GSA Connects 2021

GSA is working with its 76 Associated Societies and 22 scientific Divisions to build a dynamic GSA Connects 2021 technical program and stimulating events during the meeting. Many Associated Societies will present their representative science, hold tailored events, and have exhibit booths during the meeting. GSA is looking forward to hosting these valued partners and organizations. Members of Associated Societies also benefit by qualifying for the GSA member registration rate to attend the meeting.

GSA has a long tradition of collaborating with like-minded organizations in pursuit of mutual goals to advance the geosciences. As the Society continues to look to the future, it aims to build strong, meaningful partnerships with other societies and organizations across the country and around the world in service to members and the global geoscience community. National and international societies with consistent aims and missions of advancing the geosciences and/or science in general are invited to affiliate with GSA as an Associated Society.

Scientific Field Trips

Descriptions and leader bios are online.

401. **Warren Hamilton Field Trip: Dikes, Vents, and Magma Transport in the Columbia River Flood Basalt Province.** Tues.–Sat., 5–9 Oct. Leaders: Joseph Biasi, California Institute of Technology; Rachel Lynn Hampton; Leif Karlstrom; Kendra Murray; John A. Wolff.

402. **Deep-Water Deposits of the Eocene Tyee Formation.** Thurs.–Sat., 7–9 Oct. Leaders: Michael Sweet, University of Texas at Austin Institute for Geophysics; Gwladys Gaillot; Manasij Santra.

403. **From the Ocean to the Mountains: How Pacific Coast Geology Shapes Marine and Terrestrial Ecosystems.** Thurs.–Sat., 7–9 Oct. Endorsers: *NOAA Teacher at Sea; Climate Literacy and Energy Awareness Network (CLEAN); Edmunds Central School District.* Leaders: Spencer Cody, Edmunds Central School District; John McAlpin; Tom Savage.

404. **River versus Arc: The Geology of the Columbia River Gorge.** Thurs.–Sat., 7–9 Oct. Endorsers: *GSA Quaternary Geology and Geomorphology Division; GSA Structural Geology and Tectonics Division.* Leaders: Jim E. O'Connor, U.S. Geological Survey; Ray E. Wells; Scott Bennett; Charles M. Cannon; Lydia Staisch; Gabriel Gordon; Anthony Pivarunas.

405. **A Volcanic Tour of Central Oregon: Newberry Volcano Geothermal Scientific Drilling and Fort Rock Geoarchaeological Sites.** Thurs.–Sat., 7–9 Oct. Endorsers: *GSA Continental Scientific Drilling Division; GSA Geoarchaeology Division; GSA Limnogeology Division; Oregon State University College of Earth, Ocean, and Atmospheric Sciences.* Leaders: Adam Schulz, Oregon State University; Alain Bonneville; Johan C. Varekamp; Andrew Meigs; Tom Connolly; Jayde Hirniak; Marie Jackson.

406. **Silicic Lava Domes of the Cascades of Oregon and Northern California.** Thurs.–Sun., 7–10 Oct. Leaders: Jonathan Fink; Steven W. Anderson.

407. **A Slice into Time: Stories Written in the Walls of the Columbia River Gorge.** Fri., 8 Oct. Leader: Gina Roberti, Mount St. Helens Institute.

408. **Paleofloods and Earthquakes: Hydrologic and Seismic Loadings for USACE Dams in Central Oregon.** Fri.–Sat., 8–9 Oct. Endorser: *U.S. Army Corps of Engineers.* Leaders: Keith Kelson, U.S. Army Corps of Engineers Dam Safety Production Center; Erica Medley.

409. **Pleistocene Landscapes and Geoarchaeology of the Oregon Coast.** Fri.–Sat., 8–9 Oct. Endorsers: *Oregon State University, Department of Anthropology; Pacific Slope Archaeological Laboratory.* Leaders: Loren Davis, Oregon State University; Steve Jenevein; Michele Punke.

410. **Tectonics and Paleogeography of a Post-Accretionary Forearc Basin, Coos Bay Basin, SW Oregon.** Fri.–Sun., 8–10 Oct. Endorser: *GSA Sedimentary Geology Division.* Leader: John Armentrout, Cascade Stratigraphics.

411. **Terroir of Wine of the Willamette Valley, Oregon.** Fri., 8 Oct. Leader: Scott Burns, Portland State University.

412. **Geology of the Columbia Gorge and the Effects of Wildfire There.** Sat., 9 Oct. Leader: Scott Burns, Portland State University.

413. **Developing Landslide Chronologies Using Landslide-Dammed Lakes of the Oregon Coast Range.** Sat., 9 Oct. Endorsers: *GSA Quaternary Geology and Geomorphology Division; GSA Environmental and Engineering Geology Division.* Leaders: Logan Wetherell; William Struble; Sean LaHusen.

414. **Living with Volcanoes in the Pacific Northwest.** Sat., 9 Oct. Leader: Gina Roberti, Mount St. Helens Institute.

415. **John Day Basin of Oregon and the Evolution of Landscapes and Ecosystems through the Cenozoic.** Thurs.–Fri., 14–15 Oct. Endorser: *John Day Fossil Beds National Monument.* Leaders: Nicholas A. Famoso, John Day Fossil Beds National Monument; Samantha S.B. Hopkins; Joshua X. Samuels.

416. **Exploring an Eccentric Era of Explosivity and Extension in the Central Oregon Cascades Arc: The Deschutes Formation Ignimbrite Flare-up.** Thurs.–Sat., 14–16 Oct. Leaders: Bradley W. Pitcher, Vanderbilt University; Anita L. Grunder; Adam J.R. Kent.

417. **Flood Basalts, Rhyolites, and Subsequent Volcanism of the Columbia River Magmatic Province in Eastern Oregon.** Thurs.–Sun., 14–17 Oct. Leaders: Emily Cahoon, Washington State University; Martin J. Streck; Mark L. Ferns.

418. **Mount St. Helens—Four Decades of Geologic, Geomorphic, Ecologic, and Engineering Insights and Challenges Since its 1980 Eruption.** Thurs., 14 Oct. Endorser: *GSA Quaternary Geology and Geomorphology Division (Kirk Bryan Field Trip).* Leaders: Jon Major, U.S. Geological Survey Cascades Volcano Observatory; Scott Burns; Patrick Pringle.

419. **Stream Corridor Enhancement: Techniques for Bringing Greater Stream Function into the City.** Thurs., 14 Oct. Endorser: *Clean Water Services.* Leaders: Anne MacDonald; Matthew Brennan; Dennis O'Connor.

420. **The Mount Hood Fault Zone—Active Tectonics at the Crest of the Dynamic Cascade Range.** Thurs.–Fri., 14–15 Oct. Leaders: Ian Madin; Scott Bennett; Ashley R. Streig.

421. **Upper Grand Coulee—New Views of a Channeled Scabland Megafloods Enigma.** Thurs.–Sun., 14–17 Oct. Endorser: *GSA Quaternary Geology and Geomorphology Division.* Leaders: Richard Waitt, Cascades Volcano Observatory; Brian F. Atwater; Jim O'Connor; Isaac J. Larsen; Michelle A. Hanson; Bruce N. Bjornstad; Karin E. Lehnigk.

422. **Accessible Field Geology of the Columbia River and Mount Hood.** Thurs., 14 Oct. Endorsers: *International Association for Geoscience Diversity; GSA Geoscience Education Division; National Association of Geoscience Teachers (NAGT); GSA Committee on Diversity.* Leaders: Anita Marshall, University of Florida; Nancy Riggs; Leah Miller; Kreeya Olson; Christopher L. Atchison.

423. **Middle Jurassic to Early Cretaceous Tectonic Evolution of the Western Klamath Mountains and Outboard Franciscan Complex, Northern California–Southern Oregon.** Fri.–Mon., 15–18 Oct. Endorser: *GSA Structural Geology and Tectonics Division.* Leaders: Alan Chapman, Macalester College; Todd A. LaMaskin; J. Douglas Yule; William L. Schmidt.

424. **Terroir of Wine of the Columbia Gorge—Relationship of Wine Flavor to Geology/Soils.** Fri., 15 Oct. Leader: Scott Burns, Portland State University.

Short Courses

Learn and explore a new topic. Build your skills.

Learn: Analysis of detrital geochronology data, ground penetrating radar, geophysics for bedrock and formation mapping, brittle and ductile deformation, age-depth modelling of sedimentary deposits, geo-thermo-petro-chronology, stormwater infiltration, climate adaptation and planning, and volcanic crisis awareness.

Explore: Mars analog soil, planetary image analysis with ArcGIS, NASA data with synthetic aperture radar (SAR), geodynamic history of the Himalayan Orogenic Belt, medical geology, forensic geochemistry, virtual microscopy, and unsupervised machine learning.

Strengthen your research, data collection and fieldwork skills with these courses: High-resolution topography and 3D imaging, 3D hydrogeological modeling, 3D printing for geoscience and engineering, creating 3D video-game-style geologic field trips, Stratigraphic Data Analysis in R (SDAR), resistivity surveying, drones in the geosciences, and field-safety leadership.

Gain Tips On: Place-based geoscience education, designing geoscience courses using active learning strategies, teaching quantitative structural geology, communicating science, improv to improve the geoscience community, geosciences and society, and tools to help write better code.

Students and early career professionals can learn about: Sequence stratigraphy and seismic structural interpretation.

For details and course descriptions, check the upcoming June issue of *GSA Today* or go to **https://community.geosociety.org/gsa2021/program/short.**

This is a great opportunity to earn continuing education credits!

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GEOCAREERS

Your Guide to Career Success

Perfect your professional portfolio by attending GeoCareers events at GSA Connects 2021.
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Learn more about a career in the geosciences by viewing past recorded webinars at **https://www.geosociety.org/webinars.**

Expanding Representation in Geosciences (ERG) Scholarship

Undergraduate student from groups underrepresented in the geosciences can apply for the ERG scholarship (US$1,500) to support their pursuit of a degree in the geosciences. Awardees will receive a complimentary, one-year GSA student membership and full meeting registration to GSA Connects 2021, 10–13 October. Apply by 15 May. **https://www.geosociety.org/erg**

Be a Mentor & Share Your Experience

Become a mentor and help students navigate GSA Connects 2021, introduce them to contacts, discuss career paths, and offer advice. Graduate students, early career professionals, professionals, and retirees are welcome to serve as mentors. Learn more at **https://www.geosociety.org/mentors**

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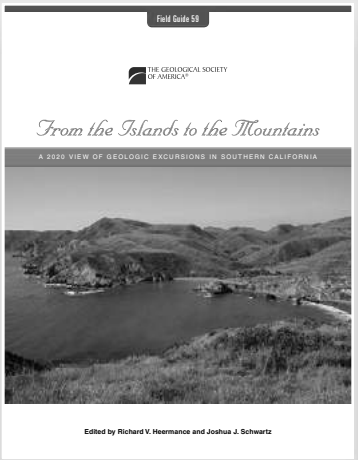

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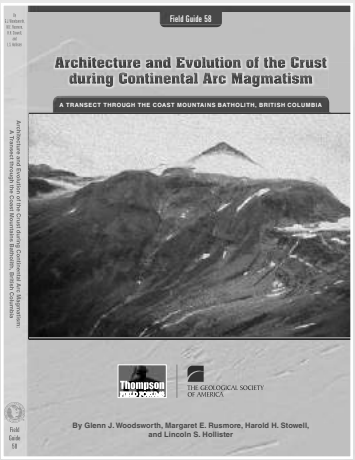

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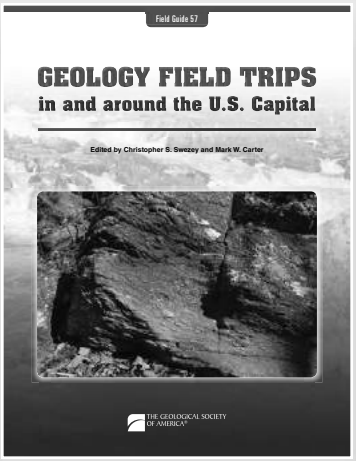

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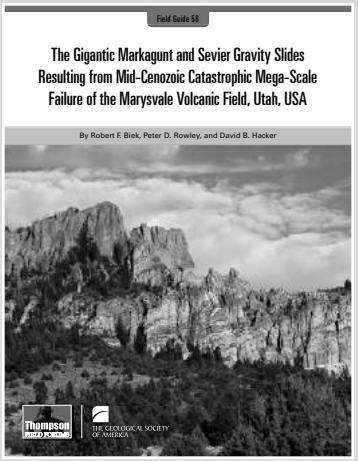

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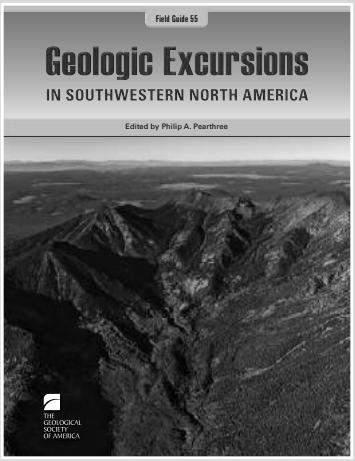

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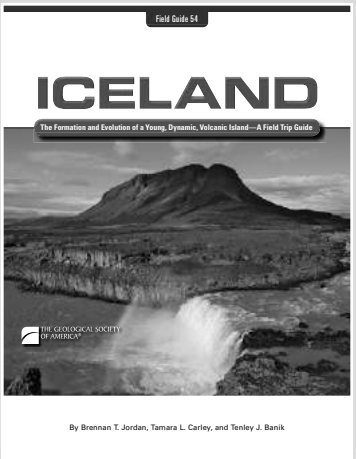

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Position Statement Revision and Call for Comments

GSA members are invited to submit comments and suggestions regarding the following major revision of the Water Resources Position Statement by 15 June 2021. Go to **https://www.geosociety.org/PositionStatements** to learn more and submit comments.

WATER RESOURCES: QUANTITY

Position Summary. Population growth drives decisions about water use for industrial, agricultural, municipal, and recreational purposes. Increasing demands and a changing climate pose significant, immediate challenges to ensuring sustainability of surface- and groundwater resources in the United States and globally. Broad, outcome-oriented water-resource science policies and initiatives are needed to address these issues.

This position statement (1) summarizes the consensus views of GSA on water-resource issues, specifically the quantity of surface- and groundwater available to meet societal needs; (2) advocates improved adaptive management of the availability of existing and future water resources through collaboration of water professionals, concerned citizens, and decision makers at all levels of government; and (3) provides a communications tool for geoscientists.

CONCLUSIONS AND RECOMMENDATIONS

Mitigating present-day and future, anticipated water shortages and managing water resources for the coming decades requires broad, sustained efforts and active collaboration among geoscientists, engineers, water-resource managers, planners, policy makers, and industry, who should seek to

- **Improve the fundamental understanding of the quality, quantity, distribution, and use of water resources to increase the reliability and use of water-resource management tools.** Critical to this is an increased understanding of (1) the interactions between geological, biological, and ecological systems and that quantity also refers to useable quality (water fit for human and ecological consumption); and (2) the impacts of climate change on the water cycle and water resource distribution, including the role of soil moisture in the hydrologic cycle, changes in type and duration of precipitation, and surface water–groundwater interaction.
- **Increase *public investment* in data collection and access to promote efforts to improve the scientific understanding of water resources.** A comprehensive understanding can be achieved by maintaining current hydrologic data and monitoring capabilities; developing new datasets and ground- and space-based collection capabilities at the spatial and temporal resolution needed to support model analyses and decision making from local to regional scales; organizing data collection and management by surface-water and groundwater hydrologic basins; and facilitating open-access to these datasets.
- **Support computational, risk-based analyses to optimize data acquisition and enhance the scientific and socioeconomic basis of decision making for water-resources management.**
- **Consider the natural behavior, distribution, and variability of surface-water and groundwater resources and identify viable twenty-first–century approaches and alternatives when developing regulations, laws, compacts, or treaties involving the allocation and use of these resources.**

RATIONALE

Surface-water and groundwater resources are inextricably linked; changes in one impact the other. Climate change exacerbates these impacts by directly affecting the hydrologic cycle on local to global scales. Increases in temperature accelerate evaporation from open water, soils, and vegetation. Additional water in the atmosphere combined with heat fuel extreme weather events, change water distribution patterns, intensify precipitation, decrease snowpack, and alter the timing of peak snowmelt. Temperatures in the U.S. increased by 0.7 °C for the period 1986–2016 relative to 1901–1960, with the largest increases seen in Alaska and the western U.S., and projected late-century increases are even greater[1,2]. Water distribution patterns will change as climate changes, resulting in too much water in some locations and too little water in others. A changing climate coupled with mis- or un-informed policy decisions further aggravate the problem.

Specifically, climate change will increase the frequency, intensity, and duration of drought in the western U.S., particularly the Southwest, with adverse impacts to water resources[1]. The Colorado River Basin and other major river basins in the western U.S. are undergoing aridification, or the ongoing, permanent transformation to a drier environment, to varying degrees[3]. Impacts of droughts include reduced surface-water flow and groundwater storage, reduced agricultural productivity, loss of biodiversity, soil degradation and loss, wildfires, increases in invasive species and disease, and increases in heat-related human deaths[4]. Droughts are the second costliest weather/climate-related disaster in the U.S. Between 1980 and 2020, 28 drought episodes resulted in more than US$1 billion in specific losses for each event, with an average loss of $9.28 billion per event[5].

Climate change will also lead to an increase in the frequency and intensity of heavy rainfall events (>99th percentile of daily values), most notably in the Midwest and in the Northeast, where changes average as much as 42% and 55% (compared to data available from 1958)[1]. Additional increases exceeding 40% are projected by the end of the century (relative to 1986–2015)[1]. Heavy rainfall events lead to increased runoff, flash flooding, mudflows and landslides, and sediment erosion and loading into the nation's waterways, all with associated impacts to infrastructure (levees, dams, stormwater management systems, etc.) or agriculture. Long periods of heavy rainfall can also reduce the capacity of the soil and underlying geologic substrate to absorb water, thereby challenging the recovery and replenishment opportunities in aquifers. In addition to the challenges offered by flooding events (see the GSA Position Statement: U.S. Flood Risk Management), significant changes in the timing and volume of precipitation can lead to agricultural drought conditions (as opposed to meteorological drought), where peak water availability may be out of phase with the growing season[6].

Thermoelectric power, irrigation, and public supply account for 90% of all surface-water and groundwater withdrawals in the U.S. (41%, 37%, and 12%, respectively)[7]. Although many renewable energy sources such as solar and wind reduce or eliminate the need for water in electricity production, reservoir hydropower and biofuel sources may have a large water footprint[8]. In addition, water is crucial for mining and processing minerals used in the manufacture of green technologies[9].

Given the longer residence time of groundwater (compared to surface water), aquifers can be slow to respond to stresses, and problems may not be noticed and remedied for many years[10]. About 70% of groundwater withdrawals in the U.S. are used for agriculture, and the extraction rate increasingly exceeds the replenishment rate in many areas, resulting in decreased groundwater storage[7]. Total groundwater depletion in the U.S. from 1900–2008 was about 1000 km^3, with faster depletion rates during 2000–2008[9]. Two-thirds of the depletion is from the High Plains aquifer (the largest in the U.S.), the Gulf Coastal Plain aquifer system (Mississippi Embayment section), and the Central Valley aquifer in California[10,11]. Sustained groundwater withdrawals and subsequent lowering of the water table can result in the loss of connectivity with and decreased flow of surface water. Streamflow losses can extend far beyond the region of pumping[12]. Drilling deeper is not a sustainable solution; deeper aquifers tend to be more saline and require treatment, and deeper wells tend to have higher construction costs and energy demands[13]. Furthermore, deeper aquifers may contain fossil groundwater, where recharge could take thousands of years.

Mitigating groundwater depletion will require reducing demand, particularly in irrigated agriculture, and increasing supply through artificial aquifer recharge and other methods[10]. Efforts at the municipal level to capture stormwater and use gray water can enhance local water supplies and show promise for sustainable urban water management[14]. Any mitigation strategy is complicated by the fact that local groundwater conditions can be highly variable and cross geopolitical boundaries. Scientific and technical issues are often coupled with political, legal, and socioeconomic considerations and constraints[10]. Given these complexities, we must recognize that one technical approach is not appropriate for all aquifers, and solutions will require comprehensive and integrated analysis and discussion.

Comprehensive and robust datasets with high spatial and temporal resolution, including basin- and aquifer-scale geophysical data and three-dimensional geologic maps are needed to inform groundwater modeling and address the issues outlined above. The U.S. Geological Survey (USGS) has developed and maintained extensive surface- and groundwater monitoring networks[15] and databases such as the National Hydrography Dataset[16], but gaps in coverage and data remain[17]; the USGS is currently developing a Next Generation Water Observing System (NGWOS) that will address these gaps and eventually "provide high temporal and spatial resolution data on streamflow, evapotranspiration, snowpack, soil moisture, water quality, groundwater/surface-water connections, stream velocity distribution, sediment transport, and water use[17]." At regional and global scales, satellites such as the Gravity Recovery and Climate Experiment (GRACE) launched in 2002 and GRACE Follow-On (GRACE-FO) launched in 2018 provide terrestrial water storage information based on changes in Earth's gravitational field[18]. Such data combined with ground- and model-based approaches are critical for understanding causes and variations in surface- and groundwater quantities, seasonal to decadal variations, and opportunities for storage and replenishment in the face of climate change, drought, flooding and runoff, and anthropogenic influence.

OPPORTUNITIES FOR GSA AND GSA MEMBERS TO HELP IMPLEMENT RECOMMENDATIONS

To facilitate implementation of the goals of this position statement, The Geological Society of America recommends that its members take the following actions:

- Collaborate with stakeholders (water managers, land managers, water users, policy makers, regulators, and the public) to identify information needs and to develop sustainable water-resource management goals and plans.
- Participate in public-education activities to foster partnership and collaboration among local, state, and federal governments; educational and research institutions; energy, industrial, and agricultural users; and the public.
- Participate in professional forums to educate peers and the public about regional water quantity issues, including the role of climate change in altering the hydrologic cycle, and identify ways that better data and analyses can improve water-resource management.
- Ensure that water footprint[19,20] (both direct and indirect water use) informs both personal and professional decisions every day as well as during future planning efforts.
- Improve communication with decision makers and the public about water resource availability issues. Communication is aided by analogies and examples relevant to the affected stakeholders/populations.

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Learn More about GSA's Environmental & Engineering Geology Division

Authors: GSA Environmental & Engineering Geology Division Board members: **Robert Mitchell,** Chair; **Thomas Oommen,** First Vice-Chair: **Arpita Nandi,** Second Vice-Chair; **Francis Rengers,** Secretary/Treasurer

Applied geology is the practice of taking geologic research and applying that knowledge to solve society's geologic problems. GSA's Environmental & Engineering Geology Division (EEGD) consists of applied geologists and geological engineers dedicated to solving some of Earth's greatest problems, from climate change to groundwater contamination. The umbrella of environmental and engineering geology covers an immense range of skill sets and backgrounds, including geologic hazards, soil and rock mechanics, hydrogeology, environmental geology, economic and mining, geoinformatics, geomechanics, remote sensing, and many others. Because of this range, there is no single research area, expertise, or academic study that defines the members of EEGD. Our membership ranges from students, academics, and professional geologists from private industry and government agencies.

Over the decades, the strength of EEGD has come from its broad interdisciplinary foundation, as evidenced by its sponsorship of numerous technical sessions and Pardee Symposia at annual GSA meetings. Though the Division was founded nearly 75 years ago, it has adapted with the changing science and interests of Division membership. The Division originally centered on the role of engineering geologists in the built environment and hazard assessments. In 2010, to embrace the growing sector of geologists involved in environmental issues, the Division leadership added "environmental" to our name.

The Division's mission is to advance the ability of geoscientists to identify, characterize, and mitigate adverse geological and environmental conditions and hazards in the interest of public health and safety and the protection of property. To do so, the Division promotes research, education, and dissemination of information relevant to members and is proud to be the only GSA Division to cosponsor publications: *Environmental and Engineering Geoscience*, cosponsored with the Association of Environmental and Engineering Geologists (AEG), and *Reviews in Engineering Geology*, cosponsored with the GSA. To encourage public health and safety, EEGD also advocates for properly trained professionals through geologic licensing. The core of our practicing members are licensed professional geologists in the states that they serve.

Although inherently interdisciplinary, a fundamental theme of the Division has historically been landslide hazards. Division leadership over the years has dominantly been academics and professionals involved in some form of landslide-related topic—mapping, mechanics, modeling, education, and mitigation. Under the leadership of former EEGD board chairs Bill Burns and Matt Crawford, the Division recently (2020) formed a Landslide Committee. The committee is open to any GSA member. Its charge is to collaborate with AEG's Landslide Workgroup to motivate research, outreach, and communication regarding landslide hazards and risk reduction. Given that landslides are one of the most common geologic hazards and occur in all 50 states, the committee's goal is to engage state and federal agencies, university researchers, cities, counties, private consultants, and others working to reduce landslide risks.

Like other GSA Divisions, our growth and sustainability rely on student participation. As such, we continue to make attempts to engage them. In 2015, we seated our first student representative on our board, which has greatly improved our outreach. Our motivated student leaders have introduced social media instruments, student newsletters, and mentoring opportunities at the annual GSA meeting. We recently voted that our EEGD student membership will be free starting in 2022. The Division also annually honors graduate research with the Roy J. Shlemon Scholarship Award and celebrates student research with its student poster competition at the annual GSA meeting.

Our most effective outreach mechanism, though, is through the Richard H. Jahns Distinguished Lectureship, which we cosponsor with AEG. Every year since 1988, an eminent applied geoscientist is chosen to promote student awareness of environmental and engineering geology through a series of lectures presented at numerous academic institutions across the nation.

Moving forward, we anticipate the Division's growth will be driven by expanding our mission to embrace a more diverse membership. In concert with the values set forth in the GSA Diversity in the Geoscience Community Position Statement we encourage a community of people from all backgrounds to ensure healthy, safe, and sustainable communities. This includes professionals with a diversity of skill sets that bridge traditional field observations with advancing technological and computational tools and science communicators who make discoveries and recommendations accessible to the public. The outcome will be more creative geoscientists and engineers with a global presence required to address emerging problems driven by climate-change resilience and a growing population. What will not change is the Division's commitment to highlight advancing applied geoscience at the annual GSA meeting, through our publication series, and a projected stronger presence at GSA Section Meetings.

Be a Part of the On To the Future Community

Increasing diversity and inclusivity is critical to innovation, scientific advancement, and solving tomorrow's geoscience challenges. Don't miss the opportunity to apply to the On To the Future (OTF) program if you are a student. The OTF program supports students from diverse backgrounds to attend their first GSA Connects meeting, which is 10–13 October this year, in Portland, Oregon, USA. As an OTF awardee, you will be paired with a mentor, have opportunities to interact with GSA leadership, learn about future opportunities, attend a professional development workshop, and experience the meeting with a cohort of first-time attendees.

GSA Connects 2021 is currently being planned as an in-person meeting with online components, but we are ready to pivot to a fully online meeting if needed. You can read GSA's official statement at **https://community.geosociety.org/gsa2021/information/planning.** Nevertheless, OTF will award full meeting registration, membership, and other costs that may include travel and/or lost wages for attending the meeting should the meeting be fully online.

Join more than 647 participants who have completed the program and apply by 28 May to attend GSA Connects 2021. GSA welcomes applications from low-income, underrepresented, first-generation, non-traditional, women, veterans, LGBTQ+, students with disabilities, and others.

Participant Comments

"My favorite part about OTF was that I loved having a mentor. Being able to ask all the questions and concerns about graduate school and future opportunities was amazing. Learning the next steps that I am supposed to take to be better prepared for my career in geosciences helps me a lot." —Santa Lucía Pérez Cortés

"I feel like OTF captures this quite well, the program gathered people in similar situations who are also succeeding in their fields, which gave me a great sense of community. Ultimately, I feel like I gained more confidence in myself and my ability to conduct meaningful research through the unity and community this program provides." —Tiffani Cáñez

"While this was not my first conference that I've attended, I felt the tools, workshops, mentoring, and opportunities discussed through the OTF program were a huge benefit." —Samsideen Ajala

https://www.geosociety.org/OTF

CALL FOR GSA COMMITTEE SERVICE

Help Shape the Future of Geoscience

Deadline: 15 June 2021
Terms begin 1 July 2022 (unless otherwise indicated)

If you are looking for the opportunity to work toward a common goal, diversify GSA leadership, network, and make a difference, then we invite you to volunteer (or nominate a fellow GSA member) to serve on a Society committee or as a GSA representative to another organization. GSA especially welcomes volunteers or nominations of people from underrepresented groups.

Learn more and access the nomination form at **https://rock.geosociety.org/Nominations/CS.aspx.** Open positions and qualifications are also online at **https://rock.geosociety.org/forms/viewopenpositions.asp.** GSA headquarters contact: Dominique Olvera, P.O. Box 9140, Boulder, CO 80301-9140, USA; fax: +1-303-357-1070; dolvera@geosociety.org.

Committee, Section, and Division Volunteers: Council Thanks You!

GSA Council acknowledges the many member volunteers who have contributed to the Society and to our science through involvement in the affairs of the GSA. Your time, talent, and expertise help build a solid and lasting Society.

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

Academic and Applied Geoscience Relations Committee

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

This committee is charged with strengthening and expanding relations between GSA members in applied and academic geosciences. As such, it proactively coordinates the Society's effort to facilitate greater cooperation between academia, industry, and government geoscientists. **Qualifications:** Committee members must work in academia, industry, or government and be committed to developing a better integration of applied and academic science in GSA meetings, publications, short courses, field trips, and education and outreach programs. Professional interest: Environmental and Engineering Geology, Hydrogeology, Karst, Quaternary Geology and Geomorphology, Structural Geology and Tectonics, Sedimentary Geology. Members must also be active in one or more GSA Divisions.

Annual Program Committee

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

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

Arthur L. Day Medal Award

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

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

Bascom Mapping Award Committee

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

This committee selects candidates for the Florence Bascom Geologic Mapping Award. This award acknowledges contributions in published high-quality geologic mapping that led the recipient to publish significant new scientific or economic-resource discoveries, and to contribute greater understanding of fundamental geologic processes and concepts. **Qualifications:** Members should be knowledgeable in the field of mapping.

Diversity in the Geosciences Committee

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

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

Education Committee

Graduate Educator Representative (4-year term; E, M);
Informal Science Educator Representative (4-year term; E, M);
Undergraduate Student Representative (2-year term; B, E, M)

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

Geology and Public Policy Committee

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

This committee provides advice on public policy matters to Council and GSA leadership by monitoring and assessing international, national, and regional science policy; formulating and recommending position statements; and sponsoring topical white papers. This committee also encourages the active engagement in geoscience policy by GSA members. **Qualifications:** Members should have experience with public-policy issues involving the science of geology;

the ability to develop, disseminate, and translate information from the geologic sciences into useful forms for the general public and for GSA members; and familiarity with appropriate techniques for the dissemination of information.

GSA International

Member-at-Large (4-year term; E, M); Member-at-Large, North America (4-year term; E, M); Member-at-Large, outside North America (4-year term; E, M); Member-at-Large Student (2-year term; E, M); International Associated Society Member (4-year term; E, M)

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

Membership and Fellowship Committee

Two Members-at-Large-Academia (3-year term; B); Member-at-Large Government (3-year term; B)

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

North American Commission on Stratigraphic Nomenclature

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

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

Nominations Committee

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

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

Penrose Conferences and Thompson Field Forums Committee

Four Members-at-Large (3-year term; E)

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

Penrose Medal Award Committee

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

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

Professional Development Committee

Former Councilor (3-year term; E); Member-at-Large Student (3-year term; E)

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

Publications Committee

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

The primary responsibilities of the committee are nomination of candidates for editors when positions become vacant; reviewing the quality and health of each Society publication; and reporting with an annual report to Council that includes recommendations for changes in page charges, subsidies, or any other publishing matter on which Council must make a decision. To carry out this charge, GSA headquarters will provide the committee with all necessary financial information.

Research Grants Committee

Eleven Members-at-Large with various specialties (3-year term; B, T)

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

Young Scientist Award (Donath Medal) Committee

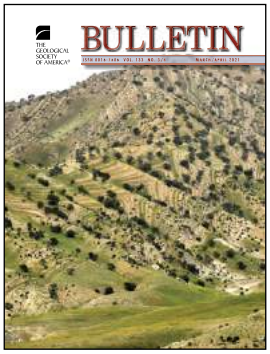
Two Members-at-Large (3-year term; E, T)

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

GSA PUBLICATIONS HIGHLIGHTS

Exceptional Reviewers for 2020

GSA appreciates the many people who make its peer-reviewed journals possible: the authors, science editors, editorial board members, associate editors, and most of all, the reviewers. Peer review of papers is the cornerstone of scientific publishing, but reviewing papers is all too often a thankless task. For all those who complete timely, thorough, and even-handed reviews, GSA thanks you. GSA's journal science editors have selected the following people for special recognition of the many prompt, insightful, meticulous, and tactful reviews they completed. (Photos of these colleagues are posted at **https://www.geosociety.org/GSA/Publications/GSA/Pubs/exceptional_reviewers.aspx**.)



GSA BULLETIN

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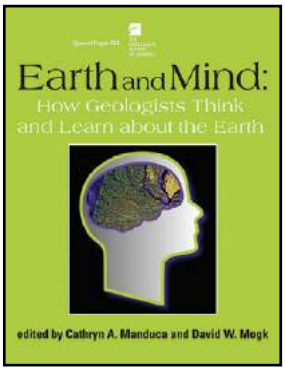
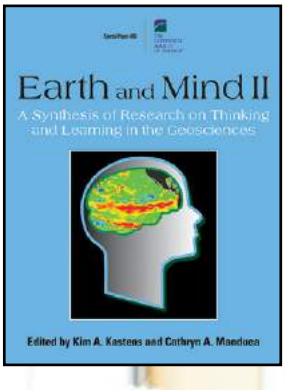
Marta E. Torres, Oregon State University

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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THE GEOLOGICAL SOCIETY OF AMERICA®

Meaningful Partnerships: Brunton and GSA

Corporate partners have long been a crucial part of the development and financial support of the GSA Foundation and GSA programs. While contributed funds are vital to the existence of many programs, so is the hands-on, engaged participation of companies and their employees. Our partners are highly committed to the next generation of geoscientists, and we are thrilled to welcome Brunton as an organizational partner. Geologist D.W. Brunton created the Pocket Transit Compass in 1894—just six years after GSA was established; the now-indispensable compass maker and the almost 133-year-old geological society are a symbiotic pairing. With Brunton's legacy of excellence in its gold-standard instruments, and the Geological Society of America's legacy of commitment to geoscience research, discovery, and stewardship, the two organizations share like values of steadfastness and distinction.

Partnering for GSA 2020 Connects Online, Brunton offered discounts to meeting attendees who could enjoy live virtual tours of the company's production facility in Riverton, Wyoming, USA. In addition to supporting the meeting with sponsorship funds, Brunton established an ongoing GSA member discount for its products. The depth and breadth of partnerships is rounded out by individuals within companies, and Brunton's new Sales Manager and Product Specialist, Lauren Heerschap, brings her own special connection to GSA: while working on her master's degree in geology at the University of Colorado Boulder, Lauren received a GSA Graduate Student Research Grant in 2002, which helped support her tectonic geomorphology fieldwork in central Taiwan. In 2003, Lauren participated in the GSA Penrose Conference on Tectonics and Climate in Taiwan, and she had the opportunity to bring participants through her tectonically active field area of Puli, Taiwan, before the main conference convened in the spectacular Taroko Gorge. She became a student member of GSA in 2002 and has attended, presented, and worked at many GSA annual and Section Meetings since then. Lauren went on to work for the Colorado Geological Survey before nine years of teaching at Fort Lewis College, including field methods courses and ten summer field camps for several schools. Through that experience, Lauren invented a new model of geologic compass and associated measurement methods, patenting and licensing to Brunton what is now the Axis Transit. Now at Brunton in Riverton, Wyoming, USA, she works alongside her husband, David, who is the head of Brunton's research and development department, to continue innovating new tools that best serve field professionals around the world. Lauren is excited to serve the geological community in this new role and looks forward to meeting many of you at future events, or better yet, out in the field!

Lauren Heerschap examining an overhanging strike and dip measurement with the Axis near Lander, Wyoming, USA.

In 2021, the company solidified its partnership with the Society in yet another meaningful contribution, specifically to students: Brunton will provide a ComPro Transit for each of GSA's 2021 J. David Lowell Field Camp Scholarship recipients. Although the financial award helps offset field camp costs, this generous gift will further decrease equipment expenses for each of these students while providing them with the geologist's most essential instrument.

GSA values ongoing corporate relationships with partners like Brunton that have strong ties to our mission and our membership. Together, we can maximize the collective ability to foster current and future leaders in the geoscience community. We strive to engage business and industry as a positive force to advance science, stewardship, and service, joining with corporations in the meaningful impacts of partnership. If you want to learn how you or your employer can join these efforts, please contact Debbie Marcinkowski at +1-303-357-1047 or dmarcinkowski@geosociety.org.

www.gsa-foundation.org

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- GSA invites the participation of individuals currently being underserved in geoscience career fields.
- Up to $10,000
- Applications open: 1 Apr. 2021
- Applications close: **26 May 2021 (5 p.m. MDT)**

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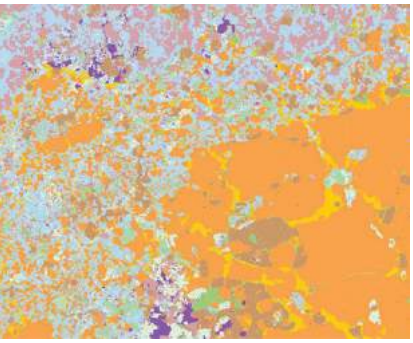

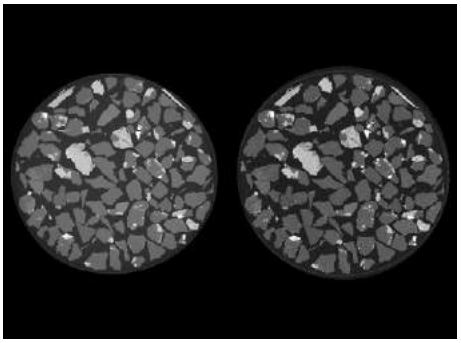

Photos: ZEISS