GSA TODAY

THE GEOLOGICAL SOCIETY OF AMERICA®

VOL. 30, NO. 5 | MAY 2020

Remnants and Rates of Metamorphic Decarbonation in Continental Arcs

EXPAND YOUR LIBRARY
with GSA E-books

The **GSA Store** offers hundreds of e-books, most of which are only $9.99.

These include:

- popular field guides and maps;
- out-of-print books on prominent topics; and
- discontinued series, such as Engineering Geology Case Histories, Reviews in Engineering Geology, and the Decade of North American Geology.

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

Get 50% off ebooks in the GSA Store until 22 May. Use coupon code EARTHDAY at checkout.

Shop now at https://rock.geosociety.org/store/.

MAY 2020 | VOLUME 30, NUMBER 5

GSA TODAY

GSA TODAY (ISSN 1052-5173 USPS 0456-530) prints news and information for more than 22,000 GSA member readers and subscribing libraries, with 11 monthly issues (March-April is a combined issue). *GSA TODAY* is published by The Geological Society of America® Inc. (GSA) with offices at 3300 Penrose Place, Boulder, Colorado, USA, and a mailing address of P.O. Box 9140, Boulder, CO 80301-9140, USA. GSA provides this and other forums for the presentation of diverse opinions and positions by scientists worldwide, regardless of race, citizenship, gender, sexual orientation, religion, or political viewpoint. Opinions presented in this publication do not reflect official positions of the Society.

Subscriptions: GSA members: Contact GSA Sales & Service, +1-888-443-4472; +1-303-357-1000 option 3; gsaservice@geosociety.org for information and/or to place a claim for non-receipt or damaged copies. **Nonmembers and institutions:** *GSA TODAY* is US$105/yr; to subscribe, or for claims for non-receipt and damaged copies, contact gsaservice@geosociety.org. Claims are honored for one year; please allow sufficient delivery time for overseas copies. Periodicals postage paid at Boulder, Colorado, USA, and at additional mailing offices. Postmaster: Send address changes to GSA Sales & Service, P.O. Box 9140, Boulder, CO 80301-9140.

***GSA TODAY* STAFF**

Executive Director and Publisher: Vicki S. McConnell

Science Editors: Mihai N. Ducea, University of Arizona, Dept. of Geosciences, Gould-Simpson Building, 1040 E 4th Street, Tucson, Arizona 85721, USA, ducea@email.arizona.edu; **Peter Copeland,** University of Houston, Department of Earth and Atmospheric Sciences, Science & Research Building 1, 3507 Cullen Blvd., Room 314, Houston, Texas 77204-5008, USA, copeland@uh.edu.

Member Communications Manager: Matt Hudson, mhudson@geosociety.org

Managing Editor: Kristen "Kea" Giles, kgiles@geosociety.org, gsatoday@geosociety.org

Graphics Production: Emily Levine, elevine@geosociety.org

Advertising Manager: Ann Crawford, +1-800-472-1988 ext. 1053; +1-303-357-1053; Fax: +1-303-357-1070; advertising@geosociety.org

GSA Online: www.geosociety.org
GSA TODAY: www.geosociety.org/gsatoday

Printed in the USA using pure soy inks.

SCIENCE

Cover: Skarn mineralization in the Mineral King roof pendant, Sierra Nevada, California, USA. Green clinopyroxene, garnet (brown), wollastonite (fine-grained white) skarn partially replace coarse-grained calcite in marble. See related article, p. 4–10.

GSA 2020 Annual Meeting

THE GEOLOGICAL SOCIETY OF AMERICA®

Remnants and Rates of Metamorphic Decarbonation in Continental Arcs

Evan J. Ramos*, *Dept. of Geological Sciences, University of Texas, Austin, Texas 78712, USA;* ***Jade Star Lackey,*** *Geology Dept., Pomona College, Claremont, California 91711, USA;* ***Jaime D. Barnes,*** *Dept. of Geological Sciences, University of Texas, Austin, Texas 78712, USA;* ***Anne A. Fulton**,*** *Geology Dept., Pomona College, Claremont, California 91711, USA*

ABSTRACT

Metamorphic decarbonation in magmatic arcs remains a challenge to impose in models of the geologic carbon cycle. Crustal reservoirs and metamorphic fluxes of carbon vary with depth in the crust, rock types and their stratigraphic succession, and through geologic time. When byproducts of metamorphic decarbonation (e.g., skarns) are exposed at Earth's surface, they reveal a record of reactive transport of carbon dioxide (CO_2). In this paper, we discuss the different modes of metamorphic decarbonation at multiple spatial and temporal scales and exemplify them through roof pendants of the Sierra Nevada batholith. We emphasize the utility of analogue models for metamorphic decarbonation to generate a range of decarbonation fluxes throughout the Cretaceous. Our model predicts that metamorphic CO_2 fluxes from continental arcs during the Cretaceous were at least 2 times greater than the present cumulative CO_2 flux from volcanoes, agreeing with previous estimates and further suggesting that metamorphic decarbonation was a principal driver of the Cretaceous hothouse climate. We lastly argue that our modeling framework can be used to quantify decarbonation fluxes throughout the Phanerozoic and thereby refine Earth systems models for paleoclimate reconstruction.

INTRODUCTION

How much "bark" was in the arc? The question of CO_2 contribution from magmatic arcs, especially continental arcs that poise platform carbonates in the paths of ascending magmas (Lee et al., 2013), is important given the power of tectonically outgassed CO_2 to modulate Earth's climate (e.g., Royer et al., 2004; Lee et al., 2013; McKenzie et al., 2016). CO_2 fluxes from continental arcs are the cumulative expression of magmatism, contact metamorphism and assimilation of sedimentary rocks by magmas, and fluid flow through the crustal column. Because of its connection to magmatic and hydrothermal systems (e.g., Baumgartner and Ferry, 1991), metamorphic CO_2 production in continental arcs remains a challenge to quantify and has thus been on the periphery of most studies. The movement of CO_2 during metamorphism is further complicated by metamorphic reaction progress, fluid availability, geothermal gradients, and chemical potentials. Nonetheless, the strides made in studies of continental arcs position us to advance our understanding of metamorphic decarbonation through geologic time, its role in the carbon cycle, and its influence on past climates.

Maps of fossilized magmatic systems and experiments replicating sub-arc and lower crustal environments have been employed to estimate CO_2 fluxes from continental arcs. In general, these studies establish upper and lower estimates for CO_2 fluxes from continental arcs, but questions remain regarding the proportion of CO_2 produced via metamorphism. For example, estimates of area addition rates of magma through geologic time proxy for magma fluxes (Cao et al., 2017; Ratschbacher et al., 2019), which are critical parameters that set the tempo and duration of metamorphic decarbonation (e.g., Cathles et al., 1997). Without information regarding the rocks in which the magma intrudes, only magmatic CO_2 fluxes from continental arcs can be approximated. Experiments replicating sub-arc and lower crustal conditions show that carbonate rock can be almost wholly decarbonated (Carter and Dasgupta, 2016), which has been corroborated by observations of extremely low $^{13}C/^{12}C$ ratios of calc-silicate xenoliths from the Merapi volcano (Whitley et al., 2019). The degree to which continental arc magmas completely decarbonate their host rocks is unknown, but given the relatively open-system nature of continental arcs, these findings likely reflect upper limits for decarbonation rates.

The geochemical and isotopic composition of volcanic emissions from active continental arcs reveal CO_2 generated by metamorphism. A global compilation of CO_2/S_T measurements shows that arcs where magma intrudes platform carbonates often produce large CO_2 fluxes (Aiuppa et al., 2019). Moreover, the isotopic composition of volcanic emissions from these continental arcs further suggests input of sedimentary carbon (Mason et al., 2017). Despite these advancements, measurement uncertainty in these data hampers a quantitative assessment of the metamorphic proportion of continental arc CO_2 outputs. By focusing on active systems, this approach cannot convey how continental arc magmatism and concomitant CO_2 fluxes have changed through geologic time.

Numerical models have been useful in understanding metamorphism in continental arcs. Studies have typically scaled observations, such as changes in the length of continental arcs through time, to fluxes of metamorphic CO_2 (e.g., Mills et al., 2019; Wong et al., 2019). Although these methods provide meaningful boundary estimates, they do not fully consider the thermodynamics of reactive transport. Other studies have used

GSA Today, v. 30, https://doi.org/10.1130/GSATG432A.1.

*Corresponding author: ejramos@utexas.edu.

**Now at Dept. of Geology and Geological Engineering, Colorado School of Mines, Golden, Colorado 80401, USA.

numerical models of open-system heat and mass transfer (e.g., Nabelek et al., 2014; Chu et al., 2019), providing accurate flux estimates. The drawback of these models, however, is that they involve geologic specificity that belies a broad representation of metamorphism in continental arcs. To predict how metamorphic decarbonation has varied through geologic time, a balance between these common approaches needs to be found.

In this paper, we show that sedimentary, igneous, and metamorphic rock evidence can be used to quantify the rates of metamorphic decarbonation in continental arcs through the Phanerozoic. Metamorphic rocks in continental arcs can directly trace decarbonation rates, but the reactive transport processes involved in their formation is not simple. We thus review common rocks that form through metamorphic decarbonation in the shallow crust, the reactions and conditions that generate them, and the CO_2 amounts that they can release as a byproduct of their formation. Additionally, through numerical modeling, we demonstrate that the volume fraction of sedimentary rock that undergoes decarbonation can be related to the relative volumes of sedimentary rock and magma in continental arcs. This finding is validated against the well-characterized rock record of the Cretaceous Sierra Nevada batholith (SNB). When compiled stratigraphic sections of North America and arc magma fluxes through the Phanerozoic are imposed in our model, we predict how fluxes of CO_2 from metamorphic decarbonation changed through geologic time.

FIELD OBSERVATIONS OF DECARBONATION AND RE-CARBONATION IN THE ROCK RECORD

There is abundant rock-hosted evidence for CO_2 liberation, transport, and immobilization in exhumed arc crust within circum-Pacific batholiths, including the SNB. Whereas the isolated screens and roof pendants of metamorphic rocks appear as slivers in granitoid plutons, they are volumetrically underrepresented at Earth's surface due to erosion, overprinting by younger intrusions, and/or downward transport to the sub-arc during pluton emplacement (e.g., Ducea et al., 2015). These rocks show abundant evidence that carbonate-bearing rocks spanned from upper crustal contact aureoles to lower crustal granulite facies domains (e.g., Kerrick, 1977; Newberry and Einaudi, 1981). The capacities of these pendants to produce CO_2 are tied to their protoliths, fluid budgets, and reaction progresses (Fig. 1A).

Skarn rocks, composed of varying proportions of garnet, pyroxene ± wollastonite, are synonymous with decarbonation (Fig. 1B) and are often associated with economic base and precious metal deposits. Skarns epitomize optimal conditions for releasing CO_2 where infiltration of water-rich fluid maintains high chemical potentials, driving decarbonation locally to completion (e.g., Chu et al., 2019, and references therein). For example, a cubic meter of garnetite skarn signifies 1.01–1.05 metric tons of CO_2 released from calcite (Lee and Lackey, 2015).

Skarns often form at shallow crustal depths (3–5 km) and along the margins of granitoid rocks that intruded into carbonates.

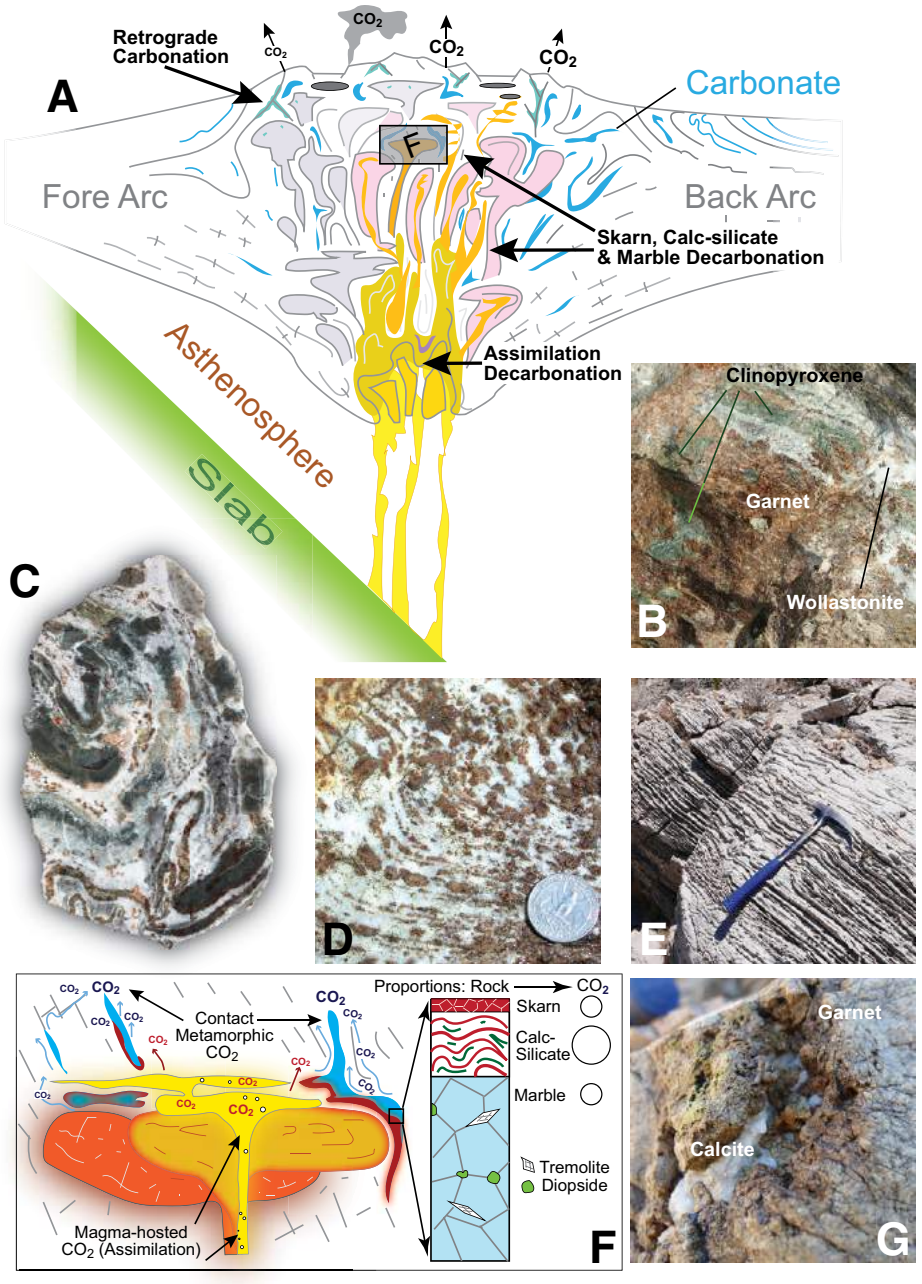


Figure 1. Arc decarbonation. (A) Schematic representation of plutons intruding carbonate-bearing crust at various depths in a magmatic arc (not to scale); (B) 30-cm-wide outcrop of garnet, clinopyroxene, and wollastonite (white) typical of Sierra Nevada batholith skarn; (C) 20-cm-wide slab of garnet-wollastonite-diopside calc-silicate rock with folding of original sedimentary structures; (D) calc-silicate with garnet (red) showing traces of Al-rich domains in garnet-wollastonite calc-silicate (coin is 24 mm across); (E) laminated carbonate typical of rocks metamorphosed to form C and D (hammer is 28 cm long); (F) cartoon depicting metamorphic decarbonation, common metamorphic rock types, their protoliths, CO_2 yields; (G) retrograde calcite deposited in 1-cm-wide cavity within garnet skarn.

Any carbonate that was not converted to skarn coarsens into *marble*. Marbles are more abundant than skarns (Fig. 2B) and can appear to be relatively unaffected by metamorphic decarbonation. Yet, small amounts of reaction progress are enabled by trace quantities (<5 modal %) of quartz present, producing considerable amounts of CO_2 (~32–46 kg CO_2 per cubic meter of rock; Ferry, 1989). Further, if marble bodies abut water-rich metapelitic units, CO_2 can diffuse out of the marble and thus export nontrivial amounts of CO_2 (e.g., Vidale and Hewitt, 1973; Ague, 2000).

Calc-silicate rocks, with white, green, or red laminations inherited from sedimentary laminations, are also composed of microcrystalline wollastonite, pyroxene, and garnet (Fig. 1C–1E). Whereas skarns see copious CO_2 release by fluid infiltration and metasomatism of originally pure carbonate rocks, calc-silicates release similar amounts of CO_2 because interbedded layers of carbonate, silica, and clay minerals predispose mixed carbonate-siliciclastic rocks to fully decarbonate (Fig. 1F). Water-rich fluids are still necessary to fully decarbonate these rocks, but their laminated character can cause a positive feedback that enables near-complete decarbonation. The enhancement of permeability during decarbonation promotes CO_2 transport, enabling further decarbonation (e.g., Zhang et al., 2000).

Even if thermodynamic conditions enable decarbonation to proceed, not all CO_2 produced makes it out of the crust. CO_2 is most often immobilized when low crustal permeability inhibits fluid flow or magma production rates decrease. Secondary carbonate deposition represents CO_2 immobilization in arcs, often occurring away from hotter, deeper areas of the arc crust, and down temperature gradients. Examples include calcite veins that cross-cut skarn rocks and precipitate in vugs and brittle fractures (Fig. 1G). Other silicates that form when CO_2 is mineralized, including retrograde serpentine and tremolite, occur appreciably (up to 2 wt%), even when crustal permeability is high enough to promote continued CO_2 removal (Nabelek et al., 2014). Veins and deposits at shallower levels in the crust are further evidence that CO_2 can be reprecipitated. Even granitoids in arc crust are noted to contain regular but small amounts of calcite (0.2–1.0 wt%; White et al., 2005). Overall, these observations suggest that seemingly trace amounts of retrograde CO_2 mineralization can manifest in large masses of CO_2 left behind after prograde metamorphic decarbonation.

The journey of an individual molecule of CO_2 can be complicated by a series of prograde and retrograde reactions at different times and locations in the arc crust. Yet, at a fundamental level, the amount of metamorphically derived CO_2 that exits from continental arcs directly relates to the composition of rocks that comprise the arc and the amount of magma that is emplaced over a given time. These underlying principles, while still considering the intricacies of metamorphic decarbonation and its geologic record, motivate our model design.

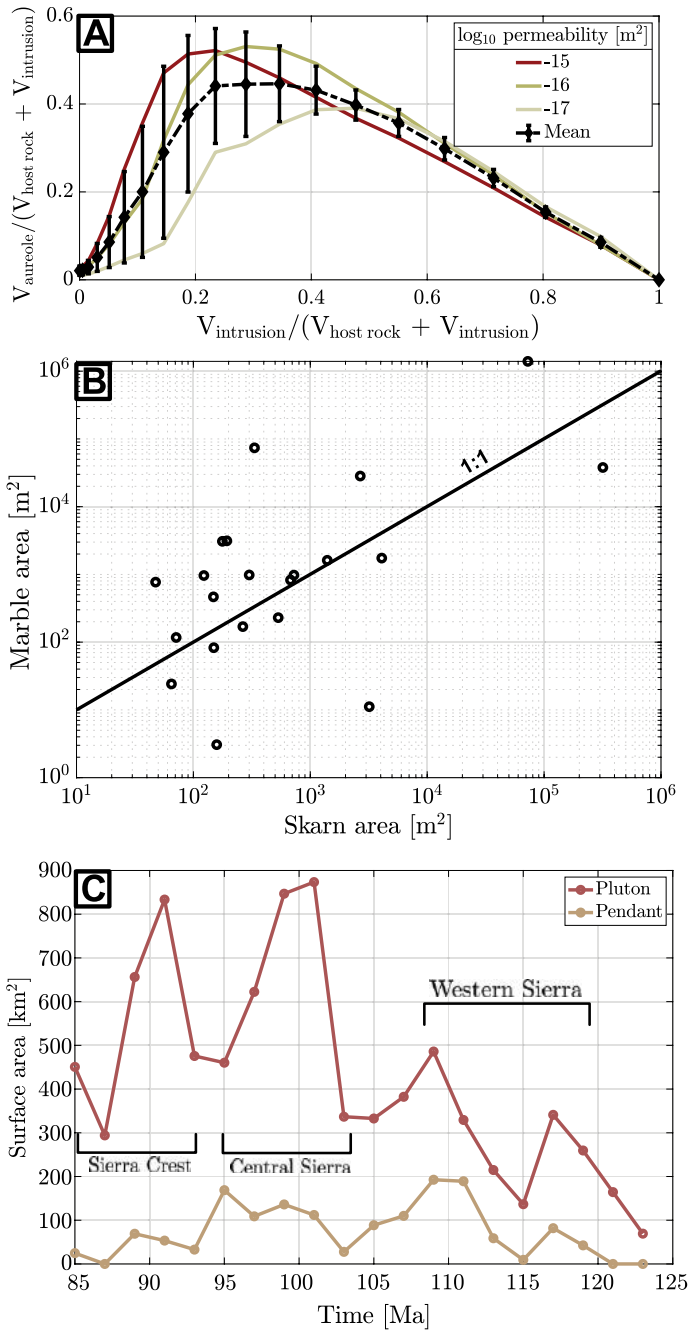


Figure 2. (A) Predicted volume fraction of aureole as a function of volume fraction of intrusion. Error is 1σ. (B) Skarn-marble area distributions for a corridor of the Sierra Nevada batholith (SNB). (C) Surface area addition rates for intrusions and metamorphic pendants in the SNB through the 40 m.y. of elevated magmatic activity.

ANALOGUE MODEL FOR METAMORPHIC DECARBONATION

The basis of the analogue model is to determine the volume of sedimentary rock

that undergoes decarbonation in a continental arc. The model simulates two-dimensional fluid flow, heat transfer, and fluid-rock oxygen isotope exchange after the emplacement of an intrusion as a proxy for metamorphic decarbonation (further model setup and assumptions are described in Ramos et al., 2018, and in the Supplementary Information[1]). The $\delta^{18}O$ values of carbonates decrease during progressive decarbonation (e.g., Bowman, 1998). Therefore, in each simulation, we track the changes in host-rock $\delta^{18}O$ values during hydrothermal fluid flow to highlight areas around a magma body that meet likely conditions for decarbonation. Once hydrothermal activity has ceased, the $\delta^{18}O$ values of the host rock define a volume of rock that undergoes decarbonation, which we term the aureole volume.

Our numerical model considers effects of crustal permeability and magma volume on aureole volumes. The model domain remains constant across each simulation (i.e., $V_{host\ rock} + V_{intrusion}$ = constant; Fig. DR3, see footnote 1). A series of model runs predicts aureole volumes as a function of intrusion volume and crustal permeability where the largest volumes of decarbonated host rock ($V_{aureole}$) are at intermediate relative intrusion volumes (Fig. 2A). Effectively, as magma volumes exceed the volume of host rock in an arc, the aureole volume diminishes, concomitant to a diminished aureole decarbonation flux. This result counters common thought, where continental arc flare-ups (i.e., times of maximum intrusion volume) are thought to be times of maximum CO_2 output from arcs (Lee and Lackey, 2015).

The mineralogy of the host rocks in which the magma intrudes controls the magnitude of the decarbonation flux it produces. We thus amass magma addition rates and sedimentary rock information—including rock types, depositional ages, and stratigraphic thicknesses—for the SNB and the entirety of North America. Details about how we compare sedimentary and magma volumes through time are given in the Supplementary Information, but in short, our model predicts a metamorphic CO_2 flux—which includes CO_2 produced via metamorphism in the aureole and by assimilation of host rock in the intrusion—based off this volume comparison. Independent of the model, we compute a CO_2 flux for the Cretaceous SNB by scaling the area distribution of metamorphic pendants and skarns within a portion of the SNB to amounts of produced CO_2 along the entire arc. This estimate is compared to our model prediction to assess its utility in estimating CO_2 fluxes.

GROUND-TRUTHING THE ANALOGUE MODEL WITH THE GEOLOGIC RECORD FROM THE CRETACEOUS SNB

The area distribution of skarns (Fig. 2B) varies considerably along the SNB corridor we examined, with some exposures containing <10 m^2 of skarn and others containing >1 km^2. The skarn area is generally dwarfed by the marble area and only comprises 4% of the total mapped area. If we assume a maintained skarn-marble ratio within pendants along the entire SNB, an average carbonate fraction in sedimentary rocks in the arc of 20%, and skarn occurrence over 7 km of depth in the SNB, we compute a total skarn volume in the SNB of 19,000 km^3. This volume, if decarbonated over a 40 m.y. time interval, produces an average CO_2 flux of ~1 Mt/yr. This value, which excludes CO_2 from calc-silicates and marbles and fluxes from magma degassing and assimilation, is fivefold less than measurements of modern global continental arcs that intersect platform carbonates (5 Mt/yr; Aiuppa et al., 2019) and nearly two orders of magnitude less than previous estimates for net CO_2 fluxes from all Cretaceous continental arcs (Lee et al., 2013; Lee and Lackey, 2015). This disparity can largely be attributed to the sparse distribution of metamorphic pendants in the SNB and the difficulty of computing assimilation fluxes from the geologic record. Thus, this skarn CO_2 flux is considered a minimum estimate for metamorphic CO_2 fluxes from the Cretaceous SNB.

When sedimentary rock volumes and proportions from SNB-specific sites (Fig. DR2, see footnote 1) are compared with granitoid volumes emplaced in North America from 125 to 85 Ma (Cao et al., 2017), we predict the net metamorphic CO_2 flux from North American arcs to be 32.3 ± 28.4 Mt/yr during the Cretaceous, with 13% of the flux deriving from assimilated wall rock and 87% coming from decarbonation in the aureole (see Supplementary Information for further details on the flux calculation). Western SNB rocks, typified by the Triassic–Jurassic Kings Sequence (Fig. DR2), which contains both mixed carbonate-siliciclastic rocks and platform carbonates, contribute 59% of all generated CO_2. Paleozoic sections such as the Morrison block in the eastern SNB, which are composed predominantly of siliciclastic rocks and 23% carbonate, contribute 41%. Notably, this net flux agrees within 2σ error of the net decarbonation estimate from (1) SNB skarn outcrops (1 Mt/yr) and when (2) North American sedimentary rock information is used (40 Mt/yr) instead of SNB-specific stratigraphic sections (Fig. 3C at ca. 100 Ma time marker). Although location-specific geology will always yield more accurate flux estimates, these findings support the utility of North American sedimentary rocks as a globally representative archive of sedimentary rock types.

PHANEROZOIC METAMORPHIC DECARBONATION RATES

The variational growth rate of sedimentary rock and granitoid volumes underpins the changes in decarbonation rates in continental arcs through time (negative slope of lines in Fig. 3A). Once corrected for erosion (assuming an erosional half-life of 400 m.y. sensu Cao et al., 2017), sedimentary rocks from North America, granitoids (from Cao et al., 2017), and their volumetric distributions grow unsteadily. Cambrian through Devonian time (542–400 Ma) is marked by similar rates of growth of different rock types, highlighting the voluminous deposition of carbonate throughout the Phanerozoic. The volume of mixed carbonate-siliciclastic rocks surpasses that of pure carbonate by latest Pennsylvanian (ca. 300 Ma) when the growth rate of siliciclastic rocks increases well beyond all other rock types. Sediment deposition rates plateau in the Triassic (245–206 Ma) after the assembly of Pangea (Cao et al., 2017) and subsequently increase upon its breakup in the Jurassic (ca. 180 Ma). Carbonate and mixed carbonate-siliciclastic rocks grow in volume in the Cretaceous but are dwarfed by increases in the siliciclastic deposition rate. These trajectories of growth remain constant through the Cenozoic.

Change in area addition rates of granitoid is out of phase with the deposition of sedimentary rocks (Fig. 3A). Globally, granitoid volumes grow at a roughly consistent rate until the breakup of Pangea, whereupon their cumulative volumes grow rapidly. Continental arc activity in North America is quiescent

[1]GSA Data Repository item 2020150, including model descriptions and data sources for rock type information, is available online at https://www.geosociety.org/datarepository/2020.

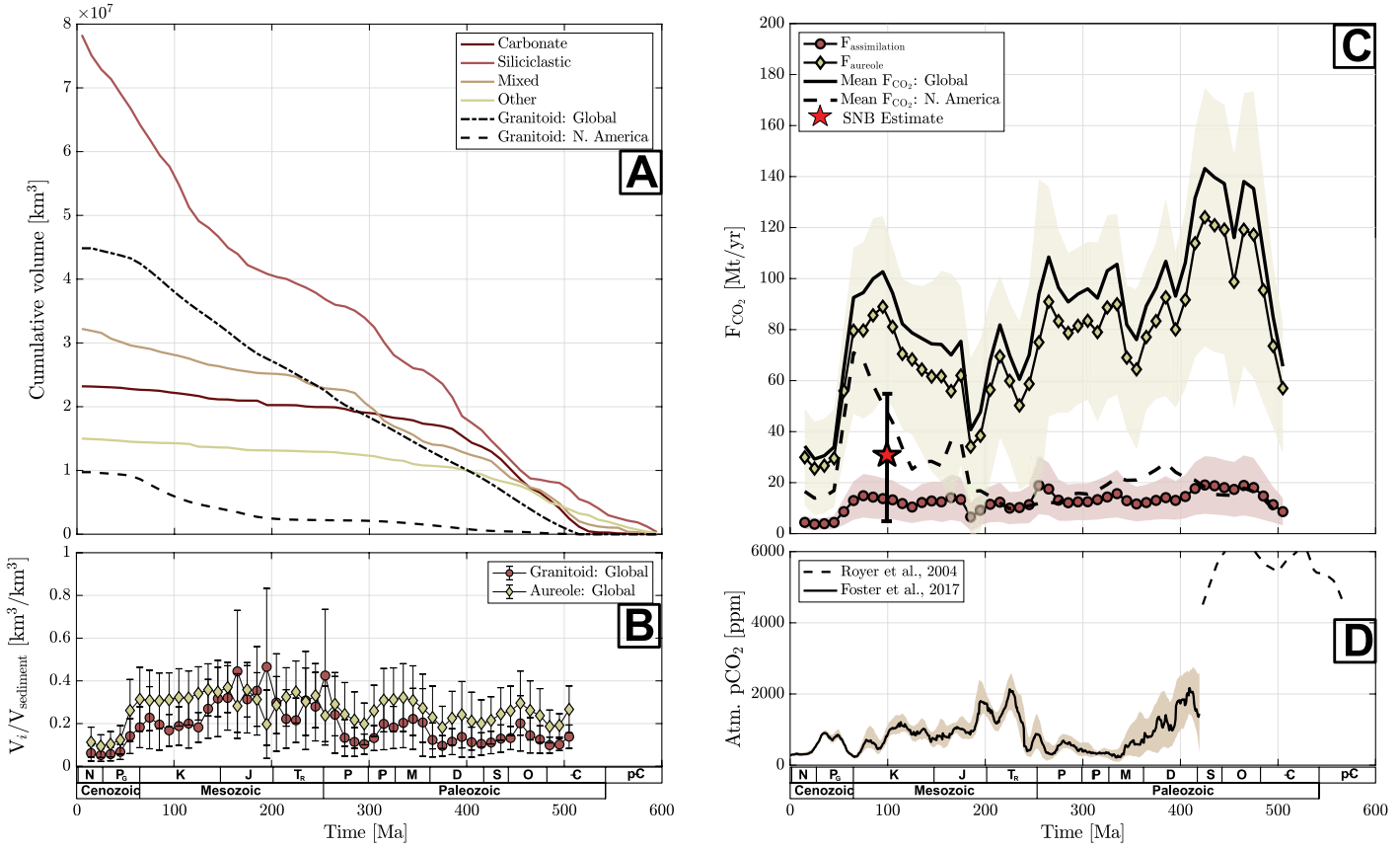


Figure 3. Phanerozoic estimates of rock volumes and decarbonation fluxes. All errors are 1 standard deviation (error bars in B and shaded volumes in C and D). (A) Cumulative volume estimates for all rock types. Rates of deposition (in units of volume/time) can be gleaned by the negative slope of the lines. (B) Volume fractions of intrusions and aureoles. (C) Metamorphic decarbonation fluxes, including the Sierra Nevada batholith (SNB)-specific flux. (D) Atmospheric pCO_2 estimates from the GEOCARB model from 570 to 420 Ma (Royer et al., 2004) and from measurements 420 Ma–present (Foster et al., 2017).

through much of the Paleozoic but quickly grows throughout the Mesozoic, punctuated by volumetrically significant emplacement of granitoids and coinciding with the formation of the large metamorphic pendants of the SNB. Juxtaposing increases in sediment deposition rates in the Cenozoic, area addition rates of granitoid decrease by threefold (fig. 4C *in* Cao et al., 2017).

Changes in the size of igneous and sedimentary rock volumes manifest in changes in metamorphic decarbonation rates through time, where gradual decreases in F_{CO_2} are predicted from the Cambrian toward the present (Fig. 3C). The confluence of high granitoid area addition rates and high proportions of carbonate rocks produces the highest metamorphic decarbonation fluxes, between the Cambrian and Silurian (540–420 Ma), where fluxes oscillate between 120 and 140 Mt/yr, or almost 2–3 times the current flux of CO_2 from all volcanoes (Fischer et al., 2019). This maximum net CO_2 flux contrasts with the minima in the Cenozoic (66–5 Ma), where granitoid area addition rates decrease by threefold, and <20% of all sediments undergo decarbonation (Fig. 3B).

Decarbonation within the aureole produces significantly more CO_2 than from assimilation of host rock by the emplaced magma, even when the volume fraction of the granitoid exceeds that of the aureole (Fig. 3B). Less decarbonation is predicted when the volume fraction of granitoids is highest (225 and 180 Ma). This marked decrease in net decarbonation fluxes underscores the propensity for metasomatized sedimentary rocks to produce more CO_2 than their assimilated counterparts. Nonetheless, all assimilated CO_2 fluxes are appreciable and within error of previous degassing estimates (Ratschbacher et al., 2019).

METAMORPHIC DECARBONATION IN THE GEOLOGIC CARBON CYCLE

The simplest way to assess the role of metamorphic decarbonation at continental arcs in the geologic carbon cycle is to compare its magnitude to those of other "endogenic" CO_2 fluxes, which are fluxes from the solid Earth (endogenic system) to the hydrosphere, biosphere, and atmosphere (exogenic system). From our model, the range of global metamorphic CO_2 fluxes we predict through the Phanerozoic (27–129 Mt/yr; Fig. 3C) is similar in magnitude to all other endogenic CO_2 fluxes (Table 1). The similarity in the range of the fluxes underscores the likelihood of the geologic carbon cycle maintaining an equilibrium state over million-year timescales (Berner and Caldeira, 1997). Endogenic CO_2 fluxes should change, however, as paleogeography, hypsometry, sea level, and the thermal states of Earth's crust and mantle change (e.g., Kelemen and Manning, 2015; Lee et al., 2018). How endogenic CO_2 fluxes temporally change, concomitant with other changes in the Earth system, remains an open question.

As an integrative climate metric, atmospheric pCO_2 is influenced by all fluxes of CO_2 between the atmosphere and solid Earth, which makes it challenging to determine the dominant CO_2 fluxes through geologic time. While endogenic fluxes establish base-level climate states, atmospheric pCO_2 is also influenced by silicate weathering, organic carbon burial, oxidation of organic matter, and the paleogeography of crustal material (e.g., Kump et al., 2000; Macdonald et al., 2019). Most tectonic

TABLE 1. COMPARISON AND SUMMARY OF ESTIMATES OF ENDOGENIC CO_2 FLUXES

Flux type	Magnitude (Mt/yr)	Method(s) for estimation	Reference(s)
Cretaceous continental arcs (Sierra Nevada batholith)	1	Area distribution of skarn	This study
Cretaceous continental arcs (North America)	4–58	Analogue decarbonation model with Sierra Nevada batholith stratigraphy	This study
Cretaceous continental arcs (global)	85–127	Mass balance calculation	Lee et al. (2013)
Contact metamorphism in continental arcs (global)	0.7–11	Reactive transport model	Chu et al. (2019)
Mid-ocean ridges (global)	53–97	[a]Geochemical analysis of mid-ocean ridge basalt glasses; [b]measurement of noble gas fluxes at mid-ocean ridges; [c]geochemical analyses of emitted volatiles from mid-ocean ridges; [d]petrologic analysis of basaltic magmas	[a]Marty and Tolstikhin (1998) [b]Hilton et al. (2002) [c]Fischer (2008) [d]Dasgupta and Hirschmann (2010)
Continental rifts	4	Gas efflux measurements	Lee et al. (2016)
Mountain building	13–440	[a]Petrologic and geochemical measurements of exhumed metamorphic rocks; [b]geochemical analysis of groundwater draining active mountain belt; [c]geochemical analyses of hydrothermal fluids in active mountain belts; [d]thermodynamic modeling (*P-T-t* path calculations) of exhumed metamorphic rocks	[a]Kerrick and Caldeira (1998) [a]Skelton (2011) [b]Chiodini et al. (2000) [c]Becker et al. (2008) [d]Stewart and Ague (2018)

fluxes appear weakly correlated with pCO_2 from 200 Ma to present (Wong et al., 2019). From our predictions, we find that the connection between metamorphic CO_2 fluxes from continental arcs and atmospheric pCO_2 is tenuous (Fig. 3D). Beyond the similar decreases from the Cambrian toward the present and the shared relative maxima prior to the Devonian, atmospheric pCO_2 and metamorphic CO_2 fluxes appear disconnected and cannot be wholly compared without knowledge of other fluxes.

Nonetheless, times where the correlation between metamorphic CO_2 fluxes and atmospheric pCO_2 are weakest can be leveraged to explore the operation of other Earth system processes. For example, between 320 and 270 Ma during icehouse conditions in the Permian, metamorphic CO_2 fluxes remain high while atmospheric pCO_2 is low. This time interval also coincides with the waning stages of Pangea formation. Despite elevated metamorphic fluxes, could atmospheric pCO_2 have remained low because generation of relief during supercontinent assembly enhanced silicate weathering (e.g., West et al., 2005)? Instead, could there have been prolonged organic carbon burial as equatorial regions remained hot and humid and forests proliferated (Ronov, 1982)? For a contrasting example, in Permian–Triassic time after Pangea's assembly, atmospheric pCO_2 increases while metamorphic CO_2 fluxes drop by a factor of 2. Does atmospheric pCO_2 increase because the aridification of continental interiors inhibits silicate weathering? If so, can modest CO_2 outputs from continental arcs with diminished silicate weathering fluxes be enough to increase atmospheric pCO_2 by a factor of 2, or are other endogenic fluxes necessary, such as organic carbon oxidation or continental rifting (e.g., Lee et al., 2016)? Between these contrasting scenarios, the unifying question concerns the thresholds at which metamorphic CO_2 fluxes can be attributed to the development of past climates, if at all.

Of all time periods on Earth, the Cretaceous period likely represents a time in which enhanced continental arc metamorphism promoted a hothouse climate. The emergence of deep-water calcifiers in the Triassic (e.g., Ridgwell and Zeebe, 2005), increases in granitoid addition rates, doubling in length of continental arcs that intersect crustal carbonates (Lee et al., 2013), and increased evidence of skarn formation within circum-Pacific batholiths (e.g., Lee and Lackey, 2015) support the plausibility of elevated metamorphic CO_2 fluxes contributing to hothouse climate conditions in the Cretaceous. Our model predicts maximum values for aureole volume fractions during the Mesozoic (Fig. 3B), purporting an increased proportion of aureole decarbonation. The average metamorphic CO_2 flux from arcs during the Cretaceous exceeds estimates for mid-ocean ridge CO_2 fluxes (60 Mt/yr; Wong et al., 2019). Unless CO_2 fluxes from continental rifts or oxidation of organic matter were significant in magnitude during the Cretaceous, continental arc metamorphism likely contributed the largest fraction of CO_2 of all endogenic fluxes. With further quantifications of endogenic CO_2 fluxes and their variation through time, benchmarked against known climatic changes, the role of tectonic outgassing in the evolution of Earth's climate will become increasingly clear.

ACKNOWLEDGMENTS

J. Muller and J. Ryan-Davis helped with digitizing maps for area calculations. We thank C.-T.A. Lee for comments on an early draft of the paper, two anonymous reviewers for thorough suggestions, and M. Ducea for careful editorial handling. All MATLAB codes used in the analogue model and for figure generation can be found in the GitHub repositories of the first author: https://github.com/ejramos/skarn_model and https://github.com/ejramos/Phanerozoic_decarbonation. National Science Foundation grant NSF-OCE-1338842 awarded to Lackey, Barnes, and others as part of the Frontiers in Earth Systems Dynamics program supported this work.

REFERENCES CITED

Ague, J.J., 2000, Release of CO_2 from carbonate rocks during regional metamorphism of lithologically heterogeneous crust: Geology, v. 28, no. 12, p. 1123–1126, https://doi.org/10.1130/0091-7613(2000)28<1123:ROCFCR>2.0.CO;2.

Aiuppa, A., Fischer, T.P., Plank, T., and Bani, P., 2019, CO_2 flux emissions from the Earth's most actively degassing volcanoes, 2005–2015: Scientific Reports, v. 9, no. 1, article no. 5442, https://doi.org/10.1038/s41598-019-41901-y.

Baumgartner, L.P., and Ferry, J.M., 1991, A model for coupled fluid-flow and mixed-volatile mineral reactions with applications to regional metamorphism: Contributions to Mineralogy and Petrology, v. 106, no. 3, p. 273–285, https://doi.org/10.1007/BF00324557.

Becker, J.A., Bickle, M.J., Galy, A., and Holland, T.J., 2008, Himalayan metamorphic CO_2 fluxes: Quantitative constraints from hydrothermal springs: Earth and Planetary Science Letters, v. 265, no. 3–4, p. 616–629, https://doi.org/10.1016/j.epsl.2007.10.046.

Berner, R.A., and Caldeira, K., 1997, The need for mass balance and feedback in the geochemical carbon cycle: Geology, v. 25, no. 10, p. 955–956, https://doi.org/10.1130/0091-7613(1997)025<0955:TNFMBA>2.3.CO;2.

Bowman, J.R., 1998, Stable-isotope systematics of skarns, *in* Lentz, D.R., ed., Mineralized intrusion-related skarn systems: Quebec, Mineralogical Association of Canada, Short Course Series, v. 26, p. 99–145.

Cao, W., Lee, C.T.A., and Lackey, J.S., 2017, Episodic nature of continental arc activity since 750 Ma: A global compilation: Earth and Planetary Science Letters, v. 461, p. 85–95, https://doi.org/10.1016/j.epsl.2016.12.044.

Carter, L.B., and Dasgupta, R., 2016, Effect of melt composition on crustal carbonate assimilation: Implications for the transition from calcite consumption to skarnification and associated CO_2 degassing: Geochemistry, Geophysics, Geosystems, v. 17, no. 10, p. 3893–3916, https://doi.org/10.1002/2016GC006444.

Cathles, L.M., Erendi, A.H.J., and Barrie, T., 1997, How long can a hydrothermal system be sustained by a single intrusive event?: Economic Geology, v. 92, no. 7–8, p. 766–771, https://doi.org/10.2113/gsecongeo.92.7-8.766.

Chiodini, G., Frondini, F., Cardellini, C., Parello, F., and Peruzzi, L., 2000, Rate of diffuse carbon dioxide Earth degassing estimated from carbon balance of regional aquifers: The case of central Apennine, Italy: Journal of Geophysical Research. Solid Earth, v. 105, no. B4, p. 8423–8434, https://doi.org/10.1029/1999JB900355.

Chu, X., Lee, C.T.-A., Dasgupta, R., and Cao, W., 2019, The contribution to exogenic CO_2 by contact metamorphism at continental arcs: A coupled model of fluid flux and metamorphic decarbonation: American Journal of Science, v. 319, no. 8, p. 631–657, https://doi.org/10.2475/08.2019.01.

Dasgupta, R., and Hirschmann, M.M., 2010, The deep carbon cycle and melting in Earth's interior: Earth and Planetary Science Letters, v. 298, no. 1–2, p. 1–13, https://doi.org/10.1016/j.epsl.2010.06.039.

Ducea, M.N., Saleeby, J.B., and Bergantz, G., 2015, The architecture, chemistry, and evolution of continental magmatic arcs: Annual Review of Earth and Planetary Sciences, v. 43, p. 299–331, https://doi.org/10.1146/annurev-earth-060614-105049.

Ferry, J.M., 1989, Contact metamorphism of roof pendants at Hope Valley, Alpine County, California, USA: Contributions to Mineralogy and Petrology, v. 101, no. 4, p. 402–417, https://doi.org/10.1007/BF00372214.

Fischer, T.P., 2008, Fluxes of volatiles (H_2O, CO_2, N_2, Cl, F) from arc volcanoes: Geochemical Journal, v. 42, p. 21–38, https://doi.org/10.2343/geochemj.42.21.

Fischer, T.P., Arellano, S., Carn, S., Aiuppa, A., Galle, B., Allard, P., Lopez, T., Shinohara, H., Kelly, P., Werner, C., and Cardellini, C., 2019, The emissions of CO_2 and other volatiles from the world's subaerial volcanoes: Scientific Reports, v. 9, no. 1, p. 1–11, https://doi.org/10.1038/s41598-019-54682-1.

Foster, G.L., Royer, D.L., and Lunt, D.J., 2017, Future climate forcing potentially without precedent in the last 420 million years: Nature Communications, v. 8, article no. 14845, https://doi.org/10.1038/ncomms14845.

Hilton, D.R., Fischer, T.P., and Marty, B., 2002, Noble gases and volatile recycling at subduction zones: Reviews in Mineralogy and Geochemistry, v. 47, no. 1, p. 319–370, https://doi.org/10.2138/rmg.2002.47.9.

Kelemen, P.B., and Manning, C.E., 2015, Reevaluating carbon fluxes in subduction zones, what goes down, mostly comes up: Proceedings of the National Academy of Sciences of the United States of America, v. 112, no. 30, p. E3997–E4006, https://doi.org/10.1073/pnas.1507889112.

Kerrick, D.M., 1977, The genesis of zoned skarns in the Sierra Nevada, California: Journal of Petrology, v. 18, no. 1, p. 144–181, https://doi.org/10.1093/petrology/18.1.144.

Kerrick, D.M., and Caldeira, K., 1998, Metamorphic CO_2 degassing from orogenic belts: Chemical Geology, v. 145, no. 3–4, p. 213–232, https://doi.org/10.1016/S0009-2541(97)00144-7.

Kump, L.R., Brantley, S.L., and Arthur, M.A., 2000, Chemical weathering, atmospheric CO_2, and climate: Annual Review of Earth and Planetary Sciences, v. 28, no. 1, p. 611–667, https://doi.org/10.1146/annurev.earth.28.1.611.

Lee, C.T.A., and Lackey, J.S., 2015, Global continental arc flare-ups and their relation to long-term greenhouse conditions: Elements, v. 11, no. 2, p. 125–130, https://doi.org/10.2113/gselements.11.2.125.

Lee, C.T.A., Shen, B., Slotnick, B.S., Liao, K., Dickens, G.R., Yokoyama, Y., Lenardic, A., Dasgupta, R., Jellinek, M., Lackey, J.S., and Schneider, T., 2013, Continental arc–island arc fluctuations, growth of crustal carbonates, and long-term climate change: Geosphere, v. 9, no. 1, p. 21–36, https://doi.org/10.1130/GES00822.1.

Lee, C.T.A., Caves, J., Jiang, H., Cao, W., Lenardic, A., McKenzie, N.R., Shorttle, O., Yin, Q.Z., and Dyer, B., 2018, Deep mantle roots and continental emergence: Implications for whole-Earth elemental cycling, long-term climate, and the Cambrian explosion: International Geology Review, v. 60, no. 4, p. 431–448, https://doi.org/10.1080/00206814.2017.1340853.

Lee, H., Muirhead, J.D., Fischer, T., Ebinger, C.J., Kattenhorn, S., and Kianji, G., 2016, Tectonic degassing of mantle-derived CO_2 along faults in the East African Rift: Nature Geoscience, v. 9, no. 2, p. 145–149, https://doi.org/10.1038/ngeo2622.

Macdonald, F.A., Swanson-Hysell, N.L., Park, Y., Lisiecki, L., and Jagoutz, O., 2019, Arc-continent collisions in the tropics set Earth's climate state: Science, v. 364, no. 6436, p. 181–184, https://doi.org/10.1126/science.aav5300.

Marty, B., and Tolstikhin, I.N., 1998, CO_2 fluxes from mid-ocean ridges, arcs and plumes: Chemical Geology, v. 145, no. 3–4, p. 233–248, https://doi.org/10.1016/S0009-2541(97)00145-9.

Mason, E., Edmonds, M., and Turchyn, A.V., 2017, Remobilization of crustal carbon may dominate volcanic arc emissions: Science, v. 357, no. 6348, p. 290–294, https://doi.org/10.1126/science.aan5049.

McKenzie, N.R., Horton, B.K., Loomis, S.E., Stockli, D.F., Planavsky, N.J., and Lee, C.T.A., 2016, Continental arc volcanism as the principal driver of icehouse-greenhouse variability: Science, v. 352, no. 6284, p. 444–447, https://doi.org/10.1126/science.aad5787.

Mills, B.J., Krause, A.J., Scotese, C.R., Hill, D.J., Shields, G.A., and Lenton, T.M., 2019, Modelling the long-term carbon cycle, atmospheric CO_2, and Earth surface temperature from late Neoproterozoic to present day: Gondwana Research, v. 67, p. 172–186, https://doi.org/10.1016/j.gr.2018.12.001.

Nabelek, P.I., Bédard, J.H., and Rainbird, R.H., 2014, Numerical constraints on degassing of metamorphic CO_2 during the Neoproterozoic Franklin large igneous event, Arctic Canada: Geological Society of America Bulletin, v. 126, p. 759–772, https://doi.org/10.1130/B30981.1.

Newberry, R.J., and Einaudi, M.T., 1981, Tectonic and geochemical setting of tungsten skarn mineralization in the Cordillera: Arizona Geological Society Digest, v. 14, p. 99–111.

Ramos, E.J., Hesse, M.A., Barnes, J.D., Jordan, J.S., and Lackey, J.S., 2018, Reevaluating fluid sources during skarn formation: An assessment of the Empire Mountain skarn, Sierra Nevada, USA: Geochemistry, Geophysics, Geosystems, v. 19, no. 10, p. 3657–3672, https://doi.org/10.1029/2018GC007611.

Ratschbacher, B.C., Paterson, S.R., and Fischer, T.P., 2019, Spatial and depth-dependent variations in magma volume addition and addition rates to continental arcs: Application to global CO_2 fluxes since 750 Ma: Geochemistry, Geophysics, Geosystems, v. 20, p. 2997–3018, https://doi.org/10.1029/2018GC008031.

Ridgwell, A., and Zeebe, R.E., 2005, The role of the global carbonate cycle in the regulation and evolution of the Earth system: Earth and Planetary Science Letters, v. 234, no. 3–4, p. 299–315, https://doi.org/10.1016/j.epsl.2005.03.006.

Ronov, A.B., 1982, The Earth's sedimentary shell (quantitative patterns of its structure, compositions, and evolution): The 20th VI Vernadskiy Lecture, March 12, 1978: International Geology Review, v. 24, no. 11, p. 1313–1363, https://doi.org/10.1080/00206818209451075.

Royer, D.L., Berner, R.A., Montañez, I.P., Tabor, N.J., and Beerling, D.J., 2004, CO_2 as a primary driver of Phanerozoic climate: GSA Today, v. 14, no. 3, p. 4–10, https://doi.org/10.1130/1052-5173(2004)014<4:CAAPDO>2.0.CO;2.

Skelton, A., 2011, Flux rates for water and carbon during greenschist facies metamorphism: Geology, v. 39, p. 43–46, https://doi.org/10.1130/G31328.1.

Stewart, E.M., and Ague, J.J., 2018, Infiltration-driven metamorphism, New England, USA: Regional CO_2 fluxes and implications for Devonian climate and extinctions: Earth and Planetary Science Letters, v. 489, p. 123–134, https://doi.org/10.1016/j.epsl.2018.02.028.

Vidale, R.J., and Hewitt, D.A., 1973, "Mobile" components in the formation of calc-silicate bands: American Mineralogist: Journal of Earth and Planetary Materials, v. 58, no. 11–12, p. 991–997.

West, A.J., Galy, A., and Bickle, M., 2005, Tectonic and climatic controls on silicate weathering: Earth and Planetary Science Letters, v. 235, no. 1–2, p. 211–228, https://doi.org/10.1016/j.epsl.2005.03.020.

White, A.F., Schulz, M.S., Lowenstern, J.B., Vivit, D.V., and Bullen, T.D., 2005, The ubiquitous nature of accessory calcite in granitoid rocks: Implications for weathering, solute evolution, and petrogenesis: Geochimica et Cosmochimica Acta, v. 69, no. 6, p. 1455–1471, https://doi.org/10.1016/j.gca.2004.09.012.

Whitley, S., Gertisser, R., Halama, R., Preece, K., Troll, V.R., and Deegan, F.M., 2019, Crustal CO_2 contribution to subduction zone degassing recorded through calc-silicate xenoliths in arc lavas: Scientific Reports, v. 9, article no. 8803, https://doi.org/10.1038/s41598-019-44929-2.

Wong, K., Mason, E., Brune, S., East, M., Edmonds, M., and Zahirovic, S., 2019, Deep carbon cycling over the past 200 million years: A review of fluxes in different tectonic settings: Frontiers of Earth Science, v. 7, p. 1–22, https://doi.org/10.3389/feart.2019.00263.

Zhang, S., FitzGerald, J.D., and Cox, S.F., 2000, Reaction-enhanced permeability during decarbonation of calcite + quartz → wollastonite + carbon dioxide: Geology, v. 28, p. 911–914, https://doi.org/10.1130/0091-7613(2000)28<911:RPDDOC>2.0.CO;2.

Manuscript received 2 Dec. 2019
Revised manuscript received 11 Feb. 2020
Manuscript accepted 13 Feb. 2020

Update on GSA's 2020 Annual Meeting in Montréal

Dear Members and Friends,

We realize you all have many issues and responsibilities that you are juggling, and we at GSA are considering everything we can do to assist you with your research, work, and careers. Currently, our dedicated volunteer leadership and staff are working hard toward the goal of hosting a very exciting program for you on 25–28 October, in Montréal, Québec, Canada. We fully embrace that the safety and well-being of our community across the world remains the highest priority. As such, we continue to closely monitor the situation and are working on viable options should we need to change plans.

Here are some steps we have taken to stay flexible and inform our decision making as the coronavirus unfolds:

- We have pushed back the opening of the abstract submission system to 1 June to both give the COVID-19 response actions more time and to give you more time to consider an abstract submission.
- Housing and registration for the meeting will also open in early June. The registration cancellation date is 28 September, and we will have made our final decision well ahead of that deadline.
- The space request system is now open, and events must be scheduled by 8 June.
- We are considering several contingency plans, including a hybrid in-person/virtual meeting or a fully virtual meeting. As the events affecting us all unfold, we will share our direction so you can share your science.

We at GSA are working to serve our members in every way we can, and planning for better days ahead. Thank you for your support and participation in the GSA family.

Check the Annual Meeting website (**https://community.geosociety.org/gsa2020/**) for updates. If you have questions or concerns about the meeting, contact meetings@geosociety.org.

Best regards,

Vicki McConnell
GSA Executive Director

25–28 October

GSA 2020

Montréal, Québec, Canada

GSA 2020 Annual Meeting

Welcome

"La Belle Province de Québec" is very proud to host the Annual Meeting of the Geological Society of America. Montréal knows how to offer a warm welcome to meeting attendees because it hosts more international meetings than any other city in North America. It is a lively cosmopolitan city that offers a wide range of activities in a very safe environment. It was named best city of the world to be a university student in 2017. Moreover, Montréal can be described as a cultural and geological crossroad.

It lies at the junction of four distinct geological entities. Located less than an hour drive away from the city center, the pleasant Laurentians are the remaining vestiges of the Grenville Province, the giant mountain belt of the Mesoproterozoic. The city sits on the St. Lawrence Lowlands, presenting the classical sedimentary section reflecting the Cambrian rifting of the Grenvillian basement followed by the passive margin of the Iapetus ocean that was then closed in the Ordovician during the Taconian orogeny that initiated the formation of the Appalachians. In Québec, this mountain belt, which may still retain colorful foliage at the end of October, exposes its fold-and-thrust belt and a spectacular ophiolite complex. The Mont Royal, from which the name Montréal was derived, constitutes the green heart of the city center and is one of the Monteregian Hills. These mid-Cretaceous alkaline intrusions, composed of unusual igneous rock types, form a swath of monadnocks through the St. Lawrence Lowland and Appalachians foothills.

Montréal is also the crossroad of North American and European cultures, with a distinctly Québecois charm. Walk around the city and sample one of the numerous microbreweries or barista cafés. For lunch and dinner, you'll have a large choice of restaurants directed by world-known chefs preparing cuisines inspired from around the world, but preserving a Montréal style.

GSA 2020 promises to be a success, with 254 topical sessions, 37 short courses, and five Pardee Symposia! There are also 15 field trips that cover everything that the regional geology has to offer. In addition, the meeting will have activities for K–12 educators, early career geoscientists, a sparkling exhibit hall, and some surprise outreach and gathering activities!

We are looking forward to welcoming you in Montréal,

Félix Gervais
GSA 2020 General Chair
Associate Professor, Department of Civil, Geological and Mining Engineering, Polytechnique Montréal

IMPORTANT DATES

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

Early June: Housing Opens (Orchid.Events is the official housing bureau for GSA 2020 Montréal)

Early June: Abstracts submission form, Registration, and Travel Grant applications open

8 June: Meeting room request deadline—fees increase after this date

4 August: Abstracts deadline

Early August: Student volunteer program opens

21 September: Early registration deadline

21 September: GSA Sections travel grants deadline

28 September: Registration and student volunteer cancellation deadline

30 September: Housing deadline for discounted hotel rates

Event Space Request

Deadline for first consideration: 8 June

Please let us know about your non-technical events via our online event space database (which can be accessed at **https://community.geosociety.org/gsa2020/connect/events**). Meeting space at the official GSA event locations is reserved on a first-come, first-served basis. The event space submission should be used for meeting rooms to hold events (i.e., business meetings, town halls, luncheons, receptions, etc.).

Official GSA Event Locations
Palais des congrès de Montréal (Palais)
Doubletree by Hilton Montréal (Doubletree)—Headquarters Hotel
Le Westin Montreal (Westin)—Co-Headquarters Hotel

© Montréal Convention Centre (Palais des congrès de Montréal).

Photo by Matthias Mullie on Unsplash.

Call for Papers

Abstracts submission form: opens 1 June

Abstracts deadline: 4 August

Submitting an Abstract
- **Submission deadline:** Tuesday, 4 August;
- To begin your submission, go to **https://community.geosociety.org/gsa2020/learn/technical**;
- An abstract submission fee of US$50 for professionals and US$25 for students will be charged;
- For guidelines on preparing your submission, go to **https://gsa.confex.com/gsa/2020AM/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;
- Posters should be on display from 10 a.m. to 6:30 p.m. each day, with authors present 4:30–6:30 p.m.;
- Want to present your poster digitally? As a poster presenter, you will be given the opportunity to present your poster in a digital format. Information on this will be provided in the acceptance notices. Presenters are responsible for all fees associated with this type of presentation.

Oral Presenters
- The 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 2013;
- Presentations should be prepared using a 16:9 screen ratio.

Abstracts Submission: Expected Behavior

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

Contents

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

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 perhaps best known for his work on Glacial Lake Missoula. These symposia consist of invited presentations covering a broad range of topics.

P1. **Assembling Laurentia: Turning Points in the Geologic Evolution of the North American Continent**

Cosponsors: *GSA Structural Geology and Tectonics Division; Mineralogical Society of America; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Sedimentary Geology Division; GSA Geophysics and Geodynamics Division*
Disciplines: Tectonics/Tectonophysics, Geophysics/Geodynamics, Geochemistry
Advocates: Dawn Kellett; Basil Tikoff; Michael L. Williams

The North American continent (Laurentia) records the evolution of tectonic processes from the earliest Archean to modern times. This Pardee Keynote Symposium will initiate a meeting-wide series of sessions focusing on "turning points" in the tectonic evolution of Laurentia. The goal is to integrate the broad range of geologic disciplines in order to scrutinize key periods in the long history of Laurentia when the character, rate, or style of tectonic processes changed or when the plate tectonic process itself may have changed in some fundamental way, and to identify potential drivers for these changes.

P2. **Frontiers of Research, Discovery, and Societal Impact in the Hydrologic Sciences**

Cosponsors: *GSA Hydrogeology Division; GSA Geology and Society Division; GSA Environmental and Engineering Geology Division; GSA Karst Division; GSA Limnogeology Division; Geochemical Society; GSA Quaternary Geology and Geomorphology Division*
Discipline: Hydrogeology
Advocates: Ingrid Y. Padilla; William L. Cunningham; Elizabeth Eide

The fields of hydrology and hydrogeology address how water interacts with the landscape and ecosystem as well as how hydrologic systems are altered by land use and climate. Hydrologic science research is often interdisciplinary and multidisciplinary, involving expertise from physical and ecosystem sciences, engineering, and/or mathematics, and integrates observational, experimental, theoretical, modeling, and field approaches. The field has changed rapidly due to new discoveries, technological advances, societal needs, and the data revolution. This session will include presentations from leaders in the field that highlight opportunities for research and societal impact in the hydrologic sciences, followed by a panel discussion.

P3. **Our Coastal Futures: Working Together to Understand Hazards and Mitigate Disasters**

Cosponsors: *GSA Marine and Coastal Geoscience Division; GSA Geology and Society Division; GSA Quaternary Geology and Geomorphology Division; GSA Limnogeology Division*
Disciplines: Marine/Coastal Science, Geoscience and Public Policy, Geoscience Information/Communication
Advocates: Rónadh Cox; Robert Weiss

As sea level rises and storm intensity increases, the coastal zone bears the brunt. As we work to understand the science of coastal hazards, we must also consider the human and societal aspects as part of effective mitigation strategies. This symposium convenes a transdisciplinary group of experts in coastal and marine geoscience, policy, anthropology, and history, to discuss the multiplex aspects of coastal hazards in the twenty-first century. This includes cutting-edge scientific approaches as well as attention to social justice and inclusivity.

P4. **The Next Generation of Geoscience Leaders: Strategies for Excellence in Diversity and Inclusion**

Cosponsors: *GSA International; Mineralogical Society of America*
Discipline: Geoscience Education
Advocates: Raquel Bryant; Benjamin Andrew Keisling

Scientists who make significant diversity, equity, and inclusion (DEI) contributions are often not rewarded, and may even be penalized for their additional efforts. In order to make real strides in achieving DEI goals, we must reframe scientific and academic excellence to include the rigorous pursuit of equity in the geoscience community. This Pardee Symposium will feature (A) speakers who are leaders and role models with demonstrated records of excellence in DEI, (B) a leadership exercise to develop targeted community-relevant solutions, and (C) a panel of non-scientist experts that can provide additional resources to support DEI efforts.

P5. **Challenges and Solutions for a Changing Climate: New Directions for GSA**

Cosponsors: *GSA Geology and Society Division; GSA Geology and Health Division; GSA Sedimentary Geology Division; GSA Structural Geology and Tectonics Division; GSA Karst Division; GSA Geochronology Division; GSA Quaternary Geology and Geomorphology Division; GSA Energy Geology Division; GSA Environmental and Engineering Geology Division; GSA Marine and Coastal Geoscience Division; GSA Soils and Soil Processes Division; GSA Mineralogy, Geochemistry, Petrology and Volcanology Division; GSA Continental Scientific Drilling Division; GSA Hydrogeology Division; GSA Limnogeology Division; GSA Geoscience Education Division; GSA Geology and Public Policy Committee; GSA International*
Disciplines: Environmental Geoscience, Energy Geology, Geoscience Information/Communication
Advocates: Beth Bartel; Malcolm Siegel; Candace L. Kairies-Beatty; Luke J. Bowman; Sinjini Sinha

Responding to a 2019 challenge from GSA President Don Siegel, this symposium in turn challenges GSA leadership and membership to think creatively, critically, and constructively about our role in climate change solutions. The year is 2020. Looking back, what will we wish we had done? This session looks forward, exploring visions and viewpoints in the themes of assessment, mitigation, adaptation, and engagement, with a focus on North America. As a society of geoscientists, it is our responsibility to drive the solutions that will ensure a sustainable existence on our favorite planet.

Topical Sessions

TECTONICS/TECTONOPHYSICS

T1. The Multidisciplinary Approach of Seismotectonics as a Key Tool to Expand Horizons on Faulting Process Understanding and to Address an Effective Seismic Hazard Assessment

Cosponsors: *CRUST - Interuniversity Center for 3D Seismotectonics with Territorial Applications; GSA Geophysics and Geodynamics Division; GSA Structural Geology and Tectonics Division*
Disciplines: Tectonics/Tectonophysics, Geophysics/Geodynamics
Advocates: Federica Ferrarini; Rita de Nardis; J Ramón Arrowsmith

The session aims to gather scientific advances in seismotectonics as the discipline that relies upon multidisciplinary approaches and that can also be also meant to focus on and to address seismic hazard assessment.

T2. Assembling Laurentia: Paleozoic Mobile Margins

Cosponsors: *GSA Structural Geology and Tectonics Division; Mineralogical Society of America; GSA Geophysics and Geodynamics Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Sedimentary Geology Division*
Disciplines: Tectonics/Tectonophysics, Petrology, Igneous, Sediments, Clastic
Advocates: Luke P. Beranek; Maurice Colpron; Cees R. van Staal

This session focuses on the mid- to late Paleozoic tectonic evolution of Laurentia's mobile margins, including tectonic, magmatic, metamorphic, and sedimentary events recorded along the Appalachian-Caledonian-Ouachita, Arctic, and Cordilleran margins.

T3. Assembling Laurentia: Mesoproterozoic to Early Neoproterozoic Tectonic Evolution of Laurentia and Its Role within the Supercontinent Rodinia

Cosponsors: *GSA Structural Geology and Tectonics Division; GSA Geochronology Division; GSA Geophysics and Geodynamics Division; GSA Sedimentary Geology Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; Mineralogical Society of America*
Disciplines: Tectonics/Tectonophysics, Precambrian Geology, Geochronology
Advocates: Nicholas L. Swanson-Hysell; Toby Rivers; Suzan van der Lee

The session is focused on Laurentia's tectonic history (and that of neighboring cratons in Rodinia) in the interval including late Mesoproterozoic accretionary growth, the development of the Midcontinent Rift, the collisional Grenville orogen, and early Neoproterozoic extension.

T4. Fluids in Faults—The Role of Fluid Activity, Fault-Rock Composition, and Alteration in the Earthquake Cycle

Cosponsors: *GSA Structural Geology and Tectonics Division; GSA Geophysics and Geodynamics Division; GSA Hydrogeology Division*
Disciplines: Tectonics/Tectonophysics, Structural Geology, Geophysics/Geodynamics
Advocates: Elisabeth S. Nadin; Elizabeth S. Petrie; Randolph T. Williams; Kelly K. Bradbury

This session explores linkages between faulting, deformation, and fluid flow in the seismogenic crust. Contributions focusing on the links between fluid flow, diagenesis/alteration, and seismic phenomena (e.g., earthquakes, slow slip events) are encouraged.

T5. Sutures and Suture Zones in the Phanerozoic and Precambrian Orogenic Belts

Cosponsors: *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, Geophysics/Geodynamics, Geochronology
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.

T6. Northern Andes Mountain Building: From Proterozoic to Quaternary

Disciplines: Tectonics/Tectonophysics, Geochronology, Geochemistry
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.

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

T7. **Fieldwork, Maps, and Orogenies: A Tribute Session for Marc St-Onge**

Cosponsors: *GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Structural Geology and Tectonics Division*

Disciplines: Tectonics/Tectonophysics, Petrology, Metamorphic, Precambrian Geology

Advocates: Benoit M. Saumur; Brendan Dyck; Daniele Regis; Diane Skipton; Michael P. Searle

Celebrating the career of Dr. St-Onge, this session welcomes submissions reflecting his research: field-based studies of the Canadian Arctic and the Himalaya, metamorphic studies dedicated to orogenic processes, and integrative regional mapping.

T8. **From Rodinia to Pangea: Evolution of the Appalachian-Caledonian Orogen**

Cosponsors: *GSA Structural Geology and Tectonics Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Geochronology Division*

Disciplines: Tectonics/Tectonophysics, Petrology, Metamorphic, Geochronology

Advocates: Chong Ma; Paul A. Mueller; Paul Karabinos; David A. Foster; Cees R. van Staal

We seek contributions addressing the structural, magmatic, metamorphic, and/or sedimentary evolution of the Appalachian-Caledonian orogen from Svalbard to Alabama, and from the breakup of Rodinia through the assembly and dispersal of Pangea.

$ T9. **Assembling Laurentia: GEON 14 Enigmas and Advances in Understanding the Crustal Evolution and Paleogeography of the Early Mesoproterozoic North America**

Cosponsors: *GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Geochronology Division; GSA Geophysics and Geodynamics Division; Mineralogical Society of America; GSA Sedimentary Geology Division; GSA Structural Geology and Tectonics Division*

Disciplines: Tectonics/Tectonophysics, Precambrian Geology, Petrology, Metamorphic

Advocates: Christopher G. Daniel; Aphrodite Indares; David P. Moecher

This session will focus on the development and evolution of the Andean-scale, Mesoproterozoic 1.4 Ga Laurentian margin, and to place the major magmatic, orogenic, ore deposits, and arc forming events in a broader and unified context.

T10. **Subduction Zone Slip Behavior: The Intersection of Deformation and Metamorphism**

Cosponsors: *GSA Structural Geology and Tectonics Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division*

Disciplines: Tectonics/Tectonophysics, Petrology, Metamorphic, Structural Geology

Advocates: Alissa Kotowski; Caroline Seyler; Cailey B. Condit

During subduction, rocks occupying the plate interface experience progressive changes due to diagenesis and metamorphism that influence their rheology. This session will investigate the interplay between deformation and metamorphism and its influence on slip behavior across space and time.

T11. **Recent Advances in Supercontinents: Paleogeography, Geodynamics, and Paleoclimate Evolution**

Cosponsors: *IGCP Project No. 648: Supercontinent Cycles and Global Geodynamics; GSA Structural Geology and Tectonics Division*

Disciplines: Tectonics/Tectonophysics, Geophysics/Geodynamics, Precambrian Geology

Advocates: Lei Wu; Galen P. Halverson; J. Brendan Murphy

This session highlights multidisciplinary contributions toward a better understanding of cyclic assembly and breakup of supercontinents and their interplay with mantle dynamics, paleoclimate, and paleoenvironment during the past two billion years.

T12. **Assembling Laurentia: Neoproterozoic to Cambrian Rifting and Continental Margin Evolution during Breakup of Rodinia and Pannotia**

Cosponsors: *GSA Structural Geology and Tectonics Division; GSA Sedimentary Geology Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Geophysics and Geodynamics Division; Mineralogical Society of America*

Disciplines: Tectonics/Tectonophysics, Stratigraphy, Precambrian Geology

Advocates: Francis A. Macdonald; Adolph Yonkee

The session focuses on Neoproterozoic tectonic, petrologic, and sedimentologic evolution of the margins of Laurentia during rifting of Rodinia and Pannotia, including associated environmental changes such as Snowball Earth and the appearance of animals.

T13. **Some Like It HOT: The Role of Late Extensional Tectonics in Collisional Orogens, with Special Emphasis on the Grenville Orogen**

Cosponsors: *GSA Structural Geology and Tectonics Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Geophysics and Geodynamics Division; GSA Sedimentary Geology Division; GSA Structural Geology and Tectonics Division*

Disciplines: Tectonics/Tectonophysics, Petrology, Metamorphic, Geochronology

Advocates: Erkan Toraman; Michelle Markley; Toby Rivers

This session covers the extensional collapse phase of large hot orogens, with a focus on the Grenville Orogen. We welcome contributions involving structural, petrological, geo/thermochronological, geophysical, and modeling techniques, multidisciplinary approaches, and comparisons with other orogens.

T14. **Strain in the Footwalls of Detachment Faults: New Insights on the 40th Anniversary of the Seminal GSA Memoir *Cordilleran Metamorphic Core Complexes***

Cosponsor: *GSA Structural Geology and Tectonics Division*

Disciplines: Tectonics/Tectonophysics, Structural Geology, Geophysics/Geodynamics

Advocates: James J. Vogl; John S. Singleton; Rory R. McFadden

Forty years after publication of GSA Memoir 153, *Cordilleran Metamorphic Core Complexes*, questions remain regarding the kinematics, rates, and dynamic significance of strain in footwalls and detachments. This session addresses these problems through contributions from field, analytical, and modeling studies.

T15. **Building the SZ4D Faulting and Earthquake Cycles Theme: What Controls Strain Accumulation and Release at Subduction Zones?**

Cosponsors: *GSA Structural Geology and Tectonics Division; GSA Geodynamics and Geophysics Division*
Disciplines: Tectonics/Tectonophysics, Geophysics/Geodynamics, Structural Geology
Advocates: Christine Regalla; Harold J. Tobin; Melodie French; Donna J. Shillington

This SZ4D session highlights ongoing research across a range of geoscience techniques that help further our understanding of the processes that underlie fault- and earthquake-related hazards in subduction systems.

T16. **Assembling Laurentia: Growth of the Western Continental Margin by Subduction, with or without Terrane Accretion, 190–70 Ma**

Cosponsors: *Mineralogical Society of America; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Structural Geology and Tectonics Division; GSA Sedimentary Geology Division*
Disciplines: Tectonics/Tectonophysics, Structural Geology, Petrology, Metamorphic
Advocates: Cathy J. Busby; Raphael Gottardi; Elisa Fitz-Diaz

This "Assembling Laurentia" session (190–70 Ma) is on the growth of the North American Cordillera and the opening of the Gulf of Mexico, including magmatism, metamorphism, sedimentology, structural geology, geochronology, and geophysics.

T17. **Evolution, Structure, and Landscapes of the North Atlantic–Arctic Realm**

Cosponsors: *GSA Geophysics and Geodynamics Division; GSA Structural Geology and Tectonics Division; GSA Quaternary Geology and Geomorphology Division; GSA Sedimentary Geology Division*
Disciplines: Tectonics/Tectonophysics, Geomorphology, Geophysics/Geodynamics
Advocates: Christian Schiffer; Scott Jess; Iwona Klonowska; Alexander Peace; Vivi Pedersen

This session will review our knowledge of the geodynamic and geomorphological processes from the surface to the upper mantle acting in the North Atlantic–Arctic region. We welcome contributions from all geoscientific disciplines.

T18. **Hot Rocks: High-Temperature Microstructures from Mantle to Surface**

Cosponsors: *GSA Structural Geology and Tectonics Division; GSA Geochronology Division; GSA Geophysics and Geodynamics Division*
Disciplines: Tectonics/Tectonophysics, Structural Geology, Geochronology
Advocates: Morgan E. Monz; Hannah J. 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.

T19. **Tectonics, Climate, and Life: Continental Drift, Large Igneous Provinces, and Global Change**

Cosponsors: *GSA Marine and Coastal Geoscience Division; Paleontological Society; GSA Structural Geology and Tectonics Division; GSA Sedimentary Geology Division*
Disciplines: Tectonics/Tectonophysics, Geochronology, Paleoclimatology/Paleoceanography
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.

T20. **Topographic and Lithospheric Evolution of Elevated Continental Passive Margins**

Cosponsor: *GSA Structural Geology and Tectonics Division*
Disciplines: Tectonics/Tectonophysics, Quaternary Geology, Geomorphology
Advocates: Peter J. Haproff; Jaclyn S. Baughman; Michelle Fame

This session is intended to present research on the post-collisional evolution of Phanerozoic orogens including rifting, passive margin sedimentation, topographic decay, and tectonic reactivation. We welcome contributions from geology, geophysics, thermochronology, sedimentology, and geomorphology.

STRUCTURAL GEOLOGY

T21. **The Geology of Induced Seismicity**

Cosponsors: *GSA Structural Geology and Tectonics Division; GSA Geophysics and Geodynamics Division; GSA Energy Geology Division*
Disciplines: Structural Geology, Energy Geology, Geoscience and Public Policy
Advocates: Owen A. Callahan; Folarin Kolawole; Elizabeth Horne

In this session, we welcome contributions from those working to understand seismic hazards by characterizing the geologic factors contributing to induced seismicity.

T22. **Best Student Geologic Map Competition (Posters)**

Cosponsors: *Association of American State Geologists; U.S. Geological Survey–National Cooperative Geologic Mapping Program; American Geosciences Institute; Geological Society of America; GSA Foundation; American Institute of Professional Geologists;* Journal of Maps*; GSA Structural Geology and Tectonics Division*
Disciplines: Structural Geology, Geomorphology, Stratigraphy
Advocates: Michael Marketti; Darcy K. McPhee

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.

T23. **A Multidisciplinary View of Brittle Structures in Layered Rock**

Cosponsor: *GSA Structural Geology and Tectonics Division*
Disciplines: Structural Geology, Stratigraphy, Tectonics/Tectonophysics
Advocates: Hannah B. Riegel; John Hooker

This section will cover brittle structures that occur in layered rock. This includes topics such as fracture pattern evolution, fault zone architecture, and hydraulic properties of brittly deformed rock layers.

T24. **Building the SZ4D Landscapes and Seascapes Theme: Geomorphic Change and Crustal Deformation from the Volcanic Arc, across the Forearc, and to the Trench**

Cosponsors: *GSA Structural Geology and Tectonics Division; GSA Quaternary Geology and Geomorphology Division; GSA Marine and Coastal Geoscience Division; GSA Sedimentary Geology Division; GSA Environmental and Engineering Geology Division*
Disciplines: Structural Geology, Geomorphology, Marine/Coastal Science
Advocates: Kristin Morell; Karen B. Gran; Juliet G. Crider; Nathan A. Niemi

This SZ4D session highlights ongoing research across a range of geoscience disciplines that further our understanding of the processes that drive topographic change, influence sediment flux, and generate related hazards in subduction settings, on- and off-shore.

T25. **Advances in Digital Field Methods for Geologic Research, Mapping, and Education**

Cosponsors: *GSA Structural Geology and Tectonics Division; GSA Geoinformatics and Data Science Division; GSA Quaternary Geology and Geomorphology Division; GSA Marine and Coastal Geoscience Division; GSA Sedimentary Geology Division*
Disciplines: Structural Geology, Tectonics/Tectonophysics, Geoscience Information/Communication
Advocates: Andrew V. Zuza; Nicholas C. Barth; Seth M. Dee

Modern geologic field research increasingly uses technological methods to document field observations, including tablet-based mapping and structure-from-motion photogrammetry, which allow for efficient, high-resolution data tabulation. This session will focus on applications of cutting-edge digital methods for both research and education.

T26. **Structural Geology and Tectonics Division 40th Anniversary Symposium: Drivers of Orogenesis**

Cosponsors: *GSA Structural Geology and Tectonics Division; GSA Geophysics and Geodynamics Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Quaternary Geology and Geomorphology Division*
Disciplines: Structural Geology, Tectonics/Tectonophysics, Geophysics/Geodynamics
Advocates: Juliet G. Crider; Nancye H. 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 keynote talks addressing this question and observational constraints from the lower crust to Earth's surface.

T27. **Approaches for Extracting Shear Zone History from the Ductile Rock Record: Probing Their Initiation, Evolution, and Reactivation**

Cosponsors: *GSA Structural Geology and Tectonics Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Geochronology Division*
Disciplines: Structural Geology, Geochronology, Petrology, Metamorphic
Advocates: Tarryn K. Cawood; Alexander Dmitri Lusk; Nicolas M. Roberts

How are *you* investigating crystal plastic shear zones? Through your approach, what have you discovered about their formation, evolution, and reactivation? Disciplinarily diverse contributions are welcome in this session focused on how to approach complex shear zone problems.

T28. **Linking Fault Zone Deformation Processes, Kinematic Indicators, and Geochronology through the Brittle and Brittle-Ductile Regimes of the Earth's Crust**

Cosponsors: *GSA Structural Geology and Tectonics Division; GSA Geochronology Division; GSA Hydrogeology Division; Canadian Tectonics Group; U.S. Geological Survey*
Disciplines: Structural Geology, Tectonics/Tectonophysics, Geochronology
Advocates: James Kirkpatrick; Dawn Kellett; Margaret Odlum; Jonathan Saul Caine

Advances in geo-thermo-chronometry facilitate integrated studies of deformation mechanisms, kinematics, timing, and associated processes in crustal fault zones. Field, analytical, numerical, and experimental studies providing holistic understanding of these structures are encouraged.

PRECAMBRIAN GEOLOGY

T29. **Life's Innovations from the Early Earth to the Search on Modern Mars: Honoring the Career of Andrew H. Knoll**

Cosponsors: *Paleontological Society; GSA Geobiology and Geomicrobiology Division; GSA Planetary Geology Division; GSA Sedimentary Geology Division; SEPM (Society for Sedimentary Geology); Geochemical Society*
Disciplines: Precambrian Geology, Paleontology, Diversity, Extinction, Origination, Geochemistry
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.

T30. **Assembling Laurentia: Neoarchean Crust Formation and Cratonization**

Cosponsors: *Mineralogical Society of America; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Geophysics and Geodynamics Division; GSA Sedimentary Geology Division; GSA Structural Geology and Tectonics Division*
Disciplines: Precambrian Geology, Tectonics/Tectonophysics, Petrology, Igneous
Advocates: Ben M. Frieman; Carol D. Frost; Paul A. Mueller

The session will focus on Neoarchean growth and cratonization of the continental nuclei that amalgamated to form Laurentia in the Paleoproterozoic, including production of voluminous granitoids, accretion of juvenile material, and the role of recycling.

T31. **Precambrian Basin Analysis**

Cosponsors: *GSA Structural Geology and Tectonics Division; GSA Sedimentary Geology Division*
Disciplines: Precambrian Geology, Stratigraphy, Structural Geology
Advocates: Marcus Kunzmann; Justin V. Strauss; Galen P. Halverson

This session brings together practitioners of Precambrian basin analysis to discuss recent advances in the field, as well as to identify future advances that are necessary to approach the resolution possible in younger basins.

T32. **Assembling Laurentia: Turning Points in Paleoproterozoic Tectonic Evolution**

Cosponsors: *Mineralogical Society of America; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Structural Geology and Tectonics Division*
Disciplines: Precambrian Geology, Tectonics/Tectonophysics, Petrology, Metamorphic
Advocates: David Corrigan; Camille A. Partin; Kevin H. Mahan

The session will focus on growth and assembly of the continental nuclei that amalgamated to form Laurentia in the Paleoproterozoic, as well as key processes (thermal, mechanical, magmatic, depositional, metallogenic, etc.) that define that era.

T33. **Evolving Perspectives on the Tonian Biosphere and Environmental Change**

Cosponsors: *GSA Geobiology and Geomicrobiology Division; Geochemical Society; Paleontological Society; GSA Sedimentary Geology Division*
Disciplines: Precambrian Geology, Geochemistry, Paleontology, Diversity, Extinction, Origination
Advocates: Timothy M. Gibson; Peter W. Crockford; Ashleigh v.S. Hood; Anne-Sofie C. Ahm

This session aims to consolidate recent advances in the timeline and nature of biological evolution and environmental change through the Tonian Period.

T34. **Exploring Earth's Adolescence between the Great Oxidation Event and the Tonian Period**

Cosponsor: *GSA Geobiology and Geomicrobiology Division*
Disciplines: Precambrian Geology, Geochemistry, Stratigraphy
Advocates: Malcolm S.W. Hodgskiss; Peter W. Crockford; Marcus Kunzmann

Recent years have seen the proliferation of studies on the mid-Proterozoic (or "boring billion"). This session aims to explore this broad interval in Earth history using the integrated geochemical, geochronological, paleontological, and rock records.

PETROLOGY, IGNEOUS

T35. **Building the SZ4D Magmatic Drivers of Eruption Theme: Geologic Evidence from Active and Exhumed Arcs**

Cosponsors: *GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Geophysics and Geodynamics Division; GSA Structural Geology and Tectonics Division*
Disciplines: Petrology, Igneous, Volcanology, Geophysics/Geodynamics
Advocates: Terry A. Plank; Ayla S. Pamukcu; Benjamin A. Black; Michael P. Eddy; Emily J. Chin

This SZ4D session highlights ongoing research across a range of geoscience techniques that further our understanding of the transcrustal magmatic processes that lead to volcanic eruptions in subduction systems.

T36. **Experimental and Petrologic Investigation of Halogens, Sulfur, and Other Volatile Species in Igneous Systems: In Honor of Jim Webster**

Cosponsors: *Geochemical Society; Mineralogical Society of America; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division*
Disciplines: Petrology, Igneous, Volcanology, Mineralogy/Crystallography
Advocates: Justin Filiberto; Daniel Harlov

This session is dedicated to Jim Webster, who devoted his professional career, both in the lab and in the field, to a broad study of halogens, sulfur, and other volatile species in igneous environments.

T37. **Rapakivi Granites and Associated A-Type Granites**

Cosponsors: *Mineralogical Society of America; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division*
Disciplines: Petrology, Igneous, Geochemistry
Advocates: Ryan Currier; Tim P. Flood

This session will focus on research devoted to the origin and evolution of rapakivi granites and/or associated A-type granites, based on recent considerations of the chemical, textural, tectonic, or temporal relationship of these rocks.

PETROLOGY, METAMORPHIC

T38. **From the Micro to Macro in Metamorphic Geology: Constraining Tectono-Metamorphic Processes with High-Resolution Approaches: In Honor of Mineralogical Society of America Roebling Medalist Andrew Putnis**

Cosponsors: *GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; Mineralogical Society of America; GSA Structural Geology and Tectonics Division*

INDUSTRY TRACKS Look for these icons, which identify sessions in the following areas:

Economic Geology | Energy | Engineering | Hydrogeology and Environmental Geology

Disciplines: Petrology, Metamorphic, Tectonics/Tectonophysics, Mineralogy/Crystallography
Advocates: Freya R. George; Adrian E. Castro; Joseph Browning-Hanson

This session will highlight research that utilizes advances in the tools and techniques employed in the investigation of microscale features of metamorphic rocks, in order to interrogate geochemical, microstructural, and geochronological records of tectono-metamorphic processes.

T39. **Granulite Terranes and Evolution of Continental Lower Crust: Insights from the Canadian Shield and Beyond**

Cosponsors: *GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Structural Geology and Tectonics Division; GSA Geochronology Division*
Disciplines: Petrology, Metamorphic, Tectonics/Tectonophysics, Precambrian Geology
Advocates: Gregory Dumond; Kevin H. Mahan; Philippe Goncalves

Granulite terranes provide some of the best constraints on the origin, characteristics, and evolution of continental lower crust. This session will highlight new research on the structural, geochemical, and geochronological evolution of deep continental crust.

VOLCANOLOGY

T40. **The Virtue of Fieldwork in Volcanology, Sedimentology, Structural Geology, and Tectonics: A Session to Honor Cathy Busby, 2020 MGPV Distinguished Geological Career Award Recipient**

Cosponsors: *GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Sedimentary Geology Division; GSA Structural Geology and Tectonics Division*
Disciplines: Volcanology, Structural Geology, Tectonics/Tectonophysics
Advocates: Keith Putirka; John Wakabayashi; Nancy R. Riggs

This session honors the career of Cathy Busby, whose diverse field studies have impacted volcanology, sedimentology, structural geology, and tectonics. Studies within or at the boundaries of these disciplines are welcome.

T41. **Volcanism and Tectonics along Rifts and Volcanic Arcs: Understanding the Relationships between Timing, Volumes, and Distributions**

Cosponsors: *GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Structural Geology and Tectonics Division*
Disciplines: Volcanology, Structural Geology, Geochronology
Advocates: Erin N. DiMaggio; Sara Mana

Magmatic activity influences the development of rifting and volcanic arcs, and their interactions occur at different temporal and spatial scales. We focus on the behavior of these dynamic systems.

STRATIGRAPHY

T42. **The Paradox of Predicting the Stratigraphic Record**

Cosponsor: *GSA Sedimentary Geology Division*
Disciplines: Stratigraphy, Geomorphology, Sediments, Clastic
Advocates: Tao Sun; Andrew Madof; Ashley D. Harris

This session addresses the universal properties and spatial structures in depositional systems and how we may be able to predict them.

T43. **Sedimentary Geology Division/SEPM Student Research Poster Competition: Dynamics of Stratigraphy and Sedimentation (Posters)**

Cosponsors: *GSA Sedimentary Geology Division; SEPM (Society for Sedimentary Geology)*
Disciplines: Stratigraphy, Sediments, Clastic, Sediments, Carbonates
Advocate: Brian A. Hampton

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.

T44. **Broken Paradigms: Shallow-Water Deposition of Organic-Rich Facies through Earth History**

Cosponsors: *GSA Marine and Coastal Geoscience Division; GSA Geobiology and Geomicrobiology Division; Geochemical Society; GSA Sedimentary Geology Division; GSA Energy Geology Division*
Disciplines: Stratigraphy, Paleoclimatology/Paleoceanography, Marine/Coastal Science
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 history.

T45. **Correlation of Global Stages, Series, and Systems into North American Stratigraphic Successions**

Cosponsors: *SEPM (Society for Sedimentary Geology); North American Commission on Stratigraphic Nomenclature (NACSN); International Commission on Stratigraphy (ICS)*
Disciplines: Stratigraphy, Paleontology, Biogeography/Biostratigraphy, History and Philosophy of Geology
Advocates: Richard Fluegeman; Stanley C. Finney; David A.T. Harper; Carlton E. Brett

Eighty-eight percent of 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.

SEDIMENTS, CLASTIC

T46. **An Interdisciplinary View of Paleozoic Glaciations and Icehouse Climates: Sedimentology, Paleoclimate, Paleontology, Geochemistry, Geochronology, and Modeling**

Cosponsors: *GSA Sedimentary Geology Division; GSA Geobiology and Geomicrobiology Division; GSA Geochronology Division; Geochemical Society; Paleontological Society*
Disciplines: Sediments, Clastic, Sediments, Carbonates, Paleoclimatology/Paleoceanography
Advocates: Libby R.W. Ives; Kathryn N. Pauls; Amy L. Weislogel; Eduardo L.M. da Rosa; John L. Isbell

Exciting advances have been made in our understanding of Paleozoic glaciations in recent years. This session seeks to bring

together those working on Paleozoic glaciations in disparate regions and eras using a variety of methodologies.

T47. **Case Studies of Diagenesis, Paragenesis, and Geochemical Transformations of Sedimentary Strata**

Cosponsors: *GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Soils and Soil Processes Division; GSA Sedimentary Geology Division; Geochemical Society*
Disciplines: Sediments, Clastic, Soils, Geochemistry
Advocates: Lauren A. Michel; Neil J. Tabor; Julia A. McIntosh

This session will highlight research that considers the roles of burial, diagenesis, and lithification and its chemical imprint upon primary minerals formed around Earth's near surface and interpretations of paleoenvironments and paleoclimates.

T48. **Insights into Cordilleran Tectonics and Magmatism from the Sedimentary Record**

Cosponsors: *GSA Structural Geology and Tectonics Division; GSA Sedimentary Geology Division*
Disciplines: Sediments, Clastic, Tectonics/Tectonophysics, Geochronology
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.

T49. **Refining Predictive Models of Modern and Ancient Source-to-Sink Systems**

Cosponsors: *GSA Sedimentary Geology Division; GSA Structural Geology and Tectonics Division; GSA Geoinformatics and Data Science Division; GSA Karst Division*
Disciplines: Sediments, Clastic, Tectonics/Tectonophysics, Geochronology
Advocates: Eugene Szymanski; Glenn R. Sharman; Matthew A. Malkowski

This session investigates the current state of source-to-sink modeling, the innovative technical approaches that improve model accuracy, and the knowledge gaps that currently prevent the creation of truly predictive frameworks in modern and ancient systems.

PALEOCLIMATOLOGY/PALEOCEANOGRAPHY

T50. **Interactions between Life, Tectonics, Climate, and Sedimentary Systems at the Neoproterozoic–Early Cambrian Transition**

Cosponsors: *GSA Sedimentary Geology Division; GSA Geochronology Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Geobiology and Geomicrobiology Division; Paleontological Society*
Disciplines: Paleoclimatology/Paleoceanography, Geochemistry, Paleontology, Paleoecology/Taphonomy
Advocates: Sarah M. Giles; Marjorie Cantine

The Neoproterozoic–Early Cambrian transition was a dynamic interval in Earth history that has been intensively studied with innovative techniques and approaches. What do we know in the year 2020? Where should new multidisciplinary research focus?

T51. **Oceans and Climates through Earth History: From Proxy Reconstructions to Model Assessments (Posters)**

Cosponsors: *Cushman Foundation; Geochemical Society; Paleontological Society; GSA Marine and Coastal Geoscience Division; GSA Quaternary Geology and Geomorphology Division; GSA Sedimentary Geology Division*
Disciplines: Paleoclimatology/Paleoceanography, Geochemistry, Paleontology, Biogeography/Biostratigraphy
Advocates: Chiara Borrelli; Megan K. Fung; Miriam E. Katz

This session brings together proxy, modeling, and proxy development studies to improve our understanding of rapid ocean and climate events, and shifts between long-term climate/ocean states, within the context of normal variability throughout Earth history.

T52. **Impacts of Volcanism on Global Climate and Oceans—Drivers of Mass Extinctions through the Phanerozoic**

Cosponsors: *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, Geochemistry, Volcanology
Advocates: Stephen E. Grasby; Gerta Keller; David P.G. 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 fingerprints such eruptions leave in the sedimentary record.

T53. **Cushman Symposium: Perspectives—Cushman Foundation 70 Years, Foraminifera 600 Million**

Cosponsors: *Cushman Foundation; GSA History and Philosophy of Geology Division; Paleontological Research Institution; Paleontological Society; SEPM (Society for Sedimentary Geology); GSA Sedimentary Geology Division*
Disciplines: Paleoclimatology/Paleoceanography, Paleontology, Biogeography/Biostratigraphy, History and Philosophy of Geology
Advocates: Pamela Buzas-Stephens; Brian Huber

For the 70th anniversary of the Cushman Foundation for Foraminiferal Research, the session showcases the latest in foraminiferal research and application. Speakers and historical accounts of the society tie the program together.

T54. **Ice-Sheet and Sea-Ice Paleo-Reconstructions from the Arctic, Antarctica, and the Southern Ocean**

Cosponsors: *GSA Marine and Coastal Geoscience Division; GSA Sedimentary Geology Division; GSA Quaternary Geology and Geomorphology Division*
Disciplines: Paleoclimatology/Paleoceanography, Marine/Coastal Science, Sediments, Clastic
Advocates: Sandra Passchier; Suzanne O'Connell; Victoria L. Peck; Kristen St. John

This session covers paleo-environmental reconstructions from ocean drilling, coring, and geophysical surveys of glacially influenced settings, including sedimentary processes of modern glacial

and sea ice systems and Cenozoic paleoceanography of the Arctic, Antarctica, and the Southern Ocean.

T55. **Insights from Microfossils and Their Modern Analogs: From Traditional to Emerging Approaches (Posters)**

Cosponsors: *Cushman Foundation; Paleontological Society; Geochemical Society; GSA Marine and Coastal Geoscience Division; GSA Limnogeology Division*
Disciplines: Paleoclimatology/Paleoceanography, Paleontology, Biogeography/Biostratigraphy, Geochemistry
Advocates: Vanessa Londoño; Maria N. Gudnitz

Traditional applications of microfossils are central to many studies, while novel approaches (especially geochemistry) utilizing microfossils have recently expanded. This session highlights traditional and innovative microfossil applications in terrestrial and marine environments, including modern analogs.

T56. **Co-Evolution of Earth's Surface Environment and Eukaryotic Life from the Mid-Proterozoic to Early Paleozoic**

Cosponsors: *GSA Geobiology and Geomicrobiology Division; GSA Sedimentary Geology Division; SEPM (Society for Sedimentary Geology); GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; Geochemical Society; Paleontological Society*
Disciplines: Paleoclimatology/Paleoceanography, Paleontology, Diversity, Extinction, Origination, Geochemistry
Advocates: Xinze Lyu; Alex Kunert

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 from the mid-Proterozoic to the Early Paleozoic.

T57. **Salinity Analysis of Ancient Depositional Systems**

Cosponsors: *GSA Sedimentary Geology Division; Geochemical Society; International Association of Sedimentologists; GSA Limnogeology Division*
Disciplines: Paleoclimatology/Paleoceanography, Sediments, Clastic, Geochemistry
Advocates: Thomas J. Algeo; Wei Wei

Salinity is an important characteristic of aqueous depositional systems but has proven challenging to reconstruct from sedimentary records. New tools and techniques for paleosalinity analysis will be explored in this session.

T58. **Integrative Approaches to Understanding Mesozoic Environmental and Biologic Perturbations**

Cosponsor: *GSA Geobiology and Geomicrobiology Division*
Disciplines: Paleoclimatology/Paleoceanography, Paleontology, Diversity, Extinction, Origination, Geochemistry
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 to outstanding questions about Mesozoic Earth System dynamics.

T59. **"Curse Your Sudden but Inevitable Betrayal": Advances and Challenges in Terrestrial Paleoclimate**

Cosponsors: *GSA Sedimentary Geology Division; GSA Soils and Soil Processes Division; GSA Continental Scientific Drilling Division; GSA Quaternary Geology and Geomorphology Division*
Disciplines: Paleoclimatology/Paleoceanography, Geochemistry
Advocates: David Colwyn; Robin R. Dawson; Gerard A. Otiniano

Preparations for a warmer future rest heavily on records of the past. Studying Cretaceous to recent terrestrial paleoclimate is important for understanding future change to the terrestrial environments and ecosystems where we live.

T60. **Women in American Paleontology: The Past as Prologue**

Cosponsors: *Paleontological Research Institution; Paleontological Society; Association for Women Geoscientists; GSA Geobiology and Geomicrobiology Division; Cushman Foundation; GSA History and Philosophy of Geology Division*
Disciplines: Paleoclimatology/Paleoceanography, History and Philosophy of Geology
Advocates: Warren D. Allmon; Robert M. Ross

This session will survey the historical contributions of women paleontologists, especially in the U.S., including biographical studies, historical and disciplinary summaries, and analyses of historical data on females in the profession.

T61. **Climatic and Biotic Processes through the Paleozoic, Mesozoic, and Cenozoic as Reconstructed from Microfossil Records**

Cosponsors: *Cushman Foundation; Micropalaeontological Society; Paleontological Society*
Disciplines: Paleoclimatology/Paleoceanography, Paleontology, Biogeography/Biostratigraphy, Paleontology, Diversity, Extinction, Origination
Advocates: Anieke Brombacher; Adriane R. Lam

This session will provide an overview of microfossil contributions to the understanding of past climates and biotas. We welcome contributions from all microfossil groups aiding Paleozoic, Mesozoic, and/or Cenozoic climatic and biotic reconstructions.

PALEONTOLOGY, BIOGEOGRAPHY/ BIOSTRATIGRAPHY

T62. **The Co-Evolution of Phanerozoic Climate, Landscapes, and Terrestrial Ecosystems**

Cosponsors: *Geochemical Society; Paleontological Society*
Disciplines: Paleontology, Biogeography/Biostratigraphy, Paleoclimatology/Paleoceanography, Paleontology, Paleoecology/ Taphonomy
Advocates: Tyler Kukla; Sandra Schachat; Jeremy K. Caves Rugenstein; Mairin Balisi

This session explores recent interdisciplinary approaches to elucidating complex deep-time interactions among climate, landscapes, and terrestrial life, with an emphasis on major biotic and abiotic events that shaped the evolution of ecosystems on land.

T63. **The Ordovician Earth: New Insights to Environmental and Biotic Responses in the Fossil and Rock Record**

Cosponsors: *Paleontological Society; IGCP652; IGCP653*
Disciplines: Paleontology, Biogeography/Biostratigraphy, Paleoclimatology/Paleoceanography, Stratigraphy
Advocates: Julie De Weirdt; Matthias Sinnesael; Christopher T. Conwell; Joshua B. Zimmt; Y. Datu Adiatma; Teresa D. Avila

This session will highlight recent advancements in our knowledge of the Ordovician Earth system as well as cross-discipline methods that provide new insight into the regional to global fossil and rock records.

T64. **Future Leaders in Paleontology**

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

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

T65. **Applications of Conodonts to Integrated Studies of Biostratigraphy, Chemostratigraphy, and Sequence Stratigraphy—North American Pander Society Annual Meeting**

Cosponsors: *Pander Society; Paleontological Society*
Disciplines: Paleontology, Biogeography/Biostratigraphy, Stratigraphy, Paleoclimatology/Paleoceanography
Advocates: Martyn L. Golding

Conodonts are a key element in Paleozoic and Triassic investigations of biostratigraphy, chemostratigraphy, and sequence stratigraphy, as well as studies of ocean chemistry and evolution. Presentations on all aspects of conodont research are welcome.

PALEONTOLOGY, DIVERSITY, EXTINCTION, ORIGINATION

T66. **Reconstructing Events of the Late Devonian: Fossil and Rock Record Insights into a Dynamic Biosphere**

Cosponsor: *Paleontological Society*
Disciplines: Paleontology, Diversity, Extinction, Origination, Paleoclimatology/Paleoceanography, Geochemistry
Advocates: Matthew Smart; John. E.A. Marshall

This session will present new findings from the fossil and rock records as well as novel analytical approaches to address current knowledge gaps regarding the two major extinction events in the Late Devonian, the Kellwasser, and Hangenberg Events.

T67. **Trends and Patterns in Neoproterozoic–Cambrian Biodiversity and Evolutionary Originations**

Cosponsors: *GSA Geobiology and Geomicrobiology Division; Paleontological Society; Geochemical Society; GSA Sedimentary Geology Division*
Disciplines: Paleontology, Diversity, Extinction, Origination, Paleontology, Phylogenetic/Morphological Patterns, Paleontology, Biogeography/Biostratigraphy
Advocates: Jessica R. Creveling; John L. Moore

This session brings together biostratigraphic, chemostratigraphic, geochronologic, taphonomic, and modeling studies to better resolve temporal trends and spatial patterns in Neoproterozoic and early Paleozoic animal originations and biodiversification.

T68. **New Insights on Arthropod Paleobiology**

Cosponsor: *Paleontological Society*
Disciplines: Paleontology, Diversity, Extinction, Origination, Paleontology, Phylogenetic/Morphological Patterns, Paleontology, Paleoecology/Taphonomy
Advocates: Matthew K. Witte; Rhiannon J. 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 has shaped our modern understanding of the processes of evolution, diversification, morphology, and more.

T69. **Polar Paleobiology and Paleoenvironmental Proxies**

Cosponsors: *Paleontological Society; Paleontological Research Institution; SEPM (Society for Sedimentary Geology); Scientific Committee on Antarctic Research; GSA Sedimentary Geology Division*
Disciplines: Paleontology, Diversity, Extinction, Origination, Paleontology, Biogeography/Biostratigraphy, Paleontology, Biogeography/Biostratigraphy
Advocates: James D. Witts; Rowan J. Whittle; Thomas S. Tobin; Benjamin J. Linzmeier

This session will highlight studies examining the effects of environmental changes on life at high latitudes in the past. All time periods, fossil groups, and paleoenvironmental proxies are welcome.

T70. **Cephalopods Present and Past: Insights into Evolution, Paleobiology, and Links to Paleoenvironmental Change**

Cosponsors: *Paleontological Society; GSA Geobiology and Geomicrobiology Division*
Disciplines: Paleontology, Diversity, Extinction, Origination, Paleontology, Paleoecology/Taphonomy, Paleontology, Biogeography/Biostratigraphy
Advocates: Shannon K. Brophy; Ekaterina Larina; Jone Naujokaityte; James D. Witts; Kathleen A. Ritterbush

INDUSTRY TRACKS Look for these icons, which identify sessions in the following areas:


Economic Geology


Energy


Engineering


Hydrogeology and Environmental Geology

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

T71. The Evolution of Early Phanerozoic Oceans: A Geobiological Perspective

Cosponsors: *Paleontological Society; GSA Geobiology and Geomicrobiology Division; GSA Marine and Coastal Geoscience Division; Geochemical Society*
Disciplines: Paleontology, Diversity, Extinction, Origination, Geochemistry, Paleoclimatology/Paleoceanography
Advocates: Pedro M. Monarrez; Joshua B. Zimmt; Richard G. 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 Ordovician.

T72. In Memory of Joanne Kluessendorf: The Winifred Goldring Award and the Promise of Women in Paleontology

Cosponsors: *Association for Women Geoscientists; Paleontological Society; Paleontological Research Institution*
Disciplines: Paleontology, Diversity, Extinction, Origination, Paleontology, Paleoecology/Taphonomy, Paleontology, Phylogenetic/Morphological Patterns
Advocates: Patricia H. 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.

T73. Cambrian–Ordovician Faunas and Events: A Session in Honor of John F. Taylor and John E. Repetski

Cosponsor: *Paleontological Society*
Disciplines: Paleontology, Diversity, Extinction, Origination, Paleontology, Biogeography/Biostratigraphy
Advocates: Paul M. Myrow; Justin V. Strauss

To honor John Taylor and John Repetski's careers, we seek contributions that cover emerging concepts related to the evolution of fauna, biostratigraphy, and changes in environments, oceans, atmosphere, and paleogeography during the Cambrian and Ordovician.

T74. Improving the Accessibility of Natural History Collections

Cosponsors: *GSA History and Philosophy of Geology Division; Paleontological Society*
Disciplines: Paleontology, Diversity, Extinction, Origination, History and Philosophy of Geology, Geoinformatics
Advocates: Jennifer E. Bauer; Jeanette Pirlo

Natural history collections are often inaccessible; this session highlights innovative and novel approaches to increasing accessibility to specimens and collections.

PALEONTOLOGY, PALEOECOLOGY/TAPHONOMY

T75. Community Ecology and the Fossil Record: Diversity, Ecological Structure, and Paleoenvironmental Responses

Cosponsor: *Paleontological Society*
Disciplines: Paleontology, Paleoecology/Taphonomy, Paleontology, Biogeography/Biostratigraphy, Paleontology, Diversity, Extinction, Origination
Advocates: Karma Nanglu; Thomas M. Cullen

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

T76. Exceptional Fossilization in Time and Space

Cosponsors: *GSA Geobiology and Geomicrobiology Division; Paleontological Society*
Disciplines: Paleontology, Paleoecology/Taphonomy, Geomicrobiology, Paleontology, Diversity, Extinction, Origination
Advocates: Lidya G. Tarhan; Ross P. Anderson

Exceptional fossils preserving soft tissues are essential to the reconstruction of the evolution of life on our planet. This session explores new geological, experimental, and modeling-based insights into the taphonomy of Konservat Lagerstätten.

T77. New Insights into the History of Life from Novel Techniques

Cosponsors: *GSA Geobiology and Geomicrobiology Division; Geochemical Society*
Disciplines: Paleontology, Paleoecology/Taphonomy, Paleontology, Diversity, Extinction, Origination, Paleontology, Biogeography/Biostratigraphy
Advocates: Katie Maloney; Brandt M. Gibson

Technological advancements and novel methodologies provide new insight into the paleontological record.

T78. Biotic Interactions through Time

Cosponsors: *Paleontological Society; GSA Limnogeology Division*
Disciplines: Paleontology, Paleoecology/Taphonomy, Paleontology, Diversity, Extinction, Origination, Paleontology, Phylogenetic/Morphological Patterns
Advocates: Tobias B. 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.

T79. Ecosystem Engineering through Earth History

Cosponsors: *GSA Geobiology and Geomicrobiology Division; Paleontological Society*
Disciplines: Paleontology, Paleoecology/Taphonomy, Paleontology, Paleoecology/Taphonomy, Geomicrobiology
Advocates: Alison T. Cribb; Katherine A. Turk; Simon A.F. Darroch; David J. Bottjer

Ecosystem engineers are organisms that influence ecosystem habitability. They are critical to understanding the co-evolution of life and the environment. This session will highlight research on the evolution and effects of ecosystem engineers through time.

T80. **Biosediments: Tracking Biogenic Materials and Sedimentation Processes through Time**

Cosponsors: *GSA Geobiology and Geomicrobiology Division; Paleontological Society; GSA Sedimentary Geology Division; GSA Limnogeology Division*
Disciplines: Paleontology, Paleoecology/Taphonomy, Sediments, Carbonates, Geomicrobiology
Advocates: Lydia S. Tackett; James H. Nebelsick

Biosediments can serve as informative proxies for geochemical processes, depositional environment conditions, and paleoecological structure of biotic communities. This session will explore the novel utilization of biogenic materials in geological research.

T81. **Ichnology as a Global Proxy Multitool to Reconstruct Biodiversity, Ecology, Hydrology, and Climate in Continental to Marine Settings**

Cosponsors: *SEPM (Society for Sedimentary Geology); GSA Sedimentary Geology Division; GSA Marine and Coastal Geoscience Division; Paleontological Society; GSA Limnogeology Division*
Disciplines: Paleontology, Paleoecology/Taphonomy, Sediments, Clastic, Paleoclimatology/Paleoceanography
Advocates: Stephen T. Hasiotis; Ilya V. Buynevich; Logan A. Wiest

Ancient and modern traces serve as proxies for biophysicochemical processes used in reconstructions of continental and marine deposits. We welcome research in all aspects of organism-sediment interactions at a range of spatial and temporal scales.

T82. **Surf to Sea, Small to Large, Bottom to Top: Ecosystem Perspectives on the Marine Fossil Record**

Cosponsors: *Paleontological Society; GSA Marine and Coastal Geoscience Division; GSA Sedimentary Geology Division*
Disciplines: Paleontology, Paleoecology/Taphonomy, Paleontology, Diversity, Extinction, Origination, Paleontology, Biogeography/Biostratigraphy
Advocates: Judith A. Sclafani; Heather L. Jones; Garett M. Brown; Pedro M. Monarrez

We aim to unite paleontologists working on various groups to better understand marine ecosystem functioning, especially following mass extinctions and major intervals of environmental perturbation in the geologic past.

T83. **Stratigraphy, Stasis, and Shales: A Celebration of the Careers of Carlton Brett and Gordon Baird**

Cosponsors: *Paleontological Society; GSA Energy Geology Division*
Disciplines: Paleontology, Paleoecology/Taphonomy, Paleontology, Diversity, Extinction, Origination, Stratigraphy
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 in these topics are welcome to celebrate their outstanding careers.

PALEONTOLOGY, PHYLOGENETIC/ MORPHOLOGICAL PATTERNS

T84. **Phylogenetic Paleobiology: Combining Evolutionary Trees and Fossils to Understand the Evolution of Life**

Cosponsors: *Paleontological Society; Paleontological Research Institution; GSA Geobiology and Geomicrobiology Division*
Disciplines: Paleontology, Phylogenetic/Morphological Patterns, Paleontology, Diversity, Extinction, Origination, Paleontology, Biogeography/Biostratigraphy
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.

T85. **Linking Biological Questions to Paleontological Data: Statistical Models, Technological Advancements, and Conceptual Improvements**

Cosponsors: *Paleontological Society; Methods in Ecology and Evolution (British Ecological Society); GSA Geoinformatics and Data Science Division*
Disciplines: Paleontology, Phylogenetic/Morphological Patterns, Paleontology, Diversity, Extinction, Origination, Paleontology, Biogeography/Biostratigraphy
Advocates: Lee Hsiang Liow; Daniele Silvestro

This session showcases methodological development, including those that are statistical or infrastructural, lab, field, or computational, that explicitly aim at integrating paleontological and neontological data or/and linking paleobiological and biological concepts and questions.

T86. **Shape, Size, and Function: New Approaches to Morphometric Analyses**

Cosponsors: *Paleontological Society; Paleontological Research Institution; Association for Women Geoscientists*
Disciplines: Paleontology, Phylogenetic/Morphological Patterns
Advocates: Carmi Milagros Thompson; Shamindri Tennakoon; Katherine A. Turk

The study of morphology is a critical component within paleontology, and new analytical techniques are constantly on the horizon. This session will focus on emerging and novel approaches to answering morphological questions across taxonomic groups and time periods.

T87. **Growing a Skeleton: Methodological and Theoretical Approaches to Unraveling the Stories Preserved in Skeletal Materials**

Cosponsors: *Paleontological Society; GSA Geobiology and Geomicrobiology Division; Geochemical Society*
Disciplines: Paleontology, Phylogenetic/Morphological Patterns, Mineralogy/Crystallography, Geochemistry
Advocates: Emilia Jarochowska; David K. Moss; Yara Haridy; Rehemat Bhatia; Ismael Coronado Vila

New tools in sclerochronology, ecology, structural and chemical analysis of skeletal tissues allow for reconstructing physiology, evolutionary processes, and an organism's interactions with the environment at the scale of individuals as well as populations.

GEOPHYSICS/GEODYNAMICS

T88. Variability of Fault Activity and Earthquakes in Space and Time

Cosponsors: *GSA Geophysics and Geodynamics Division; GSA Structural Geology and Tectonics Division*
Disciplines: Geophysics/Geodynamics, Tectonics/Tectonophysics
Advocates: Seth A. Stein; Anke M. Friedrich; Mian Liu

The earthquake cycle paradigm predicts quasiperiodic earthquakes and steady displacement accumulation. However, historic and paleoseismic records show complicated space-time variations in fault activity. We solicit papers exploring these using various data and modeling approaches.

T89. Applying Near Surface Geophysics to Solve Geological Problems

Cosponsors: *GSA Geophysics and Geodynamics Division; GSA Geoarchaeology Division; GSA Environmental and Engineering Geology Division; GSA Hydrogeology Division; GSA Karst Division; GSA Quaternary Geology and Geomorphology Division*
Disciplines: Geophysics/Geodynamics, Geomorphology, Environmental Geoscience
Advocate: Kevin L. Mickus

Abstracts are requested that use all methods of geophysics to solve near surface environmental, engineering, hydrological, archaeological, and geological mapping problems.

T90. The 2019–2020 Southwestern Puerto Rico Earthquake Sequence and the Intersection between Geoscience Research, Education, and Communication

Cosponsors: *GSA Geophysics and Geodynamics Division; GSA Structural Geology and Tectonics Division; GSA Geology and Society Division*
Disciplines: Geophysics/Geodynamics, Structural Geology, Geoscience Information/Communication
Advocates: Daniel A. Laó-Dávila; Angel A. Garcia Jr.; Angel A. Acosta Colón

The 2019–2020 earthquake sequence in Puerto Rico has been the most destructive in 100 years. This interdisciplinary session seeks contributions on geoscience, informal education, and science communication research related to the earthquake events.

T91. Using Geophysics to Evaluate and Explore for Mineral, Energy, and Groundwater Resources

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

Abstracts are requested that use the geophysical methods including electrical resistivity, electromagnetics, seismic, gravity, and/or magnetics to explore and evaluate mineral deposits, petroleum prospects, and groundwater.

T92. Structure and Dynamics of the Appalachian Orogen

Cosponsors: *GSA Geophysics and Geodynamics Division; GSA Structural Geology and Tectonics Division*
Disciplines: Geophysics/Geodynamics, Tectonics/Tectonophysics
Advocates: Fiona Darbyshire; Yvette Kuiper; Maureen D. Long; Rob L. Evans; Scott D. King

Explore the along-strike variability and evolution of the Appalachian orogen through tectonics, geological/geophysical structure, and regional geodynamics. Contributions from all disciplines are welcome, and those linking surface tectonics to deep structure are particularly encouraged.

T93. Lithospheric Structure and Evolution of Cratons

Cosponsors: *GSA Geophysics and Geodynamics Division; GSA Structural Geology and Tectonics Division*
Disciplines: Geophysics/Geodynamics, Tectonics/Tectonophysics, Precambrian Geology
Advocates: Fiona Darbyshire; Andrew Frederiksen

We explore the geophysical structure of the cratonic lithosphere, with particular emphasis on the differences between "intact" cratons and those whose keels have experienced significant tectonic modification. Studies of Laurentia and cratons worldwide are welcome.

T94. Induced and Triggered Earthquakes in the United States and Canada

Cosponsor: *GSA Geophysics and Geodynamics Division*
Disciplines: Geophysics/Geodynamics, Structural Geology
Advocates: Ryan Schultz; Hadi Ghofrani; Ruijia Wang

This session covers earthquakes associated with industrial activities (e.g., hydraulic fracturing; waste-water disposal).

GEOCHEMISTRY

T95. Sigma Gamma Epsilon Student Research (Posters)

Cosponsors: *Sigma Gamma Epsilon; GSA Marine and Coastal Geoscience Division; GSA Limnogeology Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Structural Geology and Tectonics Division*
Disciplines: Geochemistry, Structural Geology, Environmental Geoscience
Advocates: D.M. Burns; James C. Walters

Students doing research in ANY field, from archaeological geology to volcanology, are encouraged to enter in this student-centered display of talented, up-and-coming scientists. All SGE students are encouraged to submit to this session to compete for research awards and recognition.

T96. Mineralogy, Petrology, and Geochemistry: New Approaches to Harnessing the Multidimensionality of Complex Systems

Cosponsors: *Geochemical Society; Mineralogical Society of America; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division*
Disciplines: Geochemistry, Mineralogy/Crystallography, Petrology, Igneous
Advocates: Shaunna M. Morrison; Ahmed Eleish

The application of data science methods to problems in mineralogy, petrology, and geochemistry has revealed insights into emergent behaviors of complex systems. With the correct infrastructure elements, such applications are extending the frontier of research.

T97. **Deep-Time Carbon Cycles, Redox Changes, and the Evolution of the Biosphere**

Cosponsors: *GSA Geobiology and Geomicrobiology Division; GSA Sedimentary Geology Division; International Association of Sedimentologists; SEPM (Society for Sedimentary Geology); GSA Karst Division*
Disciplines: Geochemistry, Paleoclimatology/Paleoceanography, Stratigraphy
Advocates: Huan Cui; Ying Cui; Amanda Oehlert; Lawrence M.E. Percival; Alexandra Rodler

This session aims to present the latest research in biogeochemical carbon cycles and its link to redox changes and life evolution in Earth's history.

T98. **Groundwater–Surface Water Interactions under Climate and Anthropogenic Change**

Cosponsors: *GSA Quaternary Geology and Geomorphology Division; Geochemical Society; GSA Hydrogeology Division; GSA Limnogeology Division; GSA Karst Division*
Disciplines: Geochemistry, Hydrogeology, Marine/Coastal Science
Advocates: Sabina Rakhimbekova; Barret L. Kurylyk; Jana K. Levison

This session encourages contributions that cover research on groundwater–surface water interactions using novel experimental and monitoring methods, reactive transport modeling, and assessing the impact of climate change and anthropogenic factors.

T99. **Records of Early Diagenesis in Modern and Ancient Sediments**

Cosponsors: *GSA Sedimentary Geology Division; GSA Geobiology and Geomicrobiology Division; GSA Marine and Coastal Geoscience Division; GSA Limnogeology Division*
Disciplines: Geochemistry, Sediments, Clastic, Sediments, Carbonates
Advocates: Stephen C. Phillips; Natascha Riedinger; Maxwell Pommer

Post-depositional (bio-)geochemical processes in shallowly buried aquatic sediments drive textural and compositional alteration during burial, leaving a lasting imprint recorded in ancient rocks. We welcome submissions broadly related to early diagenesis in sediments and sedimentary rocks.

T100. **Using Hydrochemistry to Conceptualize Relations between Recharge and Discharge in Karst Aquifers**

Cosponsor: *GSA Hydrogeology Division*
Disciplines: Geochemistry, Karst, Hydrogeology
Advocates: Rebecca R. Nunu; Barbara J. Mahler; 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.

T101. **Fundamental Insights from Field and Laboratory Studies Related to the Genesis and Ore-Forming Processes Associated with Granitoid Generation and Evolution to Their Related Alteration and Mineralization**

Cosponsors: *Geochemical Society; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division*
Disciplines: Geochemistry, Geochronology, Mineralogy/Crystallography
Advocates: Nadia Mohammadi; Brian Cousens; Hassan Rezaee

This session provides an opportunity to discuss recent research into granitoid-related ore deposits that focuses on their genesis, geochemistry, geochronology, mineralogy, metallurgy, and mineral exploration.

T102. **Novel Approaches for Constraining the Evolution of Essential Nutrient Cycling**

Cosponsor: *GSA Geobiology and Geomicrobiology Division*
Disciplines: Geochemistry, Geomicrobiology, Paleoclimatology/Paleoceanography
Advocates: Moji Fahkraee; Benjamin Johnson; Leslie J. Robbins; Maya Gomes; Eva E. Stüeken

The cycling of essential elements has controlled life's trajectory over geological timescales. We seek to understand how this cycling has changed over Earth's history and how changes relate to major biological or environmental events.

T103. **Geochemical Signatures of Fluid-Rock Interaction: Earth Surface Weathering to Hydrothermal Systems**

Cosponsors: *GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; Geochemical Society; GSA Hydrogeology Division; GSA Energy Geology Division*
Disciplines: Geochemistry, Hydrogeology, Petrology, Metamorphic
Advocates: Brian W. Stewart; Jennifer McIntosh; Grant Ferguson

This session explores the application of novel geochemical and/or isotopic tools to understand the processes and history of interacting fluid (water, hydrocarbons, CO_2) and solid (soil, sediment, rock) in environments ranging from near-surface to hydrothermal/metasomatic.

INDUSTRY TRACKS Look for these icons, which identify sessions in the following areas:

Economic Geology | Energy | Engineering | Hydrogeology and Environmental Geology

T104. **Metamorphic Geochemistry without Borders: A Session to Honor 2020 Dana Medalist Daniela Rubatto**

Cosponsors: *Mineralogical Society of America; GSA Structural Geology and Tectonics Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division*
Disciplines: Geochemistry, Petrology, Metamorphic, Tectonics/Tectonophysics
Advocates: Suzanne L. Baldwin; Clare Warren; M.J. Kohn; Sumit Chakraborty

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.

T105. **Assessing the Fidelity of Geochemical Signals in Deep Time: Primary, Authigenic, and Diagenetic Signals in Proxy Data**

Cosponsors: *GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Sedimentary Geology Division*
Disciplines: Geochemistry, Sediments, Carbonates, Paleoclimatology/Paleoceanography
Advocates: Jiuyuan Wang; Adam Denny; Huan Cui; Benjamin J. Linzmeier

Identification of primary geochemical proxy preservation is critical to paleoenvironmental reconstruction. Presentations in this session will highlight processes that may alter geochemical proxies and methods of identifying alteration.

GEOCHRONOLOGY

T106. **Applying Petrochronology to Tectonic Provenance Studies**

Cosponsors: *GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Geochronology Division; GSA Structural Geology and Tectonics Division*
Disciplines: Geochronology, Geochemistry, Tectonics/Tectonophysics
Advocates: William T. Jackson Jr.; Matthew P. McKay; Elizabeth M. Bollen

Petrochronology data provide opportunities to interpret spatial-temporal tectonic processes. We welcome submissions that present microanalyses, geochemistry, radioisotope geochronology, and analytical imaging techniques that advance the utilization of mineral chemistry for provenance fingerprinting.

T107. **Integrating Geochronological, Geochemical, and Petrological Data—Progress in Petrochronology and Applications**

Cosponsors: *Geological Association of Canada; Canadian Tectonics Group–GAC Division; Geochemical Society; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division*
Disciplines: Geochronology, Petrology, Metamorphic, Geochemistry
Advocates: Chris Clark; Carl Guilmette; Kyle Larson; Chris Yakymchuk

This session welcomes contributions addressing conceptual and analytical petrochronological methods as well as applications in all domains, including metamorphic and igneous petrology and detrital provenance studies.

T108. **Advances and Innovations in U-Pb Geochronology and Geochemistry of Mafic, Alkaline, and Other Mantle-Derived Rocks Associated with the Evolution of the North American Shield and Its Subcontinental Lithospheric Mantle: A Session in Honor of Larry Heaman**

Cosponsors: *Geochemical Society; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division*
Disciplines: Geochronology, Petrology, Igneous, Precambrian Geology
Advocates: Joshua H.F.L. Davies; D. Graham Pearson; Thomas Stachel; Robert A. Creaser

Geochronology and geochemistry applied to mafic, alkaline, igneous, and other mantle-derived rocks, especially associated with the evolution of the North American shield and its subcontinental lithospheric mantle.

T109. **Bridging the Laboratory–Database Divide in Geochemistry**

Cosponsors: *GSA Geochronology Division; GSA Geoinformatics and Data Science Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; Geochemical Society; GSA Karst Division*
Disciplines: Geochronology, Geochemistry, Geoinformatics
Advocates: Daven P. Quinn; Benjamin J. Linzmeier; Leah E. Morgan; Kurt E. Sundell

Presentations in this session will showcase the scientific impact of lab-to-database workflows in geochemistry and geochronology. We encourage the submission of results driven by new data-management techniques and community-level synthesis.

T110. **A Matter of Time: The Stratigraphic Record of Time and the Future of Timescale Calibration**

Cosponsors: *GSA Geochronology Division; International Subcommission on Timescale Calibration; Paleontological Society*
Disciplines: Geochronology, Stratigraphy, Paleontology, Biogeography/Biostratigraphy
Advocates: Bradley D. Cramer; Mark D. Schmitz

This session encourages all who deal with time in the rock record to participate, especially encouraging integration of numerical and relative time techniques from all parts of the geologic time scale (Hadean to Holocene).

T111. **Using Paired Single-Mineral Geochronology and Geochemistry to Address Tectonic Problems from the Mid-Crust to Earth's Surface**

Cosponsors: *GSA Geochronology Division; GSA Structural Geology and Tectonics Division*
Disciplines: Geochronology, Geochemistry, Tectonics/Tectonophysics
Advocates: Kristina Lynn Butler; Margaret Odlum; Sarah W.M. George

Combined geochronologic and geochemical data on single minerals offer the potential to track tectonic processes through the crust and at Earth's surface. This session focuses on mid- to upper-crustal petrochronologic tools and innovative applications.

PLANETARY GEOLOGY

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

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

Cosponsors: *GSA Planetary Geology Division; Paleontological Society*
Disciplines: Planetary Geology, Paleontology, Diversity, Extinction, Origination, Stratigraphy
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.

T114. **Best Practices and Exciting Discoveries in Identifying, Mapping, and Analyzing Planetary Landforms and Terrestrial Analogues**

Cosponsors: *GSA Planetary Geology Division; U.S. Geological Survey Astrogeology Science Center*
Discipline: Planetary Geology
Advocates: Jeannette Wolak; 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.

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

Cosponsors: *GSA Planetary Geology Division; GSA Quaternary Geology and Geomorphology Division; GSA Sedimentary Geology Division; GSA Soils and Soil Processes Division*
Disciplines: Planetary Geology, Geomorphology
Advocates: Sharon Wilson Purdy; Marisa Palucis

This session explores the formation and modification of landforms on Mars (e.g., impact craters, fluvial features) that can be used as yardsticks to measure the evolution of the surface and constrain the planet's climate history.

T116. **Void Spaces on Planetary Bodies**

Cosponsor: *GSA Planetary Geology Division*
Discipline: Planetary Geology
Advocates: Debra L. Buczkowski; Danielle Y. Wyrick

This session solicits abstracts on subsurface void spaces and the processes that form them on Solar System bodies. It encompasses surface geology, interior evolution, and comparative planetary studies with observational, experimental, or theoretical approaches.

T117. **The G.K. Gilbert Award Session**

Cosponsor: *GSA Planetary Geology Division*
Discipline: Planetary Geology
Advocates: Emily S. Martin; Sharon Wilson Purdy; Debra H. Needham

This session will honor the 2020 winner of the Planetary Geology Division's G.K. Gilbert Award, highlighting recent contributions in the awardee's field of research.

T118. **Impact Cratering across the Solar System**

Cosponsors: *GSA Planetary Geology Division; GSA Structural Geology and Tectonics Division; GSA Geophysics and Geodynamics Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Scientific Continental Drilling Division*
Disciplines: Planetary Geology, Mineralogy/Crystallography, Geochemistry
Advocates: Jeffrey Plescia; Christian Koeberl

Impact cratering is a primary geologic process throughout the Solar System. The session focuses on the geologic, geochemical, and geophysical signatures of impacts, the impact flux, and implications for geologic evolution.

T119. **Sedimentary Landscapes across the Solar System: Planets, Moons, and Terrestrial Analogues**

Cosponsors: *GSA Planetary Geology Division; GSA Quaternary Geology and Geomorphology Division; GSA Sedimentary Geology Division*
Disciplines: Planetary Geology, Geomorphology, Sediments, Clastic
Advocates: Alessandro Ielpi; Mathieu G.A. Lapotre

We welcome both state-of-the-art contributions and recent exploits in the broad area of planetary sedimentology and geomorphology, including (bio?)geochemical cycling, and analogue modeling derived from both Precambrian and modern terrestrial systems devoid of macroscopic life.

T120. **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**

Cosponsors: *GSA Planetary Geology Division; GSA Structural Geology and Tectonics Division; GSA History and Philosophy of Geology Division; GSA Geophysics and Geodynamics Division*
Disciplines: Planetary Geology, Structural Geology, History and Philosophy of 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 past 60 years, from tectonics to the K-T impact event.

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

Cosponsors: *GSA Planetary Geology Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division*
Disciplines: Planetary Geology, Volcanology, Tectonics/Tectonophysics
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. **The Big Picture from Small Worlds: Dwarf Planets, Trans-Neptunian Objects, Asteroids, Comets, and More**

Cosponsor: *GSA Planetary Geology Division*
Disciplines: Planetary Geology, Geophysics/Geodynamics, Geochemistry
Advocates: Kynan H.G. Hughson; Debra L. Buczkowski; Jennifer E.C. Scully

Global space agencies have recently conducted a number of missions to "small worlds," such as asteroids, comets, trans-neptunian objects, and dwarf planets. We welcome abstracts related to geological, geophysical, and/or geochemical analysis of these worlds.

T123. **Rocks from Space! Using Meteorites to Understand the Physical, Chemical, and Mineralogical Evolution of Planetary Bodies**

Cosponsors: *GSA Planetary Geology Division; Mineralogical Society of America; Geochemical Society; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division*
Disciplines: Planetary Geology, Petrology, Igneous, Geochemistry
Advocates: Tasha Dunn; Justin Filiberto; Christopher D.K. Herd

This session will highlight the role that laboratory studies of meteorites (e.g., petrographic and mineralogical studies, geochronology, and isotopic analysis) play in advancing our understanding of planetary body evolution (asteroids, the moon, and Mars).

T124. **To Boldly Go: Thoughts, Approaches, and Examples for Teaching Planetary Science and Integrating Students into the Research Process**

Cosponsors: *GSA Planetary Geology Division; GSA Geoscience Education Division*
Disciplines: Planetary Geology, Geoscience Education
Advocates: Nicholas P. Lang; Jennifer L.B. Anderson

This session explores approaches used to teach planetary science content to students at the K–12, college, and graduate levels. Approaches to successfully integrating students at each level into the research process will also be addressed.

MINERALOGY/CRYSTALLOGRAPHY

T125. **Volatile Cycles from Earth's Surface to the Core**

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

Recent advances in mineral physics have revealed a number of unexpected transitions and phenomena, such as super-oxidation and super-ionization in volatile bearing minerals that lead to paradigm change in our understanding of volatile cycles.

T126. **Mapping, Minerals, and Metamorphism—Work Small, Think Big: A Tribute to the Life of Peter Robinson**

Cosponsors: *Mineralogical Society of America; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Structural Geology and Tectonics Division; GSA Energy Geology Division*
Disciplines: Mineralogy/Crystallography, Structural Geology, Petrology, Metamorphic
Advocates: John C. Schumacher; Virginia Peterson; Kurt Hollocher; Jennifer A. Thomson

In memory of Peter Robinson, a gifted scientist and teacher, this session focuses on topics Peter pursued throughout his career, including tectonics, petrology, metamorphism, structural geology, New England geology, and the Caledonides.

T127. **Gemological Research in the 21st Century: Gem Minerals and Localities**

Cosponsors: *Gemological Institute of America (GIA); Mineralogical Society of America; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division*
Disciplines: Mineralogy/Crystallography, Economic Geology, Geoscience Information/Communication
Advocates: Caroline Nelms; James E. Shigley; Wuyi Wang; Barbara L. Dutrow; John W. Valley

Gemstones are among the most recognized of all minerals. This session focuses on gem formation, exploration, and localities; physical and chemical properties of gems; as well as detection of synthetics and treatments.

GEOMORPHOLOGY

T128. **Paleoseismic and Present-Day Seismic Evidence from Marine, Lacustrine, and Terrestrial Environments**

Cosponsors: *GSA Quaternary Geology and Geomorphology Division; GSA Limnogeology Division; GSA Marine and Coastal Geoscience Division; GSA Geophysics and Geodynamics Division; GSA Sedimentary Geology Division*
Disciplines: Geomorphology, Limnogeology, Quaternary Geology
Advocates: Andree Blais-Stevens; Guillaume St-Onge; Patrick Lajeunesse

In this session, we seek contributions related to seismic and paleoseismic evidence in various recent sedimentary environments, from terrestrial, lacustrine, to marine.

T129. **Physical Experimentation and Modeling in Surface Processes**

Cosponsors: *GSA Quaternary Geology and Geomorphology Division; GSA Environmental and Engineering Geology Division; GSA Soils and Soil Processes Division; GSA Sedimentary Geology Division*
Disciplines: Geomorphology, Engineering Geology, Soils
Advocates: Zachary Phillips; Stephen A. Wolfe; Stephanie S. Day

This session highlights research utilizing physical experimentation or modeling of surface processes to simplify complex processes to answer basic research questions. Speakers from subjects including geomorphology, tectonics, soils, engineering, etc., are encouraged to submit abstracts.

T130. **Surface Process Response to Extreme Events**

Cosponsors: *GSA Quaternary Geology and Geomorphology Division; GSA Sedimentary Geology Division*
Disciplines: Geomorphology, Quaternary Geology, Geophysics/Geodynamics
Advocates: Stephanie S. Day; Karen B. Gran

This session explores how extreme events including forest fires, hurricanes, seismic events, and floods alter surface processes. We welcome field, laboratory, or modeling studies that focus on impacts and recovery from extreme events.

T131. **Changes in Coastal Geomorphology from Hurricane Dorian and Extreme Storms**

Cosponsors: *GSA Quaternary Geology and Geomorphology Division; GSA Marine and Coastal Geoscience Division*
Disciplines: Geomorphology, Marine/Coastal Science, Environmental Geoscience
Advocates: Phillipe A. Wernette; Chris Houser; Alex Smith

Extreme storms, such as Hurricane Dorian and nor'easters, significantly alter coastal geomorphology and communities over relatively short time periods. This session focuses on identifying, monitoring, modeling, and understanding coastal changes in response to extreme storms.

T132. **Bedrock Landslide and Rock Fall Deposits and Processes: Insights from the Geologic Record to Today**

Cosponsors: *GSA Quaternary Geology and Geomorphology Division; GSA Environmental and Engineering Geology Division; GSA Sedimentary Geology Division*
Disciplines: Geomorphology, Engineering Geology, Sediments, Clastic
Advocates: Daniel M. Sturmer; Jason M. Dortch; Nicholas C. Barth

We seek presentations on modern and ancient bedrock landslides and rock falls, including, but not limited to, field description, remote sensing and monitoring, modeling, mitigation, and advances in techniques and analysis.

T133. **What's in a Name? New Developments in the Ontological Work of Naming, Describing, and Quantifying Landscape Attributes**

Cosponsor: *GSA Quaternary Geology and Geomorphology Division*
Disciplines: Geomorphology, Geoinformatics, Environmental Geoscience
Advocates: Sean M.C. Smith; Joseph M. Wheaton

In this session, we focus on advancements in detection of distinguishable landscape attributes at varied scales in association with hillslopes, streams, lakes, watersheds, and mountain formations.

T134. **Fluvial Geomorphic Interactions between Water, Sediment, and Biota**

Cosponsors: *GSA Quaternary Geology and Geomorphology Division; GSA Sedimentary Geology Division*
Disciplines: Geomorphology, Environmental Geoscience, Quaternary Geology
Advocates: Lyman P. Persico; Nicholas A. Sutfin

Research investigating feedbacks between water, sediment, and biota along river corridors provides understanding about how fluvial systems will respond to changes in climate, land use, water demand, and landscape disturbances from wildfire and insect infestation.

T135. **Military Geosciences: Past Lessons and Modern Challenges**

Cosponsors: *GSA Quaternary Geology and Geomorphology Division; GSA Soils and Soil Processes Division; GSA Geology and Society Division*
Disciplines: Geomorphology, Soils, Environmental Geoscience
Advocates: Eric V. McDonald; Sally A. Shoop; Brad D. 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.

T136. **Geomorphic Processes and Change at High Latitudes**

Cosponsors: *GSA Quaternary Geology and Geomorphology Division; Canadian Permafrost Association; Canadian Geomorphology Research Group; GSA Soils and Soil Processes Division*
Disciplines: Geomorphology, Environmental Geoscience, Soils
Advocates: James King; Duane Froese; Stephen A. Wolfe

This session examines modern and past geomorphic processes at high latitudes. Student and collaborative studies are encouraged, examining geomorphic processes and ancient analogues with relevance to climate change, physical and ecological functioning and society.

T137. **Advances in Tectonic Geomorphology: Building It up and Tearing It Down**

Cosponsors: *GSA Quaternary Geology and Geomorphology Division; GSA Structural Geology and Tectonics Division*
Disciplines: Geomorphology, Tectonics/Tectonophysics
Advocates: Karl W. Wegmann; Emerson M. Lynch; Christine Regalla

This session focuses on the relationship between the building of topography by tectonics and its erosion by surface processes through the application of advancing technologies in imaging Earth's surface and dating its deposits and landforms for improved geologic hazard characterization.

QUATERNARY GEOLOGY

T138. **Sea Level and Ice-Sheet Changes, Glacial Isostatic Adjustment, and Landscape Evolution**

Cosponsors: *GSA Quaternary Geology and Geomorphology Division; GSA Marine and Coastal Geoscience Division; GSA Sedimentary Geology Division*

INDUSTRY TRACKS Look for these icons, which identify sessions in the following areas:

Economic Geology | Energy | Engineering | Hydrogeology and Environmental Geology

Disciplines: Quaternary Geology, Paleoclimatology/Paleoceanography, Geomorphology
Advocates: Jessica R. Creveling; Natalya Gomez; Vivi Pedersen

We encourage abstracts that address Pliocene–Holocene sea level changes, ice sheet stability, and solid Earth and landscape adjustment to these changes. We welcome studies across a broad range of geological time/spatial scales and methods.

T139. **The Status of the Laurentide Ice Sheet during MIS-3**

Cosponsor: *GSA Quaternary Geology and Geomorphology 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.

T140. **Wildfire as an Earth System Process—Ancient and Modern**

Cosponsors: *GSA Quaternary Geology and Geomorphology Division; GSA Sedimentary Geology Division; GSA Geology and Society Division; GSA Environmental and Engineering Geology Division*
Disciplines: Quaternary Geology, Environmental Geoscience, Geoscience and Public Policy
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.

T141. **Three-Dimensional Geological Mapping to Support Societal Development**

Cosponsors: *GSA Quaternary Geology and Geomorphology Division; GSA Marine and Coastal Geoscience Division; GSA Energy Geology Division; GSA Geophysics and Geodynamics Division; GSA Environmental and Engineering Geology Division; GSA Geoinformatics and Data Science Division*
Disciplines: Quaternary Geology, Engineering Geology, Energy Geology
Advocates: Hazen A.J. Russell; Kelsey E. MacCormack; Brian J. Todd; Oliver S. Boyd

Three-dimensional geological modeling facilitates the communication of subsurface relationships and aids decision-making for resources, groundwater, geotechnical, marine and coastal, and public safety applications. Contributions are welcome on 3D modeling methodology, standards, and case studies.

T142. **Techniques and Results of Paleoseismological and Seismic Hazard Studies of the Stable Craton of Eastern North America**

Cosponsors: *GSA Quaternary Geology and Geomorphology Division; GSA Geophysics and Geodynamics Division; GSA Environmental and Engineering Geology Division; GSA Structural Geology and Tectonics Division*
Disciplines: Quaternary Geology, Geophysics/Geodynamics, Engineering Geology
Advocates: Katrin Monecke; John E. Ebel

We seek contributions on paleoseismic investigations from eastern North America as well as studies on regional active tectonics, earthquake site response, and seismic hazard analysis. Abstracts that introduce new paleoseismological techniques are especially welcome.

T143. **Advances in Beringian Environments and Paleoclimate during the Late Glacial and Early Holocene**

Cosponsors: *GSA Quaternary Geology and Geomorphology Division; GSA Limnogeology Division; GSA Geoarchaeology Division; GSA Sedimentary Geology Division*
Disciplines: Quaternary Geology, Limnogeology, Geoarchaeology
Advocates: Lesleigh Anderson; Ben Gaglioti; Mark Abbott

In light of recent advances, we seek presentations on new techniques, study locations, and insights into the paleoenvironments and climate across Beringia during the late glacial and early Holocene period.

T144. **The Ring of Ice: North Atlantic Deglacial Chronologies Following the Last Glacial Maximum**

Cosponsors: *GSA Quaternary Geology and Geomorphology Division; GSA Geochronology Division; GSA Sedimentary Geology Division; GSA Limnogeology Division*
Disciplines: Quaternary Geology, Paleoclimatology/Paleoceanography, Geochronology
Advocates: Christopher T. Halsted

This session focuses on quantifying deglacial chronologies following the Last Glacial Maximum from ice sheets, ice caps, and valley glaciers surrounding the North Atlantic to allow better understanding of paleoclimate change over time and ice-ocean-atmosphere interactions.

T145. **From Hudson Bay to the Coastal Plain: Comparisons of Pre-LGM (Last Glacial Maximum) Quaternary Records in Glaciated and Unglaciated North America**

Cosponsor: *GSA Quaternary Geology and Geomorphology Division*
Disciplines: Quaternary Geology, Geomorphology
Advocates: David A. Grimley; Kathleen M. Farrell; Riley P.M. Mulligan

This session will highlight pre–last glacial maximum Quaternary events, depositional sequences, chronology, and paleoenvironments from glaciated and unglaciated terrains in North America. We envision topics ranging from glacial and proglacial to fluvial and marine environments.

T146. **Dynamics of the Laurentide Ice Sheet**

Cosponsor: *GSA Quaternary Geology and Geomorphology Division*
Disciplines: Quaternary Geology, Geomorphology, Limnogeology
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 LGM, LGM, and post-LGM events.

T147. **Anthropocene Sedimentology: Exploring Human-Sediment Interactions**

Cosponsors: *GSA Marine and Coastal Geoscience Division; GSA Environmental and Engineering Geology Division; GSA Geology and Society Division; GSA Quaternary Geology and Geomorphology Division; Geochemical Society; GSA Geoarchaeology Division; GSA Limnogeology Division; GSA Sedimentary Geology Division*
Disciplines: Quaternary Geology, Marine/Coastal Science, Environmental Geoscience
Advocates: Zachary T. Sickmann; Cody C. Mason; Elisabeth Steel

Understanding human interactions with natural systems is increasingly important in earth-science research. We seek studies focused on examining anthropogenic perturbations to sedimentary systems to better understand the environmental and societal impacts of human-sediment interactions.

T148. **On the Edge—New Insights into Ice-Marginal Conditions**

Cosponsors: *GSA Quaternary Geology and Geomorphology Division; American Quaternary Association (AMQUA); Canadian Quaternary Association (CANQUA)*
Disciplines: Quaternary Geology, Geomorphology, Stratigraphy
Advocates: Stephen A. Wolfe; Carolyn Olson; Roger C. Paulen

This session examines ice-marginal conditions during full glacial and transitional stages of the Laurentide and other ice sheets through presentations on paleoenvironments, geomorphic processes, paleogeography, and ice-sheet dynamics among others.

T149. **From the Caspian to Mediterranean: Environmental Change and Human Response during the Quaternary (INQUA IFG POCAS, IGCP 610)**

Cosponsors: *Avalon Institute of Applied Science, Canada; GSA Geoarchaeology Division; GSA Marine and Coastal Geoscience Division; GSA Quaternary Geology and Geomorphology Division*
Disciplines: Quaternary Geology, Geoarchaeology, Marine/Coastal Science
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.

T150. **Cold Regions Weathering and Biogeochemical Cycling: Bridging Environments and Approaches**

Cosponsors: *GSA Quaternary Geology and Geomorphology Division; GSA Geobiology and Geomicrobiology Division; GSA Soils and Soil Processes Division*
Disciplines: Quaternary Geology, Geomicrobiology, Soils
Advocates: Joseph A. Graly; Melissa Lafreniere; Ruth Heindel

By exploring weathering and chemical cycling in glacial, permafrost, and aqueous environments through microbiology, geochemistry, mineralogy, and isotope approaches, we seek to understand how the cold regions processes feedback into the broader earth system.

T151. **Glacial Hydrology: Processes Operating within, beneath, and along the Margins of Glaciers and Ice Sheets**

Cosponsor: *GSA Quaternary Geology and Geomorphology Division*
Disciplines: Quaternary Geology, Geomorphology, Paleoclimatology/Paleoceanography
Advocates: Richard K. 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.

SOILS

T152. **Soil Processes and Landscape Evolution**

Cosponsors: *GSA Quaternary Geology and Geomorphology Division; GSA Soils and Soil Processes Division*
Disciplines: Soils, Quaternary Geology, Geomorphology
Advocates: Brad D. Sion; Bruce J. Harrison; Maxwell Philip Dahlquist; Bradley G. Johnson

This session seeks studies using soil and geomorphic data to constrain the nature or timing of surficial process, including tectonic activity, climatic histories, records of sediment aggradation, rates and processes of erosion, and periglacial processes.

T153. **Soils and Long-Term Environmental Change**

Cosponsors: *GSA Soils and Soil Processes Division; GSA Quaternary Geology and Geomorphology Division; GSA Geoarchaeology Division; Geochemical Society; GSA Karst Division; GSA Energy Geology Division*
Disciplines: Soils, Geoarchaeology, Quaternary Geology
Advocates: Timothy Beach; Samantha M. Krause; Rolfe D. Mandel

This session integrates soils and environmental change across disciplines and methods from pedology to remote sensing, geochemistry, paleoecology, and archaeology. Studies could include carbon sequestration, anthropogenic impacts, soil formation over time, and soil geoarchaeology.

MARINE/COASTAL SCIENCE

T154. **Sea-Level Indicators: New Interpretations and Constraints for Future Projections**

Cosponsors: *GSA Marine and Coastal Geoscience Division; GSA Quaternary Geology and Geomorphology Division; PASLSEA—PALeo constraints of SEA level rise, a PAGES-INQUA Working Group; HOLSEA—Geographic variability of HOLocene SEA level; WARMCOASTS European Research Council Project; GSA Sedimentary Geology Division*
Disciplines: Marine/Coastal Science, Geochronology, Paleoclimatology/Paleoceanography
Advocates: Deirdre D. Ryan; Nicole S. Khan; Daniel M. Gilford

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.

T155. **Coastal Processes and Sea-Level Change on Paraglacial Coasts**

Cosponsors: *GSA Marine and Coastal Geoscience Division; GSA Quaternary Geology and Geomorphology Division; GSA Sedimentary Geology Division*

Disciplines: Marine/Coastal Science, Quaternary Geology, Geomorphology
Advocates: Joseph T. Kelley; J. Andrew G. Cooper

This session focuses on formerly glaciated coasts with heterogeneous and patchy sediment supplies, deranged river drainages, and extreme changes in sea level. Work onshore, along the coast, and offshore, including modeling efforts, are welcome.

T156. **Natural and Human Influences on Great Lakes Coasts**

Cosponsors: *GSA Marine and Coastal Geoscience Division; GSA Quaternary Geology and Geomorphology Division; GSA Geology and Society Division; GSA Sedimentary Geology Division*
Disciplines: Marine/Coastal Science, Quaternary Geology, Environmental Geoscience
Advocates: Andrew C. Phillips; C. Robin Mattheus; Clare E. Robinson

We explore the effects of natural and human drivers of coastal change in the Great Lakes over event- to millennial timeframes. Basic and applied research on geomorphic environments, groundwater, water quality, and ecosystems are welcome.

T157. **Advances and New Voices in Coastal and Marine Geoscience**

Cosponsor: *GSA Marine and Coastal Geoscience Division*
Discipline: Marine/Coastal Science
Advocates: David J. Mallinson; Suzanne O'Connell; Rónadh Cox

This session will showcase new research in marine and coastal geoscience. We welcome contributions from all, but especially encourage submissions from early career scientists exploring new ideas.

T158. **Paleo-Environmental Reconstructions and Geomorphological Processes in High-Latitude Continental Margins during the Late Quaternary**

Cosponsor: *GSA Quaternary Geology and Geomorphology Division*
Disciplines: Marine/Coastal Science, Paleoclimatology/Paleoceanography, Quaternary Geology
Advocates: Etienne Brouard; Patrick Lajeunesse; Audrey Limoges; Jean-Carlos Montero-Serrano; Alexandre Normandeau

This interdisciplinary session aims to bring together marine geoscientists interested in exploring high-latitude seafloor dynamics and its Late Quaternary evolution through the use of multiple spatial and temporal datasets such as hydroacoustic, sedimentological, micro-paleontological, mineralogical, and geochemical data.

T159. **The ICE Melted and the Seas ROSE—Depositional Patterns on Continental Shelves during Glacial-Interglacial Cycles**

Cosponsors: *GSA Marine and Coastal Geoscience Division; GSA Continental Scientific Drilling Division; GSA Environmental and Engineering Geology Division; Cushman Foundation; GSA Geochronology Division; GSA Sedimentary Geology Division; GSA Quaternary Geology and Geomorphology Division; SEPM (Society for Sedimentary Geology); Paleontological Society; American Quaternary Association (AMQUA); Paleontological Society*
Disciplines: Marine/Coastal Science, Paleoclimatology/Paleoceanography, Stratigraphy
Advocate: Scott W. Starratt

This session seeks presentations on the role of eustatic sea rise and the impact of local glacial, tectonic, and volcanic conditions on the continental shelf sediment and microfossil records.

T160. **Our Coastal Futures: Working Together to Understand Hazards and Mitigate Disasters**

Cosponsors: *GSA Marine and Coastal Geoscience Division; GSA Geology and Society Division; GSA Quaternary Geology and Geomorphology Division*
Disciplines: Marine/Coastal Science, Geoscience and Public Policy, Geoscience Information/Communication
Advocates: Robert Weiss; Rónadh Cox

To fully understand coastal hazards, and for effective mitigation strategies, both science and human/societal aspects are important. This includes attention to social justice and inclusivity. We seek abstracts from all perspectives on this issue.

T161. **Near-Shore and Offshore Freshwater Systems: Insights from Geological, Geophysical, Field, and Modeling Studies**

Cosponsors: *GSA Marine and Coastal Geoscience Division; GSA Hydrogeology Division; GSA Sedimentary Geology Division*
Disciplines: Marine/Coastal Science, Hydrogeology, Continental Scientific Drilling
Advocates: Brandon Dugan; Mark Person; Aaron Micallef

This session will highlight our knowledge of onshore-offshore freshwater systems based on geological, geophysical, and modeling studies. We will also address the importance of these systems on biogeochemical cycling and microbiological activity in near-shore environments.

T162. **Offshore Wind Energy Development in North America—Geological Perspectives on Challenges and Opportunities Presented in Our Coastal and Inner Shelf Regions**

Cosponsors: *GSA Marine and Coastal Geoscience Division; GSA Geology and Society Division; GSA Quaternary Geology and Geomorphology Division; GSA Energy Geology Division; GSA Environmental and Engineering Geology Division; GSA Sedimentary Geology Division*
Disciplines: Marine/Coastal Science, Quaternary Geology, Geomorphology
Advocate: Jordan B.R. Eamer

Geological, geomorphological, and geotechnical research from the coast to shelf that advances the nascent offshore wind energy industry in North America. Local methods and data and those from more-established (Europe, Asia) regions welcome.

T163. **Coastal Storm Impacts in Times of Changing Climate and Sea Levels: Geological Records, Historic Perspectives, and Forecasting**

Cosponsors: *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*
Discipline: 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 and storm-activity observations for refining predictive models and informing mitigation and adaptation efforts.

LIMNOGEOLOGY

T164. Crossing the Salinity Divide—Life through the Gateway between Marine and Freshwater Systems

Cosponsors: *GSA Limnogeology Division; Paleontological Society; GSA Sedimentary Geology Division*
Disciplines: Limnogeology, Paleontology, Biogeography/Biostratigraphy, Marine/Coastal Science
Advocates: Lisa Park Boush; Eric Schultz

This session will investigate lifeforms across the tree of life and through space and time that have successfully transitioned from marine to freshwater environments or that have adapted to life in a spectrum of halohabitats.

T165. Walden Pond: From Glaciation to Thoreau and Beyond

Cosponsors: *GSA Limnogeology Division; GSA History and Philosophy of Geology Division; GSA Quaternary Geology and Geomorphology Division*
Disciplines: Limnogeology, History and Philosophy of Geology, Quaternary Geology
Advocates: J. Bradford Hubeny; Francine M.G. McCarthy

We encourage contributions on the environmental and ecological history of Thoreau's iconic Walden Pond, the region, and similarly impacted ponds. Contributions on intersections between humans and nature, or changes since Thoreau's time are especially welcome.

T166. Lakes of the World through Time and Space

Cosponsors: *GSA Limnogeology Division; GSA Continental Scientific Drilling Division; GSA Environmental and Engineering Geology Division; GSA Geochronology Division; GSA Sedimentary Geology Division; GSA Quaternary Geology and Geomorphology Division; International Association of Limnogeology; SEPM (Society for Sedimentary Geology); Geochemical Society; Paleontological Society; American Quaternary Association (AMQUA)*
Disciplines: Limnogeology, Paleoclimatology/Paleoceanography, Stratigraphy
Advocates: Scott W. Starratt; Michelle F. Goman

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

T167. Sedimentary Records of Neogene and Quaternary Environmental Change from Eastern Africa

Cosponsors: *GSA Continental Scientific Drilling Division; GSA Limnogeology Division; GSA Quaternary Geology and Geomorphology Division; GSA Sedimentary Geology Division; GSA Structural Geology and Tectonics Division*
Disciplines: Limnogeology, Paleoclimatology/Paleoceanography, Quaternary Geology
Advocates: Michael M. McGlue; Sarah Ivory; Anne L. Billingsley; Catherine C. Beck

This session explores the Neogene and Quaternary history of eastern Africa, including linkages among rift tectonics, volcanism, and hydroclimate change. Contributions that use the sedimentary record to reconstruct paleoenvironments, paleoclimate, and paleoecology are welcome.

T168. Out of This World Lakes

Cosponsors: *GSA Limnogeology Division; GSA Planetary Geology Division; GSA Quaternary Geology and Geomorphology Division; SEPM (Society for Sedimentary Geology); Geochemical Society*
Disciplines: Limnogeology, Planetary Geology, Geochemistry
Advocates: Kathleen C. Benison; Brenda B. Bowen; Johan C. Varekamp

This session will 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.

HYDROGEOLOGY

T169. Integrated and Interdisciplinary Approaches in Hydrostratigraphic Characterization

Cosponsors: *GSA Hydrogeology Division; GSA Sedimentary Geology Division*
Disciplines: Hydrogeology, Environmental Geoscience
Advocates: Jessica R. Meyer; Anthony C. Runkel; Emmanuelle Arnaud; Colby Steelman

Hydrostratigraphy forms the framework for all groundwater models by supporting quantitative description of flow paths. We encourage studies presenting innovative geologic, geophysical, geochemical, and hydraulic methods for delineating hydrostratigraphy for variety settings and scales.

T170. Heat in the Hydrosphere: Elucidating Environmental Processes and Environmental Change Using Water Temperature

Cosponsors: *GSA Hydrogeology Division; GSA Marine and Coastal Geoscience Division; GSA Energy Geology Division*
Disciplines: Hydrogeology, Environmental Geoscience, Geophysics/Geodynamics

INDUSTRY TRACKS Look for these icons, which identify sessions in the following areas:

Economic Geology | Energy | Engineering | Hydrogeology and Environmental Geology

Advocates: Barret L. Kurylyk; Victor F. Bense; Christa Kelleher

Aquifers, rivers, and oceans are warming in response to climate change; however, the thermal regimes of hydrologic systems are also controlled by non-climatic processes. This session will focus on the interactions between water temperature and environmental processes.

T171. **Measuring and Modeling the Water Cycle in Cold Regions**

Cosponsor: *GSA Hydrogeology Division*
Discipline: Hydrogeology
Advocates: Jean-Michel Lemieux; Jeffrey M. McKenzie; Nathan L. Young

Global warming is reshaping the water cycle in cold regions in a number of ways. This session welcomes modeling and field studies that examine groundwater, surface-water, or critical zone dynamics in permafrost-dominated regions.

T172. **Groundwater Availability and Sustainability Studies: Advances, Methods, and Approaches**

Cosponsors: *GSA Hydrogeology Division; GSA Karst Division*
Disciplines: Hydrogeology, Geoscience and Public Policy, Environmental Geoscience
Advocates: Zhilin Guo; Graham E. Fogg; Jesse E. Dickinson; Chunmiao Zheng

We welcome presentations discussing new advances, methods, and approaches for quantifying regional groundwater systems in diverse climatic, hydrologic, social, and political settings, including regional flow and transport models.

T173. **Arsenic, Fluoride, Manganese, and Radiogenic Contaminants in Groundwater Systems—Scientific Knowledge, Public Health Concerns, and Removal Technology**

Cosponsors: *GSA Hydrogeology Division; GSA Geology and Health Division; GSA Geology and Society Division; GSA International; International Society of Groundwater for Sustainable Development (ISGSD); International Medical Geology Association (IMGA); International Water Association (IWA) Specialist Group Metals and Related Substances in Drinking Water (METRELS)*
Disciplines: Hydrogeology, Environmental Geoscience, Geoscience and Public Policy
Advocates: Prosun Bhattacharya; Arslan Ahmad; Saugata Datta; Alan E. Fryar; Mohammad Alauddin

The cycling of arsenic, fluoride, manganese, and radiogenic contaminants in groundwater systems from regional to local scales will be discussed. This encompasses natural occurrence, mobility, biogeochemical cycling, and impacts on treatment innovations.

T174. **Fluid Behavior in the Subsurface Related to Energy Development**

Cosponsors: *GSA Hydrogeology Division; GSA Energy Geology Division*
Disciplines: Hydrogeology, Energy Geology, Geochemistry
Advocates: Jean-Philippe Nicot; M. Clara Castro; Daniele L. Pinti

New discoveries on characteristics and flow behavior of fluids in low-permeability rocks as prompted by the recent growth in hydrocarbon production from so-called gas shales and tight oil formations.

T175. **Advances in Understanding Processes at or Near the Groundwater–Surface Water Interface**

Cosponsors: *GSA Karst Division; GSA Quaternary Geology and Geomorphology Division; GSA Hydrogeology Division*
Disciplines: Hydrogeology, Engineering Geology, Environmental Geoscience
Advocates: Corey D. Wallace; Reza Soltanian

The session will convey new insights on processes taking place at or near the interface between groundwater and surface water, including fluid, energy, nutrient fluxes, and biogeochemical processes. Field and lab studies, analysis, and computational research are to be included.

T176. **Novel Approaches for Understanding Groundwater Dependent Ecosystems**

Cosponsor: *GSA Hydrogeology Division*
Disciplines: Hydrogeology, Environmental Geoscience
Advocates: Marie Larocque; Eric Rosa

This session is requesting contributions on innovative approaches to understand the hydrology, geochemistry, thermal regime, and resilience of groundwater-dependent ecosystems, including field measurements, monitoring, natural tracers, remote sensing, and modeling, in a variety of environments.

T177. **A Showcase of Undergraduate Research in Hydrogeology (Posters)**

Cosponsor: *GSA Hydrogeology Division*
Disciplines: Hydrogeology, Karst
Advocates: Miguel E. Valencia; Laura K. Rademacher; Samuel J. Smidt; Martina Rogers

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.

T178. **The Water-Energy Nexus in Sedimentary Basins**

Cosponsors: *GSA Hydrogeology Division; GSA Sedimentary Geology Division; GSA Energy Geology Division*
Disciplines: Hydrogeology, Energy Geology, Geochemistry
Advocates: Jennifer McIntosh; Grant Ferguson; Christine Rivard

Demand for subsurface pore space for groundwater resources, conventional and unconventional oil and gas development, carbon sequestration, geothermal energy production, and fluid disposal has led to novel approaches to better understand the hydrogeology of sedimentary basins.

T179. **Applications for DNA Sequencing and Microbial Analysis in Hydrogeology and Environmental Geosciences**

Cosponsors: *GSA Hydrogeology Division; GSA Environmental and Engineering Geology Division; GSA Geobiology and Geomicrobiology Division; International Association of Hydrogeologists U.S. National Chapter; Geochemical Society*
Disciplines: Hydrogeology, Environmental Geoscience, Geomicrobiology
Advocates: Mark A. Higgins; Peter S.K. Knappett; Kimberly D. Myers

To advance understanding of current and potential applications in geosciences, this session welcomes a variety of abstracts relating to

microbiological analyses, including natural groundwater tracers, bioremediation, understanding biogeochemical processes, aqueous pathogen transport, and general methods.

T180. Remote Sensing Applications in Hydrology

Cosponsors: *GSA Hydrogeology Division; GSA Environmental and Engineering Geology Division; GSA Geoinformatics and Data Science Division; GSA Geophysics and Geodynamics Division; GSA Geology and Society Division*
Disciplines: Hydrogeology, Environmental Geoscience, Geoinformatics
Advocates: Richard H. Becker; Adam M. Milewski; Ryan G. Smith

Remote sensing has brought new important techniques into hydrology investigations, from satellite to UAV scale. We welcome novel contributions utilizing all types of remote sensing data to characterize hydrologic systems.

T181. Fate and Transport of PFAS in the Geologic Landscape

Cosponsors: *GSA Hydrogeology Division; GSA Environmental and Engineering Geology Division; GSA Karst Division*
Disciplines: Hydrogeology, Environmental Geoscience, Geology and Health
Advocates: Timothy Schroeder; Jonathan J. Kim; Peter Ryan; Ed Romanowicz; David F. Boutt

Per- and polyfluoroalkyl substances (PFASs) are environmental contaminants of emerging global concern. This session encourages contributions that build toward a greater understanding of the fate and transport of PFASs from release to human exposure.

T182. Novel Outcomes in the Hydrologic Sciences: Emerging Areas of Research, New Educational Approaches, Broadening Participation, and Societal Impact

Cosponsors: *GSA Hydrogeology Division; GSA Limnogeology Division; Geochemical Society; GSA Quaternary Geology and Geomorphology Division; GSA Karst Division*
Disciplines: Hydrogeology, Environmental Geoscience
Advocates: Laura K. Lautz; Justin E. Lawrence; Ingrid Y. Padilla

The hydrologic sciences have changed rapidly due to new discoveries, technological advances, changing societal needs, and the data revolution. This session will highlight new findings in the hydrologic sciences from investigators at all career stages.

T183. Coastal and Marine Hydrogeology in an Age of Rising Seas: From the Shore to the Oceanic Ridge

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

As sea levels rise, hydrogeology is crucial in coastal areas. Seawater intrusion can lead to loss of potable or agricultural water supplies. Water table rise from sea-level rise can increase flooding and affect infrastructure.

T184. Applications of Novel Isotopes in Modern Terrestrial to Marine Environments

Cosponsors: *GSA Hydrogeology Division; GSA Karst Division; GSA Marine and Coastal Geoscience Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Soils and Soil Processes Division; Geochemical Society*
Disciplines: Hydrogeology, Geochemistry, Marine/Coastal Science
Advocates: Randy L. Stotler; Thai T. Phan; Brian Kendall

Non-traditional isotope systems increasingly inform investigations of the modern environment, including hydrosphere, critical zone, soil, permafrost, and marine environments, providing insight into fluid and biogeochemical conditions and fluxes. Submissions describing these studies are encouraged.

T185. Machine Learning in Hydrogeology

Cosponsors: *GSA Hydrogeology Division; Consortium of Universities for the Advancement of Hydrologic Science, Inc.; GSA Karst Division*
Disciplines: Hydrogeology, Environmental Geoscience, Geology and Health
Advocates: Paul E. Stackelberg; Kenneth Belitz; Mason O. Stahl; James J. Butler Jr.

We seek papers related to the use of machine learning (ML) to address previously intractable problems in hydrogeology. Contributions may include perspectives, applications, development of novel datasets, and all other aspects of ML in hydrogeology.

T186. Groundwater in Mountain Systems

Cosponsors: *GSA Hydrogeology Division; GSA Quaternary Geology and Geomorphology Division*
Disciplines: Hydrogeology, Environmental Geoscience
Advocates: Jeffrey M. McKenzie; Lauren Somers

This session highlights research in mountain groundwater, including near-surface systems through to deeper regional hydrogeology. Research includes fieldwork, numerical modeling, remote sensing, and synthesis, with a goal of improving our understanding of these complex systems.

T187. Geopressures in Sedimentary Basins: Causes and Implications for Water, Energy, and Mineral Resources

Cosponsors: *GSA Hydrogeology Division; GSA Structural Geology and Tectonics Division; GSA Energy Geology Division*
Disciplines: Hydrogeology, Energy Geology, Environmental Geoscience
Advocates: Michael Plampin; Mark Person

This session is intended to cover the various types of fluid pressure distributions that exist within sedimentary basins, the underlying material properties and physicochemical processes responsible for those variations, and the implications for subsurface resources.

KARST

T188. **Karst Hydrology and Hydrogeology**

Cosponsors: *GSA Karst Division; GSA Environmental and Engineering Geology Division; GSA Hydrogeology Division; Karst Waters Institute; National Cave and Karst Research Institute*
Disciplines: Karst, Hydrogeology
Advocates: Derek C. Ford; Andrew J. Luhmann; Jason S. Polk

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.

T189. **Karst Ecosystems and Biogeochemistry**

Cosponsors: *GSA Karst Division; GSA Environmental and Engineering Geology Division; GSA Geobiology and Geomicrobiology Division; GSA Hydrogeology Division; Karst Waters Institute; National Cave and Karst Research Institute; Geochemical Society*
Disciplines: Karst, Geomicrobiology, Geochemistry
Advocates: Daniel S. Jones; Andrew J. Luhmann; Jason S. Polk

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.

T190. **Karst Sedimentary, Paleoclimate, and Historical Records**

Cosponsors: *GSA Karst Division; GSA Geochronology Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Quaternary Geology and Geomorphology Division; GSA Sedimentary Geology Division; National Cave and Karst Research Institute; Geochemical Society*
Disciplines: Karst, Stratigraphy, Paleoclimatology/Paleoceanography
Advocates: Andrew J. Luhmann; Jason S. Polk

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.

T191. **New Frontiers in Cave and Karst Research**

Cosponsors: *GSA Karst Division; Karst Waters Institute; National Cave and Karst Research Institute; GSA Geobiology and Geomicrobiology Division; GSA Hydrogeology Division; GSA Environmental and Engineering Geology Division*
Disciplines: Karst, Hydrogeology, Geomicrobiology
Advocates: Daniel S. Jones; Ellen K. Herman; Benjamin W. Tobin; Rachel Bosch; Patricia N. Kambesis; Andrew J. Luhmann

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

T192. **Karst Hazards and Monitoring**

Cosponsors: *GSA Karst Division; GSA Environmental and Engineering Geology Division; GSA Geophysics and Geodynamics Division; National Cave and Karst Research Institute*
Disciplines: Karst, Engineering Geology
Advocates: Andrew J. Luhmann; Jason S. Polk

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).

T193. **Pseudo-Karst Processes and Features**

Cosponsors: *GSA Karst Division; GSA Quaternary Geology and Geomorphology Division; National Cave and Karst Research Institute*
Disciplines: Karst, Geomorphology
Advocates: Erik B. Larson; Andrew J. Luhmann; Jason S. Polk

This session addresses the 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.

T194. **Karst Processes and Speleology**

Cosponsors: *GSA Karst Division; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division; GSA Quaternary Geology and Geomorphology Division; National Cave and Karst Research Institute; Geochemical Society*
Disciplines: Karst, Geomorphology, Geochemistry
Advocates: Rachel Bosch; Kaitlyn Gauvey, Andrew J. Luhmann; Jason S. Polk

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.

ENVIRONMENTAL GEOSCIENCE

T195. **Fate and Transport of PFAS: Current Research and Practice**

Cosponsors: *GSA Hydrogeology Division; James J. Connors and Associates; GSA Karst Division*
Disciplines: Environmental Geoscience, Hydrogeology, Geology and Health
Advocate: James J. Connors

Geoscientists working on per- and polyfluoroalkyl substances (PFAS) fate and transport research, regulations, and practical projects are encouraged to present and discuss their work in this rapidly expanding area of environmental concern.

T196. **Microplastics in the Environment: Methods, Findings, and Implications**

Cosponsors: *GSA Environmental and Engineering Geology Division; GSA Hydrogeology Division; GSA Geology and Society Division; GSA Marine and Coastal Geoscience Division;*

GSA Geology and Health Division; GSA Limnogeology Division; GSA Sedimentary Geology Division; GSA Karst Division
Disciplines: Environmental Geoscience, Hydrogeology, Limnogeology
Advocates: Jacqueline A. Smith; Brian E. Bodenbender; Jill S. Schneiderman

Evidence for microplastic pollution in marine, freshwater, and terrestrial environments continues to mount. This session encompasses all aspects of microplastic research including field and lab methodology, findings, education, and implications for health and environmental stewardship.

T197. **Intersections of Sustainability and Geosciences**
Cosponsors: *GSA Karst Division; GSA Geology and Society Division*
Disciplines: Environmental Geoscience, Geoscience and Public Policy, Geoscience Information/Communication
Advocates: Robert Brinkmann; Leslie A. North

This session will focus on the intersections of earth science and sustainability. Topics such as water management, pollution, and climate change will be explored.

T198. **The Environmental Impacts of War and Conflict**
Cosponsor: *GSA Quaternary Geology and Geomorphology Division*
Disciplines: Environmental Geoscience, Engineering Geology, Geoscience and Public Policy
Advocates: Patrick Burkhart; Gregory S. Baker; Paul Baldauf

We seek contributions focused on myriad environmental aspects of war and military conflict, past, present, and future. Our objective is to broaden our understanding of the environmental impacts of war, beyond the tragic human toll.

T199. **Site Characterization and Monitoring Techniques for Geologic Disposal of Nuclear Waste**
Cosponsors: *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*
Disciplines: Environmental Geoscience, Geoscience and Public Policy, Hydrogeology
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.

T200. **Breaking International Barriers to Scientific Collaboration: Keeping People Safe and Societies Sustainable (Posters)**
Cosponsors: *GSA Quaternary Geology and Geomorphology Division; GSA Geoarchaeology Division; GSA Continental Scientific Drilling Division; GSA Marine and Coastal Geoscience Division; GSA Geology and Health Division; GSA Hydrogeology Division; GSA Soils and Soil Processes Division; GSA Geochronology Division; GSA Environmental and Engineering Geology Division; GSA Limnogeology Division; GSA Geophysics and Geodynamics Division; GSA Structural Geology and Tectonics Division; GSA Sedimentary Geology Division; GSA International; GSA Geology and Society Division*
Disciplines: Environmental Geoscience, Geology and Health, Geomorphology
Advocates: Mae Kate Campbell; Paul Bierman

Working collaboratively across international barriers is essential to addressing geoscience hazards issues globally. This poster session brings together scientists from around the world, using simultaneous translation of posters to make geoscience topics accessible to all.

T201. **Urban Geochemistry**
Cosponsors: *International Association of GeoChemistry; Geochemical Society; GSA Soils and Soil Processes Division*
Disciplines: Environmental Geoscience, Geochemistry, Geology and Health
Advocates: W. Berry Lyons; David T. Long

This session encourages presentations that qualify and quantify the geochemical and biogeochemical impacts (temporal and spatial) of urbanization, urban activities, and urban disasters on soil, water, and air resources as well as on human and ecosystem health.

GEOARCHAEOLOGY

T202. **Losing Cultural Heritage: Geoarchaeology and Climate Change Impacts**
Cosponsors: *GSA Geoarchaeology Division; GSA Quaternary Geology and Geomorphology Division; GSA Geology and Society Division*
Disciplines: Geoarchaeology, Geoscience and Public Policy, Marine/Coastal Science
Advocate: Alice R. Kelley

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.

GEOMICROBIOLOGY

T203. **New Advances in Geobiology**
Cosponsors: *GSA Geobiology and Geomicrobiology Division; GSA Karst Division*
Disciplines: Geomicrobiology, Paleontology, Diversity, Extinction, Origination, Geochemistry

INDUSTRY TRACKS Look for these icons, which identify sessions in the following areas:

Economic Geology | Energy | Engineering | Hydrogeology and Environmental Geology

Advocates: Trinity L. Hamilton; Rowan C. Martindale; Lydia Schiavo Tackett; Victoria Petryshyn; David Gold; Andrew D. Putt; Alison T. Cribb; Simon A.F. Darroch; Amanda Lynn Godbold

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.

T204. **New Voices in Geobiology**

Cosponsors: *GSA Geobiology and Geomicrobiology Division; GSA Karst Division*
Disciplines: Geomicrobiology, Paleontology, Diversity, Extinction, Origination, Paleontology, Paleoecology/Taphonomy
Advocates: Amanda Lynn Godbold; Alison T. Cribb; Andrew D. Putt; Rowan C. Martindale; Victoria A. Petryshyn; Lydia S. Tackett; Trinity L. Hamilton; David Gold; Simon A.F. Darroch

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.

GEOLOGY AND HEALTH

T205. **Water, Health, and Wealth in a Changing World**

Cosponsors: *GSA International; Geochemical Society; GSA Hydrogeology Division; GSA Geology and Society Division; GSA Geology and Health Division*
Disciplines: Geology and Health, Hydrogeology, Environmental Geoscience
Advocates: P.S.K. Knappett; Itza Mendoza; Ryan G. Smith; Gregory T. Carling; Alexander J. Desbarats

This session addresses the impacts of human changes to the hydrologic cycle on the distribution of aqueous-phase contaminants, and the impacts of human exposure to them.

T206. **Global Water Resources and Geohealth: Tracing Inorganic Contaminant Origins, Evaluating Human Health Risks, and Remediation/Mitigation Strategies**

Cosponsors: *GSA Geology and Health Division; GSA International; GSA Hydrogeology Division; Geochemical Society; GSA Karst Division*
Disciplines: Geology and Health, Environmental Geoscience, Geochemistry
Advocates: Rachel M. Coyte; Avner Vengosh; Thomas H. Darrah; Frank W. Schwartz

This session is aimed at highlighting ways in which the geosciences are uniquely equipped to understand and tackle emerging global water-quality issues related to resource exploitation, growing populations, and climate change.

T207. **Lead Pollution, Exposure, Health Risks, and Mitigation Strategies**

Cosponsors: *GSA Geology and Health Division; GSA Geology and Society Division; GSA Environmental and Engineering Geology Division; Geochemical Society*
Disciplines: Geology and Health, Environmental Geoscience, Geoscience and Public Policy
Advocates: Reto Gieré; Richard Pepino

This session requests contributions on all aspects of lead in the natural and built environment, on the pathology of lead poisoning, and on communication, community engagement, risk mitigation and education, both nationally and globally.

T208. **Environmental Geochemistry and Health**

Cosponsors: *GSA Geology and Health Division; GSA Geology and Society Division; GSA Environmental and Engineering Geology Division; GSA Soils and Soil Processes Division; Geochemical Society*
Disciplines: Geology and Health, Geochemistry, Environmental Geoscience
Advocates: Sarah M. Hayes; Jean M. Morrison; Nicolas Perdrial; Justin Richardson

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 or have strong public outreach are welcome.

T209. **It's the Dose That Makes the Poison: Advances in Exposure and Dose Assessment for Practical Medical Geology**

Cosponsors: *GSA Geology and Health Division; GSA Environmental and Engineering Geology Division; GSA Geology and Society Division; GSA Hydrogeology Division; GSA Soils and Soil Processes Division; Geochemical Society*
Disciplines: Geology and Health, Environmental Geoscience, Hydrogeology
Advocates: Malcolm Siegel; Ann Ojeda; Saugata Datta

Exposure and dose assessment is the key interface between geology and human health. This session seeks contributions on development of methods in environmental epidemiology, toxicology, and monitoring to characterize the interaction between humans and environment.

T210. **Global Health and Environmental Matrices in a Sustainable Earth**

Cosponsors: *GSA Geology and Health Division; GSA Environmental and Engineering Geology Division; GSA Soils and Soil Processes Division*
Disciplines: Geology and Health, Geochemistry, Hydrogeology
Advocates: Harshad Vijay Kulkarni; Prosun Bhattacharya; Malcolm Siegel; Saugata Datta

This session will enhance our understanding of the fate, transport, and mobility of inorganic and organic earth materials of human health across lithosphere, hydrosphere, atmosphere, biosphere, and anthroposphere.

T211. **Natural Contamination, Natural Hazards, Health Risk, and Public Policy: Success Stories and Models for Managing, Communicating, and Updating Policy to Address Health Risks of Natural Contamination and Hazards**

Cosponsors: *GSA Geology and Health Division; Geochemical Society; GSA Geology and Society Division*
Disciplines: Geology and Health, Geoscience and Public Policy, Environmental Geoscience

Advocates: Amy J. Keyworth; Evan O. Kane; Caroline Loop

This session will consider how managing the public health risks from natural hazards and contaminants are addressed differently than manmade contaminants. Available resources, policy, and educating the public are all handled differently. Share your successes.

ECONOMIC GEOLOGY

T212. **Structural and Stratigraphic Architecture of Gold Deposits and Mining Districts**

Cosponsors: *Society of Economic Geologists; GSA Sedimentary Geology Division*
Disciplines: Economic Geology, Structural Geology, Stratigraphy
Advocates: Stéphane De Souza; Brice J. Lacroix

This session will focus on the structure and stratigraphy of gold deposits and mining districts, two fundamental aspects for our understanding of deposit genesis and the definition of exploration models in deformed and metamorphosed terrains.

T213. **Magnetite Apatite (MtAp) Deposits in Space and Time**

Cosponsor: *Mineralogical Society of America*
Disciplines: Economic Geology, Geochemistry, Geochronology
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 a potential resource for rare earth elements.

T214. **Mineral Deposits of China**

Cosponsor: *Society of Economic Geologists*
Disciplines: Economic Geology, Geochemistry, Tectonics/Tectonophysics
Advocates: Richard Goldfarb; Jun Deng

Talks will describe the spatial-temporal distribution of major mineral deposit types relative to the tectonic evolution of China, as well as describe the geology of important ore systems in various Chinese orogenic belts.

T215. **Advances in Mineral Chemistry for Petrogenesis and Exploration of Mineral Deposits**

Cosponsors: *Society of Economic Geologists; Mineralogical Society of America; GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division*
Disciplines: Economic Geology, Geochemistry
Advocates: Sarah Dare; Bertrand Rottier; Georges Beaudoin

This session will address recent advances in using in situ elemental and isotopic compositions of minerals for petrogenesis and exploration of mineral deposits using bedrock samples and indicator minerals.

T216. **Rare Earth Elements: The Behavior of Critical Minerals in Sedimentary, Magmatic, and Magmatic-Hydrothermal Systems**

Cosponsors: *Geochemical Society; Mineralogical Society of America; Society of Economic Geologists; GSA Energy Geology Division*
Disciplines: Economic Geology, Paleoclimatology/Paleoceanography, Petrology, Igneous
Advocates: Simone E. Runyon; Kimberly V. Lau

This session recognizes the recent emphasis on the investigation of rare earth element (REE) behavior across a variety of geologic environments, informing terrestrial, ocean-atmosphere, sedimentary, diagenetic, magmatic, and magmatic-hydrothermal processes.

ENERGY GEOLOGY

T217. **Geologic Energy Research**

Cosponsor: *GSA Energy Geology Division*
Disciplines: Energy Geology, Economic Geology
Advocates: Laura S. Ruhl; Travis L. McLing; Richard A. Esposito

This is the general session of the GSA 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.

T218. **Energy Transition and the Geosciences**

Cosponsors: *GSA Energy Geology Division; GSA Geology and Society Division; GSA Structural Geology and Tectonics Division*
Disciplines: Energy Geology, Economic Geology, Geoscience Education
Advocates: J. Fred Mclaughlin; John Kaszuba; Scott Quillinan

The energy transition will impact the geosciences, forcing our community to adapt. This session explores the impact of transition on energy research and education, and incorporates the regulatory and market factors behind the transition.

T219. **Effect of Fluids on Micro-Nano Pore Structure and Connectivity of High-Salt Shale Oil Reservoirs (Posters)**

Cosponsors: *Science Foundation of the China University of Petroleum, Beijing (2462017YJRC024); Foundation of Key Laboratory of Tectonics and Petroleum Resources (TPR-2017-17); Geochemical Society; GSA Energy Geology Division*
Disciplines: Energy Geology, Geochemistry, Sediments, Clastic
Advocate: Zhaofeng Li

The pore structure and connectivity changes of shale reservoirs in Qianjiang Sag, Jianghan Basin, China, under different fluids were comprehensively studied by various means. This provided some guidance for the development of shale oil.

T220. **Energy, Environment, and Health**

Cosponsors: *GSA Energy Geology Division; GSA Geology and Health Division*
Disciplines: Energy Geology, Geology and Health, Environmental Geoscience
Advocate: Laura S. Ruhl

This session will explore research relating to environmental and health issues associated with energy geology, including exploration practices, extraction of resources, and waste disposal.

T221. **The Unconventional Shale Systems: From Source-Rocks to Reservoirs**

Cosponsor: *GSA Energy Geology Division*
Disciplines: Energy Geology, Hydrogeology, Geochemistry

Advocates: Hu Qinhong; David R. Cole; Shengyu Yang

This session will present the research frontiers in hydrocarbon generation-migration-expulsion, geochemical and isotopic characteristics of kerogen-bitumen-oil-gas, genesis and evolution of multi-scale pores and fractures, as well as petrophysical characterization and fluid-shale interactions across scales.

T222. **Microbial Interactions in Energy Production and Energy-Related Systems**

Cosponsors: *GSA Energy Geology Division; GSA Geobiology and Geomicrobiology Division*
Disciplines: Energy Geology, Geomicrobiology, Environmental Geoscience
Advocates: Jenna L. Shelton; Karen Wawrousek; Christina A. DeVera

We encourage submissions focused on microbiological processes related to energy production from hydrocarbon reservoirs and the role of microbes in remediation, drilling, oil seeps, the residual oil zone, biological enhancement, and CO_2 sequestration.

T223. **Exploration of Helium in Sedimentary Basins: The New "Gold" Rush?**

Cosponsors: *Geochemical Society; GSA Energy Geology Division*
Disciplines: Energy Geology, Economic Geology, Geochemistry
Advocates: Daniele L. 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 through to petroleum geologists.

T224. **Analysis on the Influence of Hydrothermal Activity on the Development of Lower Paleozoic Shale in the Yangtze Area of China (Posters)**

Cosponsors: *GSA Hydrogeology Division; GSA Energy Geology Division*
Disciplines: Energy Geology, Geochemistry, Structural Geology
Advocates: Xiaohui Li; Zhenxue Jiang; Xin Wang; Qianyou Wang; Zixin Xue; Fan Zhang

Lower Paleozoic strata in the Yangtze area of China was selected in this study, the effects of hydrothermal activities on the genesis of shale gas were comparatively analyzed, providing guidance for shale gas exploration.

ENGINEERING GEOLOGY

T225. **From Pattern to Process and Back: Data-Driven Insights in Critical Zone Sciences**

Cosponsors: *GSA Soils and Soil Processes Division; GSA Geoinformatics and Data Science Division*
Disciplines: Engineering Geology, Soils, Environmental Geoscience
Advocates: Julia Perdrial; Hang Wen

Because data-driven approaches become more important in Critical Zone science, we encourage contributions that use novel computational tools on existing data, investigate data compilation strategies, and/or combine insights from big data with process observations using lab and field investigations.

T226. **GSA Environmental and Engineering Geology Division**

Cosponsor: *GSA Environmental and Engineering Geology Division*
Disciplines: Engineering Geology, Environmental Geoscience
Advocates: Anne C. Witt; Robert J. Mitchell

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

T227. **GSA Environmental and Engineering Geology Division Student Research Competition (Posters)**

Cosponsors: *GSA Environmental and Engineering Geology Division; GSA Karst Division*
Disciplines: Engineering Geology, Environmental Geoscience
Advocates: Anne C. Witt; Robert J. Mitchell

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.

T228. **Landslide Hazard Assessments and Risk Reduction: Data Collection and Modeling Challenges (Posters)**

Cosponsors: *GSA Environmental and Engineering Geology Division; GSA Quaternary Geology and Geomorphology Division; GSA Geoinformatics and Data Science Division; GSA Geology and Society Division*
Disciplines: Engineering Geology, Geomorphology, Geoscience Information/Communication
Advocates: Anne C. Witt; Robert J. Mitchell; Matthew M. Crawford

This session will discuss landslide hazard and risk assessment. We encourage contributions that discuss novel approaches to investigating and characterizing landslides and explore advances in landslide susceptibility modeling, inventory mapping, and hazard communication.

T229. **Landslide Hazard and Risk Assessments**

Cosponsors: *GSA Quaternary Geology and Geomorphology Division; GSA Geology and Society Division*
Disciplines: Engineering Geology, Environmental Geoscience, Geomorphology
Advocates: Andree Blais-Stevens; Didier Perret

This session welcomes contributions to landslide research that include characterization, monitoring, modeling, susceptibility, hazard, risk, and land-use management assessments.

GEOINFORMATICS

T230. **Developments in Geological Mapping**

Cosponsors: *Association of American State Geologists; GSA Karst Division; GSA Structural Geology and Tectonics Division*
Disciplines: Geoinformatics, Hydrogeology, Economic Geology
Advocates: Richard Berg; Harvey Thorleifson; William Andrews Jr.

This session will highlight new mapping and innovations in geological mapping, including data management, seamless, 3D, and applications in water and land management.

T231. **Integrating Remote Sensing and In Situ Data for Understanding Surface and Subsurface Processes**

Cosponsors: *GSA Geoinformatics and Data Science Division; GSA Structural Geology and Tectonics Division*
Disciplines: Geoinformatics, Environmental Geoscience, Geophysics/Geodynamics
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.

T232. **Tales from the Front Lines: How Data Rescue and Conservation Really Happen (Posters)**

Cosponsor: *GSA Geoinformatics and Data Science Division*
Disciplines: Geoinformatics, Geoscience and Public Policy, Geoscience Information/Communication
Advocates: Denise J. Hills; Sarah Ramdeen

Share your data rescue and conservation experiences—the highs, the lows, the unexpected successes—and learn from your peers so that we all may become better data stewards.

GEOSCIENCE AND PUBLIC POLICY

T233. **The Next Step: Teaching about Practical Preparedness and Emergency Management (i.e., Prepping)**

Cosponsor: *GSA Geology and Society Division*
Disciplines: Geoscience and Public Policy, Geoscience Education, Geoscience Information/Communication
Advocates: Stan P. Dunagan; Angela Van Boening

This session explores "the next step" in natural hazard pedagogy focusing on emergency management and preparedness. We encourage presentations highlighting effective instructional, experiential, and practical techniques that integrate the subject of "prepping" into instructional design.

T234. **Economic and Societal Benefits of Geologic Maps and Geologic Data**

Cosponsors: *GSA Geoinformatics and Data Science Division; GSA Structural Geology and Tectonics Division*
Disciplines: Geoscience and Public Policy, Geology and Health, Geoscience Information/Communication
Advocate: William Andrews Jr.

This session will explore recent trends and new methods for quantifying and documenting the critical impacts and value of geologic maps and data.

T235. **Building the Workforce of the 21st Century: Understanding Diversity, Intersectionality, Ethics, and Inclusivity in the Geosciences and Implementing Transformative Change in Our Culture**

Cosponsor: *GSA Geoscience Education Division*
Disciplines: Geoscience and Public Policy, Geoscience Education
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.

T236. **Expanding Geoheritage Awareness in North America**

Cosponsors: *GSA Geoscience Education Division; Canadian Geopark Network; Canadian Commission for UNESCO*
Disciplines: Geoscience and Public Policy, Geoscience Information/Communication, History and Philosophy of Geology
Advocates: John H. Calder; Thomas Casadevall; Terri L. Cook

Geoheritage sites enable public understanding of geoscience, earth history, and societally important topics. This session will explore models of geoheritage recognition; geoconservation concepts; sustainable economic development; indigenous practice; and increasing public interest in the geosciences.

GEOSCIENCE EDUCATION

T237. **Supporting and Advancing Geoscience Education Beyond 2020: Individual, Department, Program, and Institutional-Level Approaches to Student Success**

Cosponsors: *SAGE-2YC; National Association of Geoscience Teachers (NAGT); National Association of Geoscience Teachers (NAGT) Geoscience Education Research (GER) Division; GSA Geoscience Education Division*
Disciplines: Geoscience Education, Geoscience Information/Communication, Geoscience and Public Policy
Advocates: David D. Mrofka; Peter J. Berquist; Becca Walker

Student success depends on a variety of factors, inside and outside of the classroom. We encourage talks sharing approaches that two- and four-year college faculty have taken to improve the success of all students.

T238. **Incorporating Identities to Advance Diversity throughout Geoscience Disciplines**

Cosponsors: *GSA Geoscience Education Division; GSA Geology and Society Division; GSA Diversity in the Geosciences Committee*
Disciplines: Geoscience Education, Geoscience Information/Communication
Advocates: Darryl Reano; Angel A. Garcia Jr.; Leila M. Joyce Seals

This session focuses on the intersection between diverse cultures, identities, and geoscience disciplines. This includes the use of identities and culture to teach or conduct research that advances diversity, equity, and inclusion throughout geoscience disciplines.

INDUSTRY TRACKS Look for these icons, which identify sessions in the following areas:


Economic Geology


Energy


Engineering


Hydrogeology and Environmental Geology

T239. **Integrating Active Learning Strategies into College-Level Geoscience Classrooms II: Implementation, Effects, and "Lessons Learned"**

Cosponsors: *GSA Geoscience Education Division; National Association of Geoscience Teachers (NAGT); National Association of Geoscience Teachers (NAGT) Geoscience Education Research (GER) Division; National Association of Geoscience Teachers (NAGT) Teacher Education Division (TED); National Association of Geoscience Teachers (NAGT) Geo2YC Division*
Disciplines: Geoscience Education, Geoscience Information/Communication
Advocates: Jason P. Jones; Katherine Ryker; C. Doug Czajka

The integration of active learning strategies into college-level STEM courses has been shown to improve student outcomes. This session will explore the evidence behind incorporating active learning into geoscience courses.

T240. **Advances in Undergraduate Research and Education, Colorado Geology, and Igneous Petrology: Celebrating the 55-Year Career of Reinhard "Bud" Wobus**

Cosponsors: *National Association of Geoscience Teachers (NAGT); GSA Geoscience Education Division*
Disciplines: Geoscience Education, Precambrian Geology, Petrology, Igneous
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.

T241. **Geoscience Education in the Food-Energy-Water Nexus: Transdisciplinary Capacity-Building through Networked Improvement Communities (Posters)**

Cosponsors: *GSA Geoscience Education Division; National Association of Geoscience Teachers (NAGT); National Association of Geoscience Teachers (NAGT) Geoscience Education Research (GER) Division; GSA Energy Geology Division*
Disciplines: Geoscience Education, Geoscience Information/Communication
Advocates: Cory Forbes; Nicole Colston; Aida Farough; Kathleen Quardokus Fisher

This session leverages a FEW-Nexus perspective on education and education research, highlighting the *National Collaborative for Research on Food, Energy, and Water Education* and related educational programs, theory, and research within the GSA community.

T242. **Hands-On Teaching Demonstrations that Combine Geoscience and Societal Issues: Audience Participation Requested!**

Cosponsors: *GSA Geoscience Education Division; National Association of Geoscience Teachers (NAGT); GSA Structural Geology and Tectonics 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.

T243. **Making Sense of Methodologies and Theoretical Frameworks in Geoscience Education Research**

Cosponsors: *GSA Geoscience Education Division; National Association of Geoscience Teachers (NAGT) Geoscience Education Research (GER) Division*
Disciplines: Geoscience Education, Geoscience Information/Communication
Advocates: Leilani Arthurs; Cory Forbes; Bailey Zo Kreager; Katherine Ryker

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

T244. **Engaged Students and Citizens Advancing Science**

Disciplines: Geoscience Education, Environmental Geoscience, Geoscience Information/Communication
Advocates: William G. Minarik; Kristyn Jessica Rodzinyak; Jesse Rogerson

We encourage the submission of project ideas that advance scientific inquiry made by students and non-academics. Projects using innovative methods designed for primary, secondary, or undergraduate research projects are especially solicited.

T245. **Fluid Earth Science Education: Research and Practice**

Cosponsors: *GSA Geoscience Education Division; National Association of Geoscience Teachers (NAGT) Geoscience Education Research (GER) Division; GSA Hydrogeology Division*
Discipline: Geoscience Education
Advocates: Peggy M. McNeal; Heather Petcovic; Kathleen Quardokus Fisher

This session explores education research and classroom practices that inform teaching oceanography, hydrogeology, and atmospheric science. We encourage work examining cognitive and affective dimensions of learning about fluid Earth and examples of successful teaching innovations.

T246. **The Transformative Role of Field Instruction: Research on Student Experiences and Impacts on Persistence in the Geosciences and Career Intent through the Lens of Gender, Culture, and Elements of Diversity**

Cosponsors: *GSA Geoscience Education Division; National Association of Geoscience Teachers (NAGT)*
Discipline: Geoscience Education
Advocates: Eric M. Riggs; Julie M. Sexton; Jessica McKay

This session will consist of evidence-based studies into the transformative impact of field instruction on students' academic growth and career aspirations in the geosciences, especially examining differential impacts of field experience by dimensions of diversity including gender, ethnicity, culture, and ability.

T247. **Mitigating Geologic Blindness: What Are You Doing in Your Introductory Geology Course?**

Cosponsors: *GSA Geoscience Education Division; West Chester University*
Discipline: Geoscience Education
Advocates: Christopher Roemmele; Richard M. Jones

What ARE we teaching in introductory geology, and why does it matter? Changing introductory geology students' attitudes and improving conceptual understanding is vital to recruit more geoscience majors and help address critical socio-scientific issues.

T248. **Showcasing Posters of Undergraduate Research by 2YC and 4YCU Geoscience Students (Posters)**

Cosponsors: *GSA Geoscience Education Division; National Association of Geoscience Teachers (NAGT); National Association of Geoscience Teachers (NAGT) Geo2YC Division; National Association of Geoscience Teachers (NAGT) Geoscience Education Research (GER) Division; International Association for Geoscience Diversity (IAGD)*
Discipline: Geoscience Education
Advocates: Stephanie M. Rollins; Gretchen L. Miller; Adrianne A. Leinbach; Sara Rutzky

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.

T249. **An Early Involvement of K9–16 Students in Geoscience-Related Research: Potential Tool for Recruitment and Retention (Posters)**

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

K9–16 students working on fundamental geoscience-related topics including sedimentation, surficial processes, landscape development, environmental consequences, urban geology, and geoscience outreach aspects are encouraged to submit abstracts for this session.

T250. **Expanding Opportunities in the Geosciences: Exploring Examples of GEO-STEM Learning Ecosystems that Promote Justice, Equity, Diversity, and Inclusion**

Cosponsors: *National Association of Geoscience Teachers (NAGT); GSA Geoscience Education Division*
Disciplines: Geoscience Education, Geoscience and Public Policy
Advocates: Cheryl L.B. Manning; M. Brandon Jones

GEO-STEM learning ecosystems connect young people to the geosciences through sustainable, long-term collaborations between researchers, industry, and education. They engage diverse cadres of learners in solving local problems related to resources, disasters, and environmental quality.

GEOSCIENCE INFORMATION/COMMUNICATION

T251. **Geologic Maps and Their Derivatives (Posters)**

Cosponsors: *Association of American State Geologists; GSA Geoinformatics and Data Science Division; GSA Structural Geology and Tectonics Division*
Disciplines: Geoscience Information/Communication, Hydrogeology, Engineering Geology
Advocates: Richard Berg; Harvey Thorleifson

This poster session will highlight new geologic maps, mapping programs, and innovations in geological mapping, including data management, web accessibility, 3D, and applications in water and land management.

T252. **Geoscience and Hydrology of Your Public Lands: STEM Internships, Research, Science, Mapping, Resource Management, and Education**

Cosponsors: *U.S. National Park Service; U.S. Forest Service; U.S. Bureau of Land Management; Parks Canada; GSA Geoscience Education Division*
Disciplines: Geoscience Information/Communication, Geoscience and Public Policy, Geoscience Education
Advocates: Jason P. Kenworthy; Matthew Dawson; Limaris R. Soto; Johanna Kovarik; F. Edwin Harvey; Scott E. Foss; Gilles Seutin

This is an interdisciplinary forum for earth scientists, land managers, Geoscientists-in-the-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.

T253. **3D Printing for Geoscience and Engineering: Emerging Technology in Education, Research, and Communication**

Cosponsors: *GSA Geoinformatics and Data Science Division; GSA Structural Geology and Tectonics Division*
Disciplines: Geoscience Information/Communication, Geoinformatics, Geoscience Education
Advocates: Serg Ishutov; Kevin Hodder; Rick Chalaturnyk; Gonzalo Zambrano-Narvaez

3D printing is a rapidly evolving tool that provides functional, repeatable, and accessible models in engineering and geosciences. In this context, the session will provide insights on 3D printing initiatives for research, communication, and education.

T254. **Updates on Library Research and Services for the Lifecycles within Geosciences Information (Posters)**

Cosponsor: *Geoscience Information Society*
Disciplines: Geoscience Information/Communication, Geoscience Education, Geoscience and Public Policy
Advocate: Emily C. Wild

Finding geosciences information includes the discovery, access, instruction, assessments, and preservation of physical and digital materials. This session will provide an opportunity for a scholarly discussion of trends transforming geosciences collections and services.

2020 Joint Technical Program Committee

Technical Program Chair: Kevin Mickus, kevinmickus@missouristate.edu
Technical Program Vice-Chair: Amy Brock-Hon, amy-brock-hon@utc.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
Paul A. Baker	continental scientific drilling	GSA Continental Scientific Drilling Division
Laura S. Ruhl; Travis L. McLing	energy geology	GSA Energy Geology Division
Robert J. Mitchell; 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	geomicrobiology	GSA Geobiology and Geomicrobiology Division
Alan Rooney	geochronology	GSA Geochronology Division
Frank Ramos	geochemistry	Geochemical Society
Xiaogang Ma; Denise Hills; Kenneth H. Rubin	geoinformatics	GSA Geoinformatics and Data Science Division
Saugata Datta	geology and health	GSA Geology and Health Division
Susan Stover; Beth Bartel	geoscience and public policy	GSA Geology and Society Division
Ting Chen; Benjamin Drenth	geophysics/geodynamics	GSA Geophysics and Geodynamics Division
Kelly Lazar; Charles D. Czajka	geoscience education	GSA Geoscience Education Division
Emily Wild	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
Jeffrey M. McKenzie; Don Rosenberry	hydrogeology	GSA Hydrogeology Division
Andrew Luhmann; Jason Polk	karst	GSA Karst Division
Jeffery Stone; Scott Starratt	limnogeology	GSA Limnogeology Division
Bernard J. Coakley	marine/coastal science	Marine/Coastal Geology
Rosemary C. Capo; Rosemary Hickey-Vargas	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
Simon Darroch; Elizabeth Petsios; 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
Martha Cary Eppes; Julie Brigham-Grette	geomorphology; Quaternary geology	GSA Quaternary Geology and Geomorphology Division
Ryan F. Morgan; Piret Plink-Bjorklund	sediments, carbonates; sediments, clastic; stratigraphy	GSA Sedimentary Geology Division
Piret Plink-Bjorklund	sediments, carbonates; sediments, clastic; stratigraphy	SEPM (Society for Sedimentary Geology)
Richard Goldfarb	economic geology	Society of Economic Geologists
Gary Stinchcomb; Ashlee Dere	soils	GSA Soils and Soil Processes Division
Juliet Crider; Christie Rowe	structural geology; tectonics	GSA Structural Geology and Tectonics Division

GSA Partners with our Associated Societies for the Annual Meeting

Building a dynamic Annual Meeting technical program and other stimulating events draws GSA together with its 76 Associated Societies. Many of GSA's Associated Societies will present their representative science, hold tailored events, and run exhibit booths during the Annual Meeting. GSA is looking forward to hosting these valued partners and organizations. Members of Associated Societies also receive 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 looks to the future, it aims to build more 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.

For a full list of GSA's Associated Societies, go to **https://www.geosociety.org**, click on "About," then "Who We Are," and then "Associated Societies" in the left-hand menu.

Hotel Information

The official GSA housing bureau is Orchid.Events. To receive the GSA group rate at each hotel, reservations must be made through Orchid.Events and not directly with the hotels.

GSA has selected a range of hotels in terms of proximity to the Palais des congrès de Montréal (Palais) at rates and styles to meet your needs and preferences. **Rates are in Canadian dollars** and do not include the current applicable tax per room, per night.

ALERT: GSA and Orchid.Events will NOT contact attendees directly to solicit new reservations. If you are contacted by a vendor who claims to represent GSA, please notify the GSA meetings department at meetings@geosociety.org or +1-303-357-1041. Please do not make hotel arrangements or share any personal information through any means other than a trusted, reliable source.

Hotel	Single Rate* (tax not included)
Doubletree by Hilton Montréal	C$239
Embassy Suites by Hilton Montréal**	C$229
Hôtel Delta Montréal by Marriott	C$173
Hôtel Faubourg Montréal**	C$159
Hôtel Le Dauphin Montréal**	C$178
InterContinental Montréal	C$199
Le Centre Sheraton Montréal	C$215
Le Westin Montréal	C$255
Marriott Springhill Suites Old Montréal**	C$195

*Rates based on single occupancy/one bed; check the meeting website at **https://community.geosociety.org/gsa2020/attend/travel/hotels** for additional rate information.
**Rate includes breakfast (varies from continental to full buffet depending on hotel).

Guest Program: Local Tour Highlights

Montréal Flavors Tour

Guests will discover the city from a different point of view while receiving historical background, as well as learn about the ethnic influence on this culinary community. From "Little Italy" to "Chinatown" and including the Greek, Portuguese, and Jewish neighborhoods, guests will visit some of the most popular food stops and try some of the local specialties on this tour.

Lunch at an Authentic Sugarshack

Step back in time and experience a unique glimpse into Québec folklore at the Sucrerie de la Montagne—an official Québec heritage site. Your sugaring-off party will begin with a brief tour of the facilities and a welcome cocktail of traditional "Caribou" around the bonfire. Guests are then welcomed into the dining room for a feast of traditional Québécois dishes, served family-style, all-you-can-eat.

© Tourisme Montréal - Madore - Maude Chauvin

© Sucrerie de la Montagne

Scientific Field Trips

Descriptions and leader biographies are online at **https://community.geosociety.org/gsa2020/learn/field.**

401. **Trace the Steps of 19th-Century French Hydrogeologists Henry Darcy and Jean-Baptiste Paramelle.** Wed., 14 Oct.–Wed., 21 Oct. Leader: Patricia Bobeck.

402. **Transect of a Hot, Long Orogen: The Grenville Province of Western Québec.** Wed.–Sat., 21–24 Oct. Leaders: Christopher W. Lambert, Stellenbosch University; Félix Gervais; Charles Kavanagh-Lepage.

403. **From Obduction to Collision: A Transect across Ordovician to Devonian Sedimentary Basins of the Québec Appalachians.** Wed.–Sat., 21–24 Oct. Cosponsor: *Université du Québec à Montréal*. Leaders: Stéphane De Souza, Université du Québec à Montréal; Morgann Perrot, Alain Tremblay.

404. **Eldorado Gold Lamaque.** Thurs.–Sat., 22–24 Oct. Cosponsors: *GSA Continental Scientific Drilling Division; Eldorado Gold Lamaque*. Leader: Timothy John Palmer, Mississippi State University.

405. **Field Trip to the Adirondack Mountains, in New York State, to Explore the Regional Geology and to Visit Several Spectacular Exposures of Magnetite-Apatite (MtAP) Deposits and Their Hydrothermally Altered Host Rocks.** Thurs.–Sat., 22–24 Oct. Leaders: John M. Hanchar, Memorial University of Newfoundland; Jeffrey Chiarenzelli; Marian Lupulescu.

406. **Ancient Earthquake Fault Zone Geology in Coastal Maine.** Fri., 23 Oct. Leaders: Mark T. Swanson, University of Southern Maine; Christie D. Rowe.

407. **Ottawa & Gatineau Accessible Geoheritage Tour.** Fri.–Sat., 23–24 Oct. Cosponsors: *International Association for Geoscience Diversity (IAGD); Canadian Geoscience Education Network (CGEN)*. Leaders: Anita M.S. Marshall, University of Florida; Beth McLarty Halfkenny; Jennifer L. Piatek; Jean Dougherty; Janice Aylsworth; Lesley Hymers.

408. **Kirk Bryan Field Trip: Pre-LGM Stratigraphic Record in the Central St. Lawrence Lowlands—How Much Ice in Southern Québec and Adjacent New England during MIS-3?** Sat., 24 Oct. Cosponsor: *GSA Quaternary Geology and Geomorphology Division*. Leaders: Michel Parent; Lamothe.

409. **Geoarchaeology of the Middle Saint Lawrence River Valley of Southern Québec, Canada.** Sat., 24 Oct. Cosponsor: *GSA Geoarchaeology Division*. Leaders: Laura R. Murphy, Kansas Geological Survey; Brendan Fenerty; L.M. Joyce Seals; Adrian Burke.

410. **The Hydrology, Biogeochemistry, and Mineralogy of a Montregian Hill: Mont Sainte Hilaire.** Sat., 24 Oct. Leaders: Peter M Douglas, McGill University; Greg Langston.

411. **Geological Field Trip in the Mount Royal Park.** Thurs., 29 Oct. Leader: Pierre Bédard, Polytechnique Montréal.

412. **A Walking Tour of Ottawa's Building and Monument Stones.** Sat., 24 Oct. US$20. Leader: Quentin Gall.

413. **Cambrian–Lower Ordovician of SW Québec–NE New York.** Thurs.–Sat., 29–31 Oct. Leaders: Osman Salad Hersi, University of Regina; Ed Landing; David G. Lowe; James Hagadorn; David Franzi.

414. **Geology and Wine: What Grows Together, Goes Together.** Sat., 24 Oct. Leader: Kristyn Jessica Rodzinyak, McGill University; Chimira Andres.

415. **Canada's Role in Space.** Thurs., 29 Oct. Cosponsor: *Canadian Space Agency*. Leader: Kristyn Jessica Rodzinyak, McGill University.

416. **Geology and Wine: What Grows Together, Goes Together.** Fri., 30 Oct. Leader: Kristyn Jessica Rodzinyak, McGill University; Chimira Andres.

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

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

Short Courses

Learn and explore a new topic. Build your skills.

Learn: analysis of detrital geochronology data, detrital applications of U-Pb geochronology, ground-penetrating radar, geophysics for geotechnical site investigation, Stratigraphic Data Analysis in R (SDAR), and tools to help write better code.

Explore: surface processes using CSDMS modeling tools, petroleum geochemistry for basin evaluation, quantitative structural geology, geodynamic history of the Himalayan Orogenic Belt, medical geology, planetary geologic mapping, and NASA data with SAR.

Strengthen your research, data collection, and fieldwork skills with courses that address: high-resolution topography and 3D imaging, 3D hydrogeological modeling, 3D printing for geoscience and engineering, 3D geological mapping, resistivity surveying, sedimentary field data collection, drones in the geosciences, and field safety leadership.

Gain tips on: improving workplace climate, fostering GEOSTEM learning ecosystems, teaching geoscience courses using active learning strategies, communicating science, understanding open science, and geosciences and society.

Students and early career professionals can learn about: sequence stratigraphy and petroleum structural geology.

For details and course descriptions, check the upcoming June issue of *GSA Today* or go to **https://community.geosociety.org/gsa2020/learn/short.**

This is a great opportunity to earn continuing education credits!

The Geological Society of America®

GEOCAREERS

GeoCareers: Your Guide to Career Success

Envision your future career in the geosciences and learn about how to make it a reality by attending these events at GSA 2020.

GeoCareers Day

(Sunday)

Direct access to company representatives

Career Workshop
Company Information Booths
Mentoring Roundtables
Panel Luncheon

GeoCareers Center

(Sunday–Wednesday)

Career guidance and information

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

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

BE A MENTOR, SHARE YOUR EXPERIENCE

Become a mentor and help students navigate the meeting, introduce them to contacts, discuss career paths, and offer advice. Graduate students, early career professionals, professionals, and retirees are welcome to serve as mentors. Complete the Mentor Interest Form to become a mentor at **https://forms.gle/bZeKibPue7BXEsyQ9.**

On To the Future Offers Friendships, Mentorship, and an Entry into Future Opportunities

The On To the Future (OTF) program supports students from diverse backgrounds to attend their first GSA Annual Meeting, this year in Montréal, Québec, Canada, 25–28 October. Each year awardees are 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.

More than 647 students have gone through the program, including 47% who are from underrepresented minority groups, 74% are the first in their families to attend higher education, 37% are non-traditional students, and 9% are veterans. Post-program surveys demonstrate the value of OTF for students, which offers friendships, mentorship, and knowledge of opportunities that will support their academic and career pathways.

Increasing diversity and inclusivity is critical to innovation, scientific advancement, and solving tomorrow's geoscience challenges. Don't miss an opportunity to become an OTF student or mentor. Students should apply by **29 May** to attend the 2020 GSA Annual Meeting. 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

Seven Strategies for Success at Field Camp

Kurtis Burmeister

Prepare Your Mind & Body

Yes, you should spend some time reviewing rock-forming minerals, the components of good rock descriptions, and types of faults, but do make sure you are eating healthy, staying hydrated, and getting enough sleep. You will likely soon find yourself hiking five or six days a week at elevation. Try to add some more aerobic activity to your daily life between now and then. You will be happy that you did.

Avoid Careless Injuries

As most of you cross the threshold from indestructible teenager into vulnerable adult, be intentional in caring for your body. Protect feet and ankles with the best hiking boots you can afford and make sure they are broken in before you arrive at camp. Protect your knees and back by using three points of contact when moving through the field. Shield your eyes when breaking rocks. Avoiding careless injuries is an easy way to prevent premature departures from camp and to ensure your body lasts your entire career.

Always Know Where North Is

Give your brain a break by orienting your map to north before you look at it. A properly oriented map minimizes the work your brain must do when translating between your map and the real world. Use your compass to identify a landmark on a distant horizon that corresponds to a cardinal direction and use it to keep your map oriented.

Data Placement is Key

Avoid wandering aimlessly in units. Follow geologic contacts and mark them on your map as you go. Stay honest with your work and avoid the temptation to map what you cannot see. Buy several Westcott W-8 protractors (you will lose them) and learn how to use them to plot strike & dips in a single step. Always carefully plot your measurements before leaving an outcrop.

Don't Let Your Interpretations Drive Your Mapping

Few applications of the scientific method are as pure as geologic mapping. Remembering this simple truth will help you more than you can imagine. Always have more than one working hypothesis. Keeping observations separate from interpretations will help ensure that the relationships you observe guide your mapping, and not the other way around.

Paige Voss, 2019 J. David Lowell Field Camp Scholarship Awardee.

Baby Steps

Let your map evolve contact by contact and measurement by measurement. Fast mapping generally yields poor results. Keep moving at a reasonable pace and avoid sitting down and taking off your backpack. Use hip pouches or field vests to keep pencils, hammers, and water bottles easily accessible. If you ever find yourself feeling lost or overwhelmed, take a deep breath and remember that all you need to do is go back to the last place things made sense and try again.

Keep Your Cool

There is often only one degree of separation among folks in geology. Everyone knows everyone else. Field camp is where you truly begin to build the professional network you will rely upon for the rest of your career. Make sure the reputation you begin building is a good one. Smile and be kind. Handle stress with grace, be a team player, and treat everyone with respect, empathy, and compassion.

Kurtis Burmeister, a professor of geology at the University of the Pacific, has been on the faculty of the Wasatch-Uinta Field Camp since 2003 and has served as the program's co-director since 2007. Burmeister is the executive secretary of the National Association of Geoscience Teachers (NAGT)–U.S. Geological Survey Cooperative Field Training Program and is an advocate for field safety.

POSITION STATEMENT DRAFT

U.S. Flood Risk Management

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

POSITION SUMMARY

Across the United States and worldwide, flooding is the deadliest and most costly natural disaster. The rising costs of flooding largely result from continued development of flood-prone land and modifications to river and coastal systems, amplified by climate change. By most metrics, the U.S. is losing the fight to manage the nation's flood risk. Science provides tools for quantifying flood risk, estimating future conditions, balancing human uses of floodplains with ecosystem services, and identifying effective mitigation strategies. The Geological Society of America recommends policies that move the U.S. toward long-term resilience, focusing on pathways toward sustainable floodplain management and flood-risk reduction.

RATIONALE

Flooding—including the inundation of inland waterways, coasts, and urban areas—ranks among the costliest and most frequent type of natural disaster in the U.S. and worldwide. The economic consequences of flooding are growing rapidly, with floods causing hundreds of billions of dollars in losses in the last decade alone [1], displacing communities, and damaging livelihoods. The rising economic and humanitarian costs of flooding are largely the result of continued development in watersheds and floodplains and other modifications to river and coastal systems, amplified by climate change [2].

Responsibility for managing flood risks across the U.S. spans every level of government (federal, state, local, tribal, territorial) and involves individuals, businesses, and other community stakeholders. Under the National Flood Insurance Program (NFIP), the federal government underwrites insurance for more than 22,000 participating communities in exchange for community adoption and enforcement of baseline land-use and construction requirements intended to mitigate losses associated with the base flood (1% annual chance or 100-year flood). As of September 2019, 52% of NFIP participating communities have recognized the need to go beyond the NFIP minimum standards, adopting more stringent requirements. Model building codes and standards [e.g., 3] require most buildings to be elevated above the NFIP minimum. While individual federal agencies have adopted higher standards for planning and projects (e.g., [4]) or as conditions for financial assistance (e.g., [5]), the base flood currently remains the minimum federal flood standard nationwide.

Most current assessments of flood hazard assume that recent conditions are representative of the future (i.e., flooding is "stationary"), but geoscientists have repeatedly demonstrated that flood hazard is highly sensitive to climatic, geomorphic, and human-driven change and thus non-stationary [6–7]. In the United States, climate change is already altering the frequency, intensity, type, and seasonality of intense precipitation events and contributing to sea-level rise. Combined with increases in impervious cover, modifications to river floodways and shorelines, and development of flood-prone land, many communities are experiencing flood damages and risk greater than current assessments.

Not all flood risks are shown on flood maps. In urban areas, for example, intense rainfall combined with inadequate storm-water drainage can cause widespread damage [8]. Behind levees, there exists the "residual risk" of failure or levee overtopping even in communities with protection adequate for removal from FEMA's regulatory floodplain. Many residents in leveed areas are unaware of their residual risk [9]. Similarly, downstream of dams, residual risk is not universally mapped nor widely publicized.

River and flood science are fundamentally geological sciences. Geoscientists collect data on the characteristics and causes of flooding using field-based methods, modeling, and remote sensing. More broadly, geoscientists bring unique perspectives critical to understanding, predicting, and mitigating flood hazards, including how nature functions over long time scales and the variability and dynamics of natural systems. For example, paleoflood and paleoclimate records supplement short instrumental records, better predict extreme events, and help to parse out natural and human-caused shifts in flood hazard [10–12].

CONCLUSIONS AND RECOMMENDATIONS

The U.S. has experienced more than 250 weather- and climate-related disasters since 1980, with damages of $1 billion or more (adjusted for inflation), and flooding contributing to nearly 70% of these events [13]. By most metrics, the U.S. is losing, not winning, the fight to manage the nation's flood risk. But tools are available to chart a more sustainable path for the future. Science provides the best possible basis for estimating future conditions, informing hazard assessment, balancing human uses of floodplains with ecosystem services, and identifying effective mitigation strategies against future damages. Key recommendations are outlined below.

- **Move U.S. flood policy toward long-term sustainability, focusing on pathways to flood-risk reduction and resilience:**

Every disaster provides a window of opportunity to rebuild better. In the face of spiraling losses from flood damages, communities across the U.S. and worldwide seek solutions to increase their resilience—the ability to withstand a shock with minimal degradation and restore function in a reasonable amount of time. Specific policies, programs, and resources are needed that move away from rebuilding "just in time for the next disaster" and toward mitigating, protecting, and adapting to reduce losses long term, improve ecosystem services, and foster community safety and resilience.

- **Invest in basic river and flood data and research:**

Flood-risk management and investment decisions, involving billions, and ultimately trillions of dollars, should be based on

more detailed and better hydrologic and climatological data and science. Great strides in flood assessment have been made—including high-resolution topography (e.g., lidar) and related modeling, but basic areas like hydrologic instrumentation lag. Investment today in continuing hydrogeoscience data collection and analysis translates into flood losses avoided, communities spared, and lives saved in the future.

- **Incorporate uncertainty and changing conditions in flood planning and flood-risk communication:**

Flood hydrology and climate are understood by scientists to be both stochastic and non-stationary systems—meaning they are subject to uncertainty and changes over time. But most assessments of flood risk in the U.S. are communicated as fixed and certain values and lines on maps. Given evidence of shifting flood hazard in many locations, risk analyses that assume static conditions may underestimate present-day and future flood risk, sometimes significantly. Policy and risk management associated with flooding must recognize both uncertainty and past trends while predicting for future conditions.

- **Provide the public with actionable flood-risk information, including for present and future conditions:**

Communities need a clearer and more complete picture of their flood risk and what they can do about it. Comprehensive flood-risk information is essential to supporting planning, mitigation, and funding and policy priorities. Tools now exist to put such information into the hands of individual homeowners, renters, and business owners. Existing flood maps should be supplemented with data on residual risks behind levees and downstream of dams, areas with repeated pluvial flooding, and projections of future conditions resulting from development and climate change. Comprehensive flood risk information should drive communications, planning, mitigation actions, policies, and funding priorities among all stakeholders.

- **Maximize use of natural systems and processes to mitigate flooding:**

Wherever possible, development and infrastructure projects should incorporate non-structural and nature-based approaches to flood-risk management, including strategies to retain water and sediment in uplands and floodplains and to attenuate storm surge and wave energy in coastal areas. Projects that use natural features or otherwise mimic natural processes can also provide significant co-benefits (e.g., water quality, habitat, cultural, and recreation opportunities). Wherever possible, infrastructure and development that degrade these natural protective systems should be avoided.

OPPORTUNITIES FOR GSA AND GSA MEMBERS TO HELP IMPLEMENT RECOMMENDATIONS

- **Educate the next generation of flood-aware scholars and citizens:**

Dealing with the challenges of flooding requires a multidisciplinary understanding of earth systems, hydrology, climate, and engineering, with an appreciation of social sciences and policy. From large introductory classes to specialized graduate seminars, geoscience educators have a role in broadening students' awareness of flood risk and training them in managing, mitigating, and adapting to this risk. At the broadest level, students who come from flood-prone areas—or may move to at-risk areas in the future—should be aware of flood hazards and ways to address that risk. Among advanced students, flooding should be recognized as a geological hazard alongside earthquakes and slope failures, with specific skill sets and tool kits that can be applied to flood management. Key concepts including hydrology, statistics, GIS, and modeling should be taught in the context of flood hazards and management, and broader study of infrastructure, finance, planning, emergency management, and disaster- and preparedness-related policy should be encouraged. Geoscience students should recognize flood-risk and floodplain management as career paths.

- **Communicate flood risk and mitigation and resilience strategies with the broader public:**

Geoscientists can lead in helping the public understand the spectrum of threats from flooding, now and looking into the future. The nature of flooding, with recurrence times of decades or centuries between major events, requires a long-term perspective. Geoscientists are trained to communicate this perspective to others. A sunny parcel of riverside land may be attractive for a new house or shopping mall, but the substrate may include numerous layers of overbank alluvium documenting a history of extreme floods. Similarly, historical precipitation data, gage records, and/or downscaled climate models may in some watersheds show long-term trends in flood magnitude, but however slow, planners would be remiss in calculating future flood risk assuming static conditions. Tools for managing flood risk in the future include avoiding flood-prone locations [14], mitigating existing exposure, and adapting to future changes. The key to implementing these strategies is a broad public understanding of the nature of the hazard and a public will to use the best available science to guide society toward a sustainable and resilient future.

- **Translate flood data and science into actionable policy recommendations:**

The Geological Society of America, its membership, and other scientific voices encourage the implementation of balanced, nonpartisan, flood-risk management policies. Geoscientists are poised to be leaders in collaborative efforts with policy makers, planners, and engineers to improve flood-hazard management and mitigation. Geoscience offers unique perspectives on a broad range of topics relevant to flooding, founded on an appreciation of "deep time" and hydrologic and atmospheric processes that interact with Earth's surface in complex ways over many scales. Geoscience professionals should help bring the best available science to the challenges of flooding, communicating and translating their findings into tangible products for use by planners, engineers, and decision makers. GSA and its members should take opportunities to reach out to local, state, tribal, and federal leaders to communicate the relevant science and offer expertise to help improve U.S. flood-risk management.

REFERENCES CITED

1. U.S. National Oceanic and Atmospheric Administration (NOAA), National Centers for Environmental Information (NCEI), 2020, U.S. Billion-Dollar Weather and Climate Disasters: https://www.ncdc.noaa.gov/billions/ (last accessed 6 Mar. 2020).
2. Winsemius, H.C., Aerts, J.C.J.H., van Beek, L.P.H., Bierkens, M.F.P., Bouwman, A., Jongman, B., Kwadijk, J.C.J., Ligtvoet, W., Lucas, P.L., van Vuuren, D.P.,

and Ward, P.J., 2016, Global drivers of future river flood risk: Nature Climate Change, v. 6, p. 381–385, https://doi.org/10.1038/nclimate2893.
3. American Society of Civil Engineers, 2014, Flood Resistant Design and Construction: ASCE/SEI 24-14, https://ascelibrary.org/doi/book/10.1061/asce24 (last accessed 6 Mar. 2020).
4. Public Law 115-232, John S. McCain National Defense Authorization Act for Fiscal Year 2019: https://www.govinfo.gov/app/details/PLAW-115publ232.
5. U.S. Dept. of Housing and Urban Development, 2019, Allocations, common applications, waivers, and alternative requirements for Community Development Block Grant mitigation grantees, RIN: FR-6109-N-02, https://www.hudexchange.info/news/hud-publishes-cdbg-mitigation-notice/ (last accessed 6 Mar. 2020).
6. Milly, P.C., Betancourt, J., Falkenmark, M., Hirsch, R.M., Kundzewicz, Z.W., Lettenmaier, D.P., and Stouffer, R.J., 2008, Stationarity is dead: Whither water management?: Science, v. 319, p. 573–574, https://doi.org/10.1126/science.1151915.
7. Salas, J.D., and Obeysekera, J., 2014, Revisiting the concepts of return period and risk for nonstationary hydrologic extreme events: Journal of Hydrologic Engineering, v. 19, p. 554–568, https://doi.org/10.1061/(ASCE)HE.1943-5584.0000820.
8. University of Maryland and Texas A&M University, 2018, The Growing Threat of Urban Flooding: A National Challenge: https://cdr.umd.edu/urban-flooding-report (last accessed 6 Mar. 2020).
9. National Research Council, 2013, Levees and the National Flood Insurance Program: Improving Policies and Practices: Washington, D.C., The National Academies Press, https://www.nap.edu/catalog/18309/levees-and-the-national-flood-insurance-program-improving-policies-and (last accessed 6 Mar. 2020).
10. Munoz, S.E., Giosan, L, Therrell, M.D., Remo, J.W.F., Shen, Z., Sullivan, R.M., Wiman, C., O'Donnell, M., and Donnelly, J.P., 2018, Climatic control of Mississippi River flood hazard amplified by river engineering: Nature, v. 556, p. 95–98, https://doi.org/10.1038/nature26145.
11. Wilhelm, B., and 21 others, 2019, Interpreting historical, botanical, and geological evidence to aid preparations for future floods: Wiley Interdisciplinary Reviews: Water (Basel), v. 6, p. e1318.
12. Kochel, R.C., and Baker, V.R., 1982, Paleoflood hydrology: Science, v. 215, p. 353–361, https://doi.org/10.1126/science.215.4531.353.
13. U.S. National Oceanic and Atmospheric Administration (NOAA), 2020, Billion-dollar weather and climate disasters: Overview: https://www.ncdc.noaa.gov/billions/ (last accessed 6 Mar. 2020).
14. Geological Society of America, 2019 (latest update), GSA Position Statement: Integrating geoscience with sustainable land-use management: https://www.geosociety.org/GSA/Science_Policy/Position_Statements/Current_Statements/gsa/positions/position13.aspx (last accessed 6 Mar. 2020).

GSA Testifies in Support of the U.S. Geological Survey

Ryan Haupt, GSA Science Policy Fellow

On 10 February, the White House released the President's budget request for fiscal year (FY) 2021. The request isn't binding to Congress, which ultimately holds the nation's budgetary purse strings, but is seen as one of the ways the executive branch outlines its priorities for the upcoming year.

The administration's request proposed a budget of US$12.8 billion for the Department of the Interior (DOI) for FY 2021, of which US$971.2 million would go to the United States Geological Survey (USGS). For FY 2020, the request for the USGS was US$983.5 million, but the actual amount enacted in the budget passed by Congress was US$1.27 billion. In the FY 2021 request, every mission area would see proposed cuts except for energy and minerals resources. The largest proposed cut—nearly 50% from FY 2020—would be to the ecosystems mission area, tasked to "provide science to help America achieve sustainable management and conservation of its biological resources."

The request also proposes some restructuring of the USGS. This would include organizational changes, such as splitting the portfolio of the deputy director between two positions, one overseeing operations and another for administration and policy, establishing a chief scientist position, and paring down the mission areas from seven to five by eliminating or moving the programs within land resources and environmental health mission areas.

Now the House Committee on Appropriations and the Senate Committee on Appropriations will begin the process of drafting their appropriations bills, which can differ substantially from the request, as exemplified by the 10% increase in the USGS budget last fiscal year. Each committee has 12 subcommittees responsible for different parts of the budget. DOI falls under the Subcommittee on Interior, Environment, and Related Agencies, which also includes the Environmental Protection Agency, the Forest Service, and the Smithsonian Institution.

On 6 February, GSA's Director for Geoscience Policy, Kasey White, testified before this subcommittee on the House side. She thanked them for increasing the USGS budget in FY 2020 and urged Congress to continue that trend by providing USGS with a US$1.35 billion budget for the upcoming FY 2021, noting that increased funding "would allow the USGS to implement new initiatives created by recent legislation, sustain base funding for critical research and monitoring, and update and maintain its facilities." She emphasized that USGS has "a distinctive capacity to engage interdisciplinary teams of experts to gather data, conduct research, and develop integrated decision support tools about our Earth," and pointed to how USGS research is used by communities and businesses to inform decision making. White reminded the panel that legislation supporting the USGS often has bipartisan support, such as the *John D. Dingell, Jr. Conservation, Management, and Recreation Act*, which established a national volcano early warning and monitoring system and reauthorized the USGS national cooperative geologic mapping program.

The testimony included some of the crucial roles USGS plays. For example, in 2019 there were 14 weather and climate disasters where losses exceeded US$1 billion each. The USGS provides data to help decision makers mitigate the effects of these disasters, such as alerting the aviation sector of volcanic activity that could affect flight routes and providing data to National Oceanic and Atmospheric Administration to issue flood, drought, and tsunami warnings. Space weather has the potential to impact the electric power grid, satellite communications, and navigation systems, but remains difficult to predict. White noted that the "USGS is a key partner in obtaining measurements necessary to predict severe space weather events." The USGS also connects science to local communities via climate adaptation science centers, which "work with communities to make smart, cost-effective decisions on issues as diverse as protecting cultural resources to planning for wildfires."

Chair Betty McCollum (D-MN-04) said she appreciated how the witnesses informed the committee's ability to help make decisions. In response to White's testimony, she replied, "We're talking about Earth. Most high schools don't even have an earth science class anymore; they may have a climate class but that's not the same thing. I was the only girl in my earth-science class, and I found it as useful as a biology class. I want to thank you for shouting out earth science. Thank you for pointing that out. I'm going to do some lobbying with my education colleagues."

As the budget process progresses, GSA will continue to monitor the situation on Capitol Hill and make the case for strong federal science funding via additional testimony, congressional visits, and work with like-minded organizations through collaborative efforts, such as the USGS Coalition.

CALL FOR COMMITTEE SERVICE

Make an Impact by Serving on a GSA Committee

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

If you are looking for the opportunity to work toward a common goal, network, and make a difference, 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.

Learn more and access the nomination form at **https://rock.geosociety.org/Nominations/CS.aspx.** Use the online form to make a nomination or self-nomination. Open positions and qualification information is online at **https://rock.geosociety.org/forms/viewopenpositions.asp.** GSA headquarters contact: Dominique Olvera, P.O. Box 9140, Boulder, CO 80301-9140, USA; +1-303-357-1060; dolvera@geosociety.org.

Academic and Applied Geoscience Relations Committee

One member-at-large vacancy (industry-related field) (three-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 interests: 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 Division.

Annual Program Committee

Three vacancies: two members-at-large (four-year term; B, E, M); one student member-at-large (two-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 Society meetings as a whole; and developing 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 member-at-large vacancies (three-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 the months of February and March; committee decisions must be made by 1 April.

Diversity in the Geosciences Committee

Three member-at-large vacancies (three-year term; E, M)

This committee provides advice and support to GSA Council and raises awareness and initiates activities and programs that will increase opportunities for diverse groups in the geosciences, particularly along 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 for which this committee is expected to serve.

Education Committee

Member-at-large vacancy (four-year term; E, M); two-year-college faculty representative vacancy (four-year term; E, M); pre-college educator (K–12) representative vacancy (four-year term; E, M); graduate student representative vacancy (two-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 member-at-large vacancies (three-year term; E, M)

This committee provides advice on public-policy matters to GSA Council and 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 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.

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.

GSA International

Two member-at-large vacancies (four-year terms; 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 GSA Divisions and Associated Societies on international issues, and serve as a channel for member-generated proposals for international themes.

Membership and Fellowship Committee

Member-at-large vacancy: industry (three-year term; B, T)

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.

Nominations Committee

Member-at-large vacancy: industry (three-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.

North American Commission on Stratigraphic Nomenclature

GSA representative (three-year term; E, M)

This committee 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 units, and formulates expressions of judgment on these matters.

Qualifications: Members must be familiar with the fields of paleontology, biostratigraphy, and stratigraphy.

Penrose Conference and Thompson Field Forum Committee

Two member-at-large vacancies: early career scientist (three-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 member-at-large vacancies (three-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; committee decisions must be made by 1 April.

Professional Development Committee

Member-at-large vacancy (three-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 vacancy (four-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 providing 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, headquarters will provide the committee with all necessary financial information.

Research Grants Committee

Fifteen member-at-large vacancies with various specialties (three-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 Apr.; each member reviews approximately 40 applications. More information: www.geosociety.org/gradgrants.

Young Scientist Award (Donath Medal) Committee

Member-at-large vacancy (three-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 which marks a major advance in the earth sciences." All of the committee's work will be accomplished during the months of February and March; committee decisions must be made by 1 April.

A Message from the GSA President and GSA Council

Science Often Teaches Us That Amazing Discoveries Happen When We Least Expect Them

GSA President Don Siegel

Most of us did not expect a novel coronavirus to envelope the earth in a global pandemic this spring, and many of us now face obstacles that we hadn't even begun to imagine only a few weeks ago because of COVID-19. You may be wondering, "What and where are the resources I can use to take my teaching online?" "How can I further my research when I can't get to the field or attend conferences?" "Can I find (or keep) a job in this sudden economic downturn?"

GSA understands that scientists, including geoscientists, will be considered heroes in this historical saga, not just those at the front lines in medicine but at every level of society. We will be the ones who will lead the innovation and mitigation to find our way into this new world order. GSA's mission is to support the geoscience community in this endeavor.

To that end, GSA Council has authorized open access to some resources that may help you keep moving forward in these uncertain times. We now have posted the GSA Online Education Resource Guide (**www.geosociety.org/online-resources**) to help with teaching, learning, and remote research, including links to third-party offerings that might be helpful. We encourage you to use and share this information to benefit your work.

GSA is also moving quickly to take advantage of the opportunities that the new world of virtual communication can bring to our members and the organization as the medium evolves. In the future, we anticipate that our conferences and meetings will have more virtual content that mirrors and/or enhances in-person communication. More flexibility across all platforms of communication enables us to offer our services to members and the broader community without the kind of disruption that COVID-19 has brought to us and to all other organizations. GSA staff was already building on virtual platforms as part of our strategic plan before COVID-19 struck, and so the build-out should proceed quickly.

The GSA community wants to share the burden of your very stressful life right now and in the uncertain future ahead of us. Reach out to your colleagues, use our resources, and make an amazing discovery about the life-saving value of your network, even if you didn't expect to!

Stay Well.
GSA President Don Siegel and the GSA Council

2019 Exceptional Reviewers

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
Michael Benton, University of Bristol
Mingcai Hou, Chengdu University of Technology
Wei-Qiang Ji, Institute of Geology and Geophysics Chinese Academy of Sciences
Fulai Liu, Chinese Academy of Geological Sciences
Jocelyn McPhie, University of Tasmania
Junpeng Wang, China University of Geosciences (Wuhan)
Dan-Ping Yan, China University of Geosciences (Beijing)
Kai-Jun Zhang, University of Chinese Academy of Sciences (Beijing)
Xiaoran Zhang, Institute of Earth Sciences Academia Sinica
Jun-Hong Zhao, China University of Geosciences (Wuhan)

Geology
Gail Lee Arnold, The University of Texas at El Paso
Carolyn Boulton, Victoria University of Wellington
Brendan Duffy, University of Melbourne
Katy Evans, Curtin University (Australia)
Christopher Jackson, Imperial College (London)
Kate Kiseeva, University College Cork
Brendan P. Murphy, Utah State University
Arnold Jan Reesink, Lancing College (UK)

Geosphere
Stephen Angster, U.S. Geological Survey Earthquake Science Center Seattle Field Office
Nicholas W. Hayman, Institute for Geophysics Jackson School of Geosciences, The University of Texas at Austin
Andrew Kozlowski, New York State Museum–Geologic Survey
Andrew Meigs, Oregon State University
Jonathan Perkins, U.S. Geological Survey GMEG Science Center, Moffett Field
Jaime Toro, West Virginia University
Paul Umhoefer, Northern Arizona University
Douwe J.J. van Hinsbergen, Utrecht University (The Netherlands)

Lithosphere
Kathleen DeGraaff Surpless, Trinity University
Marc Hässig, University of Geneva
Dawn Kellett, Geological Survey of Canada
Ruth Keppler, Universität Bonn
Richard D. Law, Virginia Tech
Laura Morrissey, University of South Australia
Iain Neill, University of Glasgow
Yang Sun, Institute of Earth Sciences Academia Sinica
Derek Thorkelson, Simon Fraser University
Erin Todd, U.S. Geological Survey
Hilmar von Eynatten, University of Göttingen
David Waters, University of Oxford

Ads (or cancellations) must reach the GSA advertising office no later than the first of the month, one month prior to the issue in which they are to be published. (Note: Combined March/April issue releases on March schedule.) Print ads will also appear on the Geoscience Job Board to coincide with the month of print issue. **Contact: advertising@geosociety.org,** +1-800-472-1988 ext. 1053, or +1-303-357-1053. Email correspondence should include complete contact information (including phone and mailing address). Rates are in U.S. dollars.

Classification	Per Line for 1st month	Per line each addt'l month (same ad)
Positions Open	$9.40	$9.35
Fellowship Opportunities	$9.35	$9.30
Opportunities for Students		
First 25 lines	FREE	$5.00
Additional lines	$5.00	$5.00

OPPORTUNITIES FOR STUDENTS

Graduate Student Opportunities (online non-thesis MS), Ohio University. The Department of Geological Sciences at Ohio University invites applications to its online non-thesis MS degree in Geology for the fall of 2020. The program provides geology graduates and those from related STEM disciplines with advanced, applied training and experiences through a wide range of topics in earth sciences, including environmental geology, geodata analytics, sedimentary geology, planetary geology, and paleontology. The mission of the program is to enhance graduates' marketability as the next generation of practicing geoscientists, earth-science educators, and allied professionals. Students normally complete the program in three semesters. These flexible and 100% online courses are well-suited for working professionals and K–12 science educators. For additional program and application information, please visit the program website at https://www.ohio.edu/cas/geology/graduate/ms-non-thesis or contact the graduate chair, Dr. Daniel Hembree (hembree@ohio.edu), or the online M.S. program coordinator, Jenny Schenk (xschenk@ohio.edu). The application deadline for the fall of 2020 is July 15.

GSA Foundation Hires New President

Dr. Christopher Grant Maples

The GSA Foundation (GSAF) has selected Dr. Christopher Grant Maples as the next GSAF President. He replaces Dr. John W. (Jack) Hess, who has been the President of GSAF since January 2015.

Dr. Maples earned his M.S. and Ph.D. degrees at Indiana University and his B.S. at West Georgia College. He has held senior leadership positions at both geoscience centers (Dept. Chair, Geological Sciences, Indiana University; executive vice president for research, Desert Research Institute) and technology-focused universities (president, Oregon Institute of Technology; interim chancellor, Missouri University of Science and Technology). Currently, he is the interim president at the Pacific Northwest College of Art (PNCA). He also has served at the National Science Foundation and the Kansas Geological Survey. In addition, he has some 16 years of continual advanced leadership training at several prestigious institutions. He is a GSA Fellow and a Fellow of the Paleontological Society.

The Foundation Board feels that he has excellent skills as both a manager and fundraiser and will help us expand our ranks of friends and donors to the Society.

Dr. Maples will join GSAF in July of this year. The Foundation gives its most sincere thanks to Jack Hess for many years of thoughtful, bold, and very successful leadership and we welcome Chris Maples into our family.

GSA FOUNDATION Update

John W. (Jack) Hess, *GSA Foundation President*

How Important is On To the Future, Really?

On To the Future (OTF) student Mariana Yolotzin Alcántara-Torres shares her expectations going into the GSA 2019 Annual Meeting and her on-site experience of OTF, her mentor, and the meeting.

QUESTIONS LEADING UP TO GSA 2019

What are your expectations for GSA 2019 and OTF?
I have never participated in a geology meeting. I chose the GSA Annual Meeting as my first because it is one of the most important geological meetings around the world.

What do you want to get out of the program?
My expectations are to receive recommendations, advice, and knowledge from expert geoscientists in order to support me as I start my career in geology. I would also like feedback on my research project so that I can improve my future research methods.

What are you most looking forward to?
I hope to meet established geologists and learn from them. I believe that I will enjoy my time with the OTF team as I share their values, and it is an excellent opportunity for me to network with the international geoscience community for the first time.

What would you like your mentor to help with during the meeting?
I would like my mentor to share her experience and knowledge working as a geologist. I'd also like to learn how I can be most effective in networking and in deciding on the best sessions, workshops, and poster presentations to attend according to my interests within the field of geology.

Mariana Yolotzin Alcántara-Torres, a student at the National University of Mexico, is finishing her thesis for her undergraduate degree and will then start graduate school.

MEETING IMPRESSIONS

Did OTF meet your expectations?
Yes, it did; OTF was more than I expected. It was a new and pleasant experience.

What aspect of your OTF experience had the greatest impact?
It was the early career workshop about how to apply for jobs and grad school. It was very important to meet other students with the same interests and in similar situations because we received feedback that will help in my future applications.

What do you remember most from the annual meeting?
I spoke with a presenter from Alabama University whose presentation was similar to research I am interested in. We had a good conversation about my research. He gave me his email and recommended I write to him and keep in touch for tips on my research and future grad school interests.

What was your mentorship experience like?
My experience was fruitful because my mentor helped me network with people and gave me a lot of advice about my poster presentation because I was very nervous (it was my first time presenting my research work in another language). She also introduced me to some of her contacts.

How do you see OTF influencing or impacting your future?
I made many connections with students and professors who are working in the research I am interested in. I learned about many grad programs where I can apply in the future and even jobs that I am interested in. In my poster presentation, I received good feedback. I also received instructions on how to make a good résumé and application letter.

Read more interviews on the Foundation blog at **https://gsa-foundation.org/news-events/.** Make a gift to help more students like Mariana at **https://gsa-foundation.org/fund/on-to-the-future-fund/.**

A Guide to Graduate School Admissions in the Geosciences

Samuel J. Smidt, *Soil and Water Sciences Department, University of Florida, Gainesville, Florida 32611, USA, ssmidt@ufl.edu;*
and ***David J. Gates,*** *Department of Geosciences, University of Arkansas, Fayetteville, Arkansas 72701, USA, djgates@email.uark.edu*

ABSTRACT

While information on pursuing graduate studies is widely available from both web sources and faculty advisers, many prospective students find a lack of organization and consistency in materials. This article seeks to streamline student preparation by providing a guide to graduate program admissions. In addition, we suggest target completion dates and cite open-source material for further documentation. Further, this article helps structure an approach for prospective students while alleviating the demands on faculty by consolidating the advising process.

INTRODUCTION

Total bachelor's degree graduates in the geosciences have doubled over the past decade, increasing competition for available graduate positions (National Center for Education Statistics, 2017). Here, we seek to equip applicants with an annotated timeline (summarized in Fig. 1) and referenced open-source material for extended information, as not all students are equally exposed to this process through their home institution. This guide assumes fall enrollment and is designed for prospective graduate students regardless of current academic level.

TASK 1. GAIN EXPERIENCE

Successful applicants often highlight past experiences viewed favorably by a graduate selection committee, such as independent research, professional employment, abroad studies, external teaching, or even nontraditional activities. There is no recipe for the perfect applicant, but a common thread is personal growth from past experiences. Many find success conducting research with a faculty adviser at a home institution. Other popular options include the National Science Foundation Research Experiences for Undergraduates program or Fulbright Program, which promote research and education with outside institutions and laboratories. *Target date: 1 September of the student's last undergraduate year.*

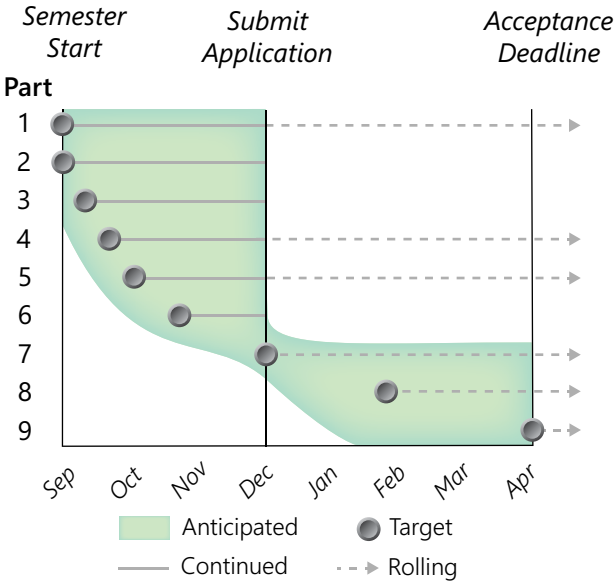


Figure 1. Summarized timeline for outlined tasks. Target refers to the date listed here for each task; anticipated refers to a plausible window outside the target; continued refers to ongoing task activity; and rolling refers to programs with rolling deadlines (i.e., no formal deadline).

TASK 2. DEVELOP A CV

Many professional employers require a résumé, but academia operates with the *curriculum vitae* (CV). In short, a résumé self-promotes skills and attributes, whereas a CV highlights what has been accomplished, and it accumulates accomplishments over time. Critical to the CV at the applicant level are degree and graduation date, relevant coursework and technical knowledge, any research or relevant experience, internships, teaching assistantships, and conference proceedings or publications. Refer to Stark (2015) and Smidt (2018b) for extended details. *Target date: 1 September.*

TASK 3. TAKE THE GRE

The Graduate Record Examinations (GRE) is currently the required entrance exam for most graduate programs and is an opportunity to cement a strong application. Graduate departments looking to recruit top applicants may offer scholarships and awards using exam scores as a metric for selection. The GRE is measured across all takers regardless of discipline, so scores in the Quantitative and Writing categories may be weighted more with geoscience programs than Verbal Reasoning. Students may also consider a second attempt; attempts must be at least 21 days apart. Note: Some departments do not require, plan to not require, or will waive the GRE. Refer to Educational Testing Service brochure (ETS, 2017) for extended details. *Target date: Early September.*

TASK 4. IDENTIFY POTENTIAL ADVISERS

Selecting a program based on a specific adviser and faculty can be more valuable than selecting one based on institution name alone, and programs should mirror the applicant's professional goals. Department websites or conference proceedings are great

GSA Today, v. 30, https://doi.org/10.1130/GSATG410GW.1.

places to identify target advisers, and faculty members often have personal websites with details on research and position openings. There are hundreds of graduate programs, each with many faculty members (Wilson, 2017), and prospective students should develop a list of target advisers based on interest. Students can also explore network and adviser connections. *Target date: Late September, although the list will evolve as new connections are made.*

TASK 5. CONTACT POTENTIAL ADVISERS

A contact e-mail is often necessary, as many prospective students have never communicated with a potential adviser. Here, the goals are to succinctly (1) introduce yourself, (2) state the purpose of your inquiry, (3) communicate your overlapping interests and motivation, and (4) establish a secondary conversation. Some advisers may not respond immediately due to busy schedules, travel, or other various reasons; anticipated reply times are about two weeks. Interested faculty will accept a request for a follow-up conversation while others may not be accepting students. If no response is received after two weeks, a polite follow-up email may be sent. Refer to Smidt (2018a) for a template e-mail. *Target date: Late September to mid-October.*

TASK 6. NETWORK AT A CONFERENCE

Attending a professional conference is an efficient way to connect with advisers and graduate students from prospective departments. Students can attend the presentations of prospective advisers and schedule in-person meetings. Department booths are also available in exhibit halls for further information, and prospective students should make their interest known by leaving their contact information with the department sign-in sheet; some advisers may contact students using this list. *Target date: October–December, although abstract deadlines are often several months before the conference.*

TASK 7. SUBMIT APPLICATIONS

Applications typically require five things, in addition to supplemental documents specific to an institution: (1) undergraduate transcripts, (2) GRE scores, (3) recommendation letters, (4) a completed application package, and (5) a statement of purpose (i.e., personal statement). There is often an application fee, transcript request fee, and GRE score request fee. Applicants will also be asked to select M.S. or Ph.D. program consideration (Toké and Arrowsmith, 2009). Applications are evaluated as a package; notable deficiencies should be reconciled in the personal statement. Refer to Maher (2017) for extended details. *Target date: Deadlines are set by the department and may be as early as 1 December.*

TASK 8. VISIT CAMPUS

Throughout the selection process, applicants may be invited for a campus visit. Campus visits help gain insight into department culture and further develop working relationships with prospective advisers. Most visits include conversations with other faculty and graduate students, a campus tour, and extended time with an adviser. Prospective students often find these visits to be one of the most critical deciding factors in selecting their eventual program. *Target date: Early in the spring semester for most institutions.*

TASK 9. ACCEPT AN OFFER

A graduate offer will typically include three things: (1) tuition waver, (2) living stipend, and (3) health insurance. An offer will likely designate a teaching assistantship (TA), research assistantship (RA), or both. Each can provide excellent opportunities, although having time for research is often a main priority for thesis-option students. Once a program has been selected, applicants sign and submit the paperwork. In the case of multiple offers, applicants should notify rejected departments promptly. If self-funded, students may elect to enroll while seeking external scholarships and grants or forgo admission. Refer to Osmond et al. (2015) for extended details. *Target date: 15 April for the national acceptance deadline (CGS, 2019).*

ACKNOWLEDGMENTS

We thank past and present faculty advisers, colleagues, and reviewers for helping to develop the context of this guide, including the editors of *GSA Today* for their valuable feedback.

REFERENCES CITED

Council of Graduate Schools (CGS), 2019, Resolution Regarding Graduate Scholars, Fellows, Trainees and Assistants: https://cgsnet.org/ckfinder/userfiles/files/CGSResolution_March2019Rv.pdf (last accessed 1 October 2019).

Educational Testing Services (ETS), 2017, The GRE® General Test Accepted at top-ranked schools worldwide: https://www.ets.org/s/gre/pdf/gre_test_taker_brochure.pdf (last accessed 4 February 2019).

Maher, H.D., Jr., 2017, Applying to graduate schools: http://maps.unomaha.edu/maher/GraduateSchool.pdf (last accessed 4 February 2019).

National Center for Education Statistics, 2017, U.S. Department of Education, Institute of Education Sciences: https://nces.ed.gov/ (last accessed 4 February 2019).

Osmond, J., Meado, A., and Cheney, A., 2015, Selecting and applying to geoscience graduate schools: http://docplayer.net/16107136-Selecting-and-applying-to-geoscience-graduate-schools-by-jonathon-osmond-andrea-meado-and-alex-cheney.html (last accessed 4 February 2019).

Smidt, S., 2018a, Contacting a prospective graduate adviser: https://www.geogradguide.com/getting-into-grad-school/2018/6/2/contacting-a-prospective-graduate-adviser (last accessed 4 February 2019).

Smidt, S., 2018b, Writing a curriculum vitae: https://www.geogradguide.com/general-tasks/2018/6/3/writing-a-curriculum-vitae (last accessed 4 February 2019).

Stark, L., 2015, The Scientist's Conundrum: CV, Resume or Something In-Between: https://ocs.fas.harvard.edu/files/ocs/files/gsas-just-for-scientists-cvs-resumes.pdf (last accessed 4 February 2019).

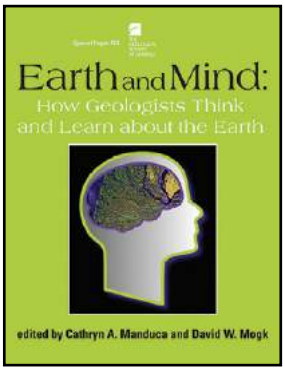
Toké, N.A., and Arrowsmith, JR., 2009, Selecting and Applying to Geoscience Graduate Schools: http://arrowsmith310.asu.edu/Lectures/Gradschool_ApplicationGuide_Toke_Arrowsmith.pdf (last accessed 4 February 2019).

Wilson, C.E., 2017, Directory of Geoscience Departments and Other Geoscience Organizations: Washington, D.C., American Geosciences Institute, 52nd edition.

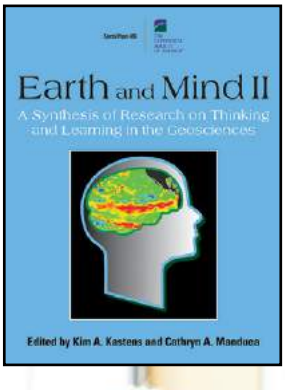
Manuscript received 10 April 2019
Revised manuscript received 2 Oct. 2019
Manuscript accepted 13 Feb. 2020

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)

Get your copy today at
https://rock.geosociety.org/store

THE GEOLOGICAL SOCIETY OF AMERICA®

Field Guide 57

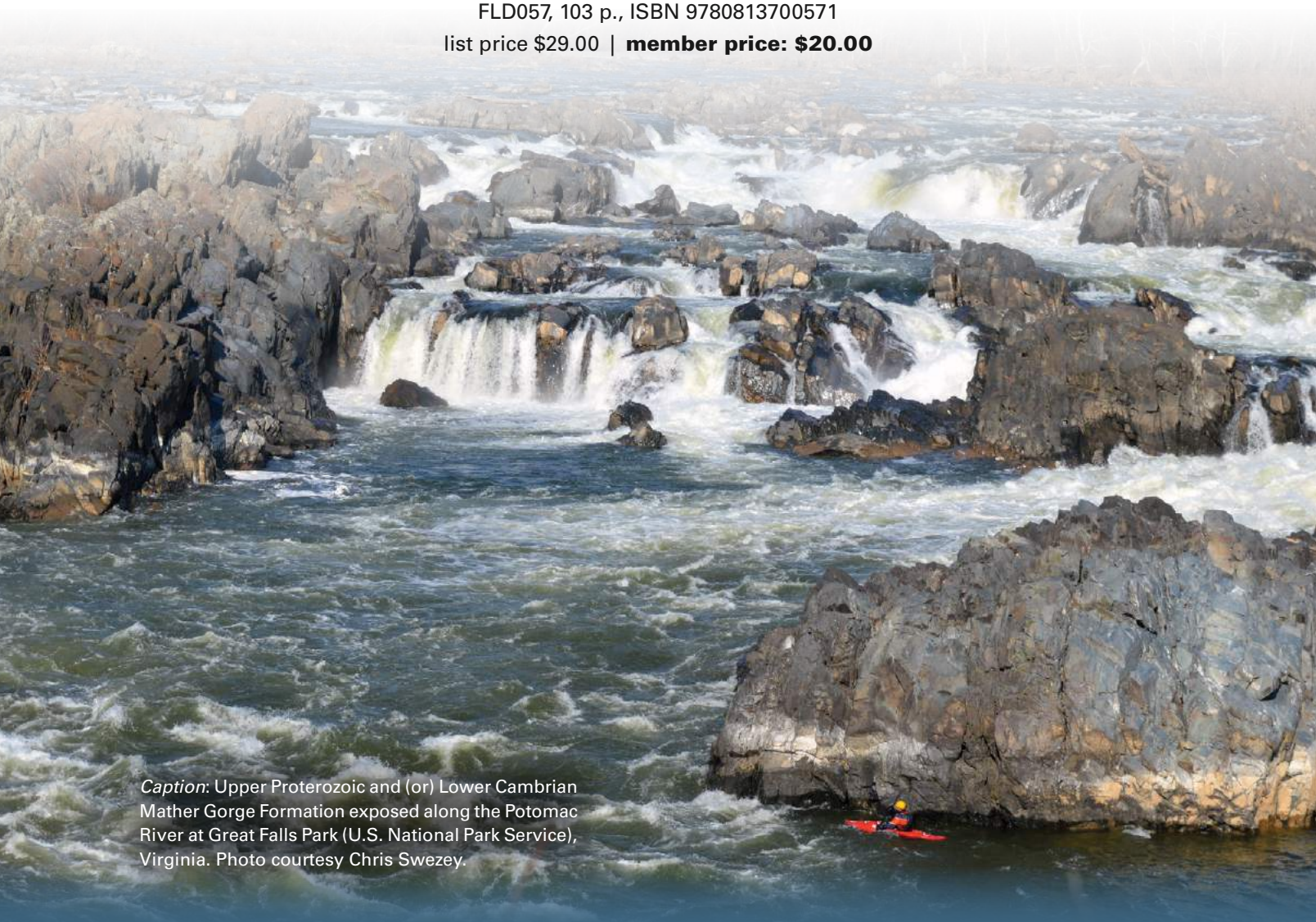
Geology Field Trips in and around the U.S. Capital

Edited by Christopher S. Swezey and Mark W. Carter

Prepared in conjunction with the Southeastern and Northeastern Sections Joint Meeting in Reston, Virginia, the four field trips in this guide explore various locations in Virginia, Maryland, and West Virginia. The physiographic provinces include the Piedmont, the Blue Ridge, the Valley and Ridge, and the Allegheny Plateau of the Appalachian Basin. The sites exhibit a wide range of igneous, metamorphic, and sedimentary rocks, as well as rocks with a wide range of geologic ages from the Mesoproterozoic to the Paleozoic. One of the trips is to a well-known cave system in West Virginia. We hope that this guidebook provides new motivation for geologists to examine rocks in situ and to discuss ideas with colleagues in the field.

FLD057, 103 p., ISBN 9780813700571

list price $29.00 | **member price: $20.00**



Caption: Upper Proterozoic and (or) Lower Cambrian Mather Gorge Formation exposed along the Potomac River at Great Falls Park (U.S. National Park Service), Virginia. Photo courtesy Chris Swezey.