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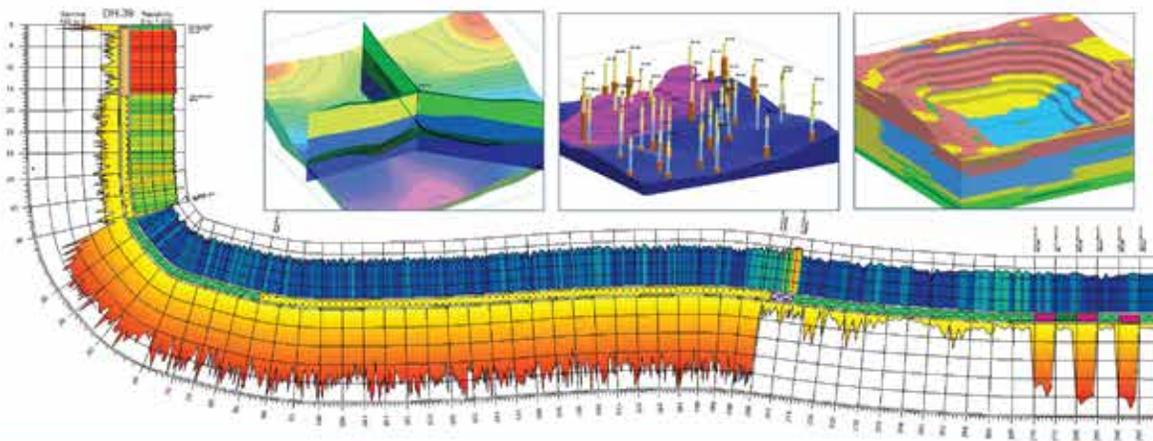
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Stromatolites and MISS— Differences between relatives



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Cover: Actively growing, subtidal stromatolites north of Carbla Point, Shark Bay, Western Australia. The individual build-ups are separated by areas of rippled, bare sand. The sand is not overgrown by microbial mat because the grains are in constant motion by waves and tidal currents. Photo by Stan Awramik. See related article, p. 4–9.



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Stromatolites and MISS—Differences between relatives

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ABSTRACT

Benthic microorganisms form highly organized communities called “biofilms.” A biofilm consists of the individual cells plus their extracellular polymeric substances (EPS). In marine and non-marine environments, benthic microbial communities interact with the physical sediment dynamics and other factors in the environment in order to survive. This interaction can produce distinctive sedimentary structures called microbialites. Binding, biostabilization, baffling, and trapping of sediment particles by microorganisms result in the formation of microbially induced sedimentary structures (MISS); however, if carbonate precipitation occurs in EPS, and these processes happen in a repetitive manner, a multilayered build-up can form—stromatolites. Stromatolites and MISS are first found in the early Archean, recording highly evolved microbial activity early in Earth’s history. Whereas the stromatolites show enormous morphologic and taxonomic variation, MISS seem not to have changed in morphology since their first appearance. MISS might be the older relative, but due to the lack of well-preserved sedimentary rocks older than 3.5 billion years, the origin of both stromatolites and MISS remains uncertain.

INTRODUCTION

Benthic microorganisms build a variety of organo-sedimentary structures (“microbialites”; Burne and Moore, 1987) of which the best known are stromatolites. Stromatolites are laminated microbialites (Figs. 1A–1C). Based on the appearance of the microbialite at the mesoscopic scale (= centimeter to millimeter scale; Kennard and James, 1986), microbialites also include thrombolites, dendrolites, and leiolites (Riding, 2000, 2011). Leiolites lack any observable features at the mesoscale; dendrolites have a mesostructure consisting of millimeter- to centimeter-scale “bushes”; and thrombolites have a clotted appearance, with clots often at the millimeter scale.

“Stromatolite” is the anglicized version of “Stromatolith,” a term coined by Kalkowsky (1908) that combines the Latin “stroma,” meaning layer or bed, and the Greek “lithos,” meaning rock. Kalkowsky (1908, p. 68) considered these structures to be the result of the life activity of “niedriger Pflanzen” (= lower plants). The layering that is so characteristic of stromatolites derives from the microorganisms themselves. Benthic microorganisms do not

colonize the sediment surface at random, but rather, trillions of microscopic cells assemble to form an organic layer covering the sedimentary surface like a coherent carpet. Indeed, in tidal flats, where such carpets reach centimeter thickness, one could peel off such a carpet, roll it up, and carry it away. Under the microscope, the microorganisms form a meshwork of filaments, rods, and cocci in a slimy matrix along with sediment and/or mineral particles; such microorganism-rich carpets therefore are called “microbial mats.” Although there are many different types of microbes involved in mat formation, filaments are most important in the construction of stromatolites. The iterative process of sediment trapping and binding, along with carbonate precipitation, forms layer upon layer of stacked microbial mats, producing structures that can reach meters in thickness and beds that can be traced for many kilometers. As such, stromatolites are defined as laminated microbialites produced by sediment trapping, binding, and/or precipitation as a result of the growth and metabolic activity of microorganisms, principally cyanobacteria (Awramik and Margulis, 1974).

However, there is a fifth group of microbialites that are generated by microbial mats: microbially induced sedimentary structures, or MISS (Noffke et al., 1996, 2001) (Figs. 1D–1F). MISS form on siliciclastic substrates with little if any carbonate or other mineral precipitation (Gerdes and Krumbein, 1987; contributions in Hagadorn et al., 1999; Schieber et al., 2007; and Noffke, 2009, 2010; and contributions in Noffke and Chafetz, 2012). MISS include a number of morphologies, though not as many as stromatolites, and range in lateral dimensions from millimeters to many kilometers. MISS are best observed both on sediment surfaces or bedding planes, whereas stromatolites are best observed in vertical section.

It is imperative to understand that the morphology of microbialites—be they stromatolites or MISS—is a result of an overlap of two factors: (1) the intrinsic control (the biology, or genotype and phenotype of the microbenthos that form the structure); and (2) extrinsic factors (size and nature of the sediment and the effect of hydraulic and sediment dynamics, such as waves and currents, etc.). While the shape of a stromatolite or MISS reflects the combined genetic information of all microorganisms in the microbial mat, the shape is also modulated, for example, by waves and currents. The surface of mat-overgrown sediment is the interface along which water movement affects the deposits. This interaction causes that interfacial surface to develop a topography. The topography of the surface (= stromatolite or MISS) is a reflection of the water movement, sediment, and biology of the mat along the interface. However, one of the puzzling features with regard to stromatolites is that there are some distinctive and elaborate morphologies that are restricted in time (e.g., Grey et al., 2011) and in

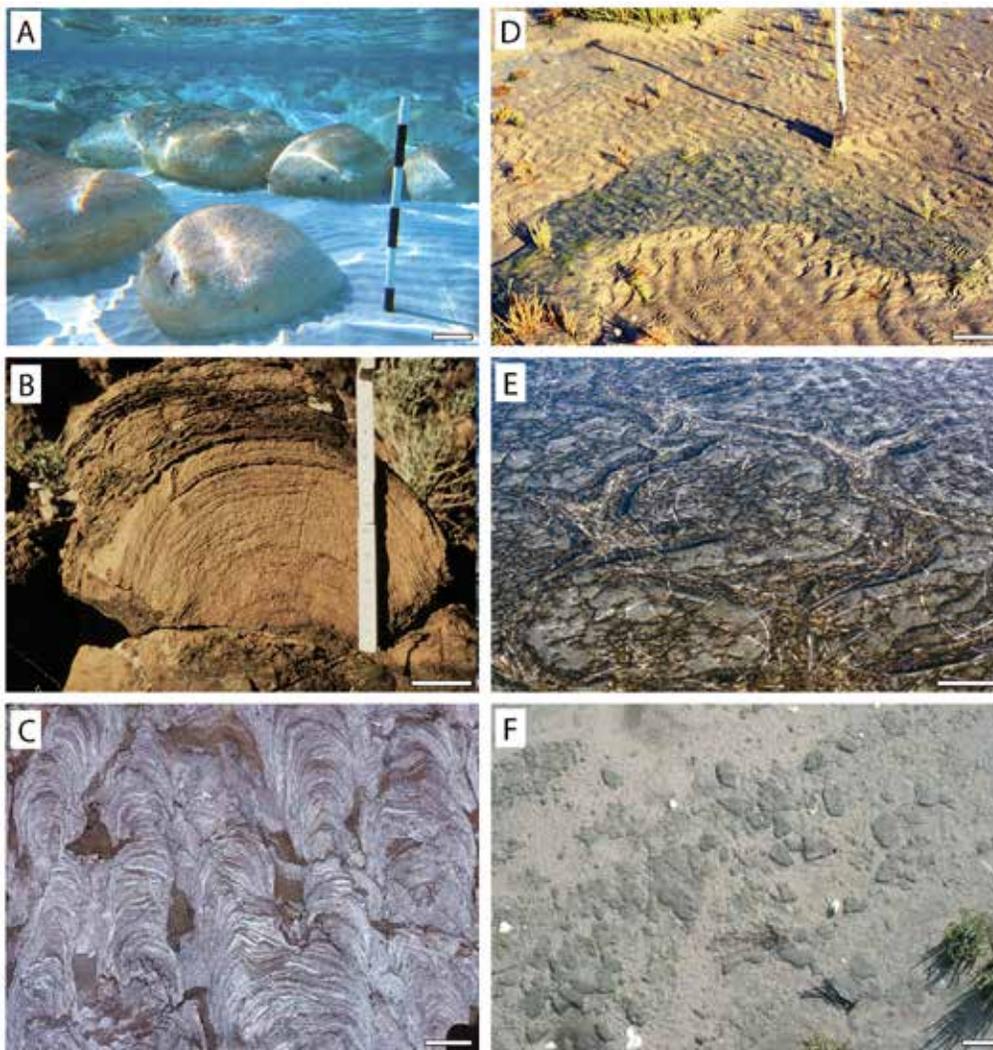


Figure 1. Modern examples of stromatolites and microbially induced sedimentary structures (MISS). (A) Stromatolites north of Carbla Point, Shark Bay, Western Australia. The stromatolites are distinct build-ups of carbonate with vertical relief. The living microbial mat layer colonizes the surface of the stromatolite. Bar scale: 10 cm. (B) Domical stromatolite displaying stack of laminae in vertical section, Brighton Limestone, Cryogenian, South Australia. Bar scale: 5 cm. (C) *Baicalia cf. rara* from the Shisanlitai Formation, Neoproterozoic, Liaoning Province, China. Bar scale: 2 cm. (D) Tidal flats of Mellum Island, Germany. Erosional remnants and pockets, sometimes called “the siliciclastic answer to stromatolites.” The microbial mats are planar, projecting only to a very minor degree from the sedimentary surface. Bar scale: 10 cm. (E) Coastal sabkha Bahar Alouane, Tunisia. Polygonal oscillation cracks form in microbial mats in semi-arid climate zones. Bar scale: 10 cm. (F) Tidal flats of Fishermans Island, Virginia, USA. Microbial mat chips scattered on sandy sediment. Bar scale: 5 cm.

all likelihood reflect time-restricted microbial communities interacting with sediment and hydraulics within the context of an evolving Earth system.

While we can observe how stromatolites and MISS form today, fossil examples of the biogenic structures are known from some of Earth’s oldest sedimentary rocks (Hofmann et al., 1999; Awramik, 2006; Noffke, 2010). And since their record covers almost 3500 million years, they provide an opportunity to track their occurrences and look for patterns that reflect both the evolution of microbes and the communities that built these structures, as well as the evolution of conditions on Earth with which the microbes interacted.

SPATIAL DISTRIBUTION OF STROMATOLITES AND MISS

There are two important divides that make it difficult to understand MISS and stromatolites: a carbonate/siliciclastic divide and a two-dimensional/three-dimensional divide. Although both stromatolites and MISS have a microbial mat as the principal constructional layer, MISS are generally surface phenomena (two-dimensional) and lack a substantial third dimension of stacked layers (mats). Stromatolites on the other hand have a pronounced third dimension, which is due to mineral precipitation and

cementation of microbial mats stacked one on top of another. Stromatolites form primarily in environments rich in calcium and bicarbonate, usually at low latitude in marine settings, but at much wider latitudinal settings in lakes, occurring even at 77.5 °S in perennial ice-covered lakes in Antarctica (Love et al., 1983). MISS occur in siliciclastic and evaporitic environments that are prevalent in low to high latitudes, both marine and terrestrial.

The most famous example of modern stromatolites occurs in the hypersaline Hamelin Pool of Shark Bay, Western Australia. Here, columnar and domical stromatolites, some over a meter in size, as well as smaller structures and a variety of microbial mats (e.g., smooth, blister, tufted), extend from the supratidal to subtidal zones (Jahnert and Collins, 2012). Shark Bay was often used as the modern analog to the rich record of ancient stromatolites, particularly in the Proterozoic (e.g., Walter, 1972). Early studies of the stromatolites interpreted them to be intertidal to supratidal (Logan, 1961), and this was used to interpret the setting of ancient stromatolites (e.g., Laporte, 1963). It wasn’t until 1974 that subtidal stromatolites were discovered (Logan et al., 1974). The supratidal forms (the columns that have become iconic) appear to be inactive due to a sea-level drop that exposed the columns (Reid et al., 2003). Hypersalinity and periodic, tidally induced, sediment

input and movement resulted in reduced metazoan activity, thus permitting the stromatolites to form. Such stressed marine conditions were thought to be the model for the occurrence of other modern examples (supratidal of Andros Island, Bahamas [Monty, 1972]; presence on sabkhas [e.g., Gerdes and Krumbein, 1987]). Later, subtidal stromatolites were discovered, which broadened the depositional setting for ancient analogs. After a subsequent major discovery of multi-meter size subtidal stromatolites forming in marine waters of normal salinity in the Exumas of the Bahamas (Dill et al., 1986), it became clear that other factors affect where modern stromatolites can form. For these subtidal Bahamian examples, environmental stress was involved, but it was the strong tidal currents sweeping across the carbonate platform that controlled initiation and growth of stromatolites. These currents kept carbonate sands highly mobile, and shifting subtidal dunes produced unfavorable conditions for metazoans and macroalgae. Studies on the modern stromatolites of the Bahamas show that the lamination results from two to three mat layers situated at the tops (roofs) of the build-ups. The microbial mat layers form one entity, one ecosystem, and seem to always occur together. Trapping and binding occurs; simultaneously, rapid mineralization of particles in extracellular polymeric substances (EPS) is possibly triggered by heterotrophic microbes. These processes lead to an upward growth of mat-covered sedimentary surfaces, and stromatolites emerge from the seafloor (Reid et al., 2003; Visscher et al., 2000; Andres and Reid, 2006; Dupraz et al., 2009, 2011). Unless buried by shifting subaqueous dunes, the stromatolites continue to grow upward, forming large columns and domes. Less heralded, but significant nevertheless, are spectacular examples of stromatolites forming in lakes, streams, and in spring deposits (e.g., Riding, 2000). Modern MISS develop along the rim of passive continental margins (e.g., the North Atlantic), where they mark shelf regions located within the photic zone, as well as sandy tidal flats, lagoons, and coastal sabkhas. MISS have been beautifully described from terrestrial settings as well, where microbial mats develop in interdune settings, along river shores, in and around lakes, and in swamps (e.g., Eriksson et al., 2000; Prave, 2002; examples in Schieber et al., 2007; Beraldi-Campesi et al., 2009; contributions in Noffke and Chafetz, 2012).

MICROBIAL MATS ARE BIOFILMS

Technically, microbial mats are biofilms—but of very large size (e.g., Neu, 1994). Biofilms (e.g., Davey and O’Toole, 2000) are highly organized microbial communities comprising many different microorganisms and can include cyanobacteria, bacteria, archaea, and eukaryotic unicells such as diatoms, fungi, etc. The word “biofilm” expresses nicely how those microbial communities look: a thin covering of slime with cells in it. However, what appears like an assemblage of randomly distributed coccoid, filamentous, rod-shaped, and you-name-it microbes is in fact a highly organized organismic arrangement (e.g., Donlan and Costerton, 2002; Stoodley et al., 2002). The microorganisms communicate with each other and move into positions that allow them to interact most efficiently with their neighbors. Metabolic activity is coordinated to ensure the most effective harvesting of nutrients or—in the case of photoautotrophic microbes—light; metabolic products or toxins are actively removed from the biofilm using channels along which the unwanted matter is flushed

out with circulating water currents; “decisions” are made by quorum-sensing, involving all members of the biofilm (Decho et al., 2011); in short, a microbial biofilm acts like a societal community rather than just an ecosystem (e.g., Donlan and Costerton, 2002; Stoodley et al., 2002; Decho et al., 2011). The communication and cooperation supports the survival of the biofilm and all members within.

An important component of biofilms and microbial mats is the EPS (Decho et al., 2011). These are highly adhesive mucilages that many microorganisms secrete. The amount of EPS can be so high that the cells literally are embedded in the EPS. EPS are composed primarily of long-chained polysaccharide biomolecules and acidic components. The molecules are complex and arranged in certain ways to offer structural support to the biofilm, to contain the microbes, to allow channels to form where gas and fluids migrate, to absorb nutrients, and to buffer salinity ranges. EPS can also bind calcium ions and, along with bicarbonate in the system, are important for carbonate precipitation (Dupraz et al., 2009). A basic function of EPS is to provide a wobbly, but physically and chemically highly resistant biostructure (Decho et al., 2011; Stoodley et al., 2002).

FUNDAMENTALS OF STRUCTURE FORMATION

The processes involved in the formation of MISS and stromatolites are involved and complex. We researchers are just scratching the surface of a fully integrated understanding. A fundamental problem for benthic life is to withstand hydraulic and sediment-dynamic reworking. Organisms that colonize the surface of aquatic deposits must cope with turbulent wave action, entrainment by currents, abrasive saltation, or even burial by mineral grains. How can microbenthos escape turbulence, erosion, and deposition? Microbial mats that form MISS and stromatolites share some fundamental microorganism-sediment interactions. In response to sudden erosive shear caused by water motion, the EPS of a microbial mat change their molecular structure within a fraction of a second (e.g., Stoodley et al., 2002; Paterson et al., 2010). The microbial mat is not eroded, nor are mineral grains ripped-off that are enclosed within the microbial mat matrix. Such sediment fixation by the biofilm or mat is called biostabilization; it reduces the effect of erosion.

During deposition of sedimentary particles, microorganisms can baffle the water current, causing sedimentary particles to be deposited; the microbially triggered fall-out takes place in currents of velocities that otherwise (without the presence of microbes) would hold the sedimentary particles in suspension. The grains are trapped in the tangle of filaments and glued to the mat surface by the EPS. Baffling and trapping is a microbially mediated type of deposition.

Baffling, trapping, and biostabilization form a dynamic window for the microbial mats to establish themselves and to withstand dynamic environmental stresses. Basically, the microbial mats broaden (bioengineer) this window by reducing erosion and by controlling depositional rates (Noffke, 2010). Studies on MISS show that binding is neither biostabilization (which is triggered by erosion), nor is it baffling or trapping (which is triggered by deposition). Binding is the active formation of a mat network by the cooperative effort of microbial cells during times of sedimentary and hydraulic quiescence. Grains trapped during a preceding depositional event

can be rearranged in the mat matrix, sometimes to channel light into deeper portions of the microbial mat. Growth (biomass enrichment by cell replication and EPS production) is taking place, if nutrients are readily available and supplied in abundance.

Do these physical microbe-sediment interactions cause MISS and stromatolites? In the case of the MISS, yes. But in stromatolites, another structure-forming process is added: a chemical process. In stromatolite-forming microbial mats, mineral particles (commonly carbonates) are found forming in the EPS. Laboratory studies show that the particles precipitate in the organic matrix of the EPS; the EPS provide micro-domains, where the architecture of biomolecules offers nucleation sites for carbonate precipitation that can be initiated by the activity of heterotrophic microbes (Dupraz et al., 2009).

In summary, the bulk of a stromatolite is initially formed by biomass, trapped and biostabilized sediment, plus precipitated minerals; later, the biomass is almost completely degraded. Due to the mineral precipitation in their EPS, stromatolites tend to grow upward, whereas MISS remain planar (Fig. 2).

MISS and stromatolites finally become fossils, because the organic matter of the original microbial community lithifies in situ (Krumbein et al., 1979; Schule-Lam et al., 1996; see review in Noffke, 2010). Heterotrophic members of the microbial mat (biofilm) mineralize organic matter. By mineralization in this context, we refer to the step-by-step breakdown of large biomolecules into smaller and smaller chemical compounds and ions, some of which become available to heterotrophic microorganisms, while others, such as the ions, react with the ions of the surrounding water, and mineral precipitates form (Visscher and Stolz, 2005). These initial precipitates in biofilms are usually hydrated. During successive diagenetic alteration, the “amorphous” phases recrystallize into mineralic substance with a crystalline structure often acting as a cement. Dependent on the water chemistry, the structures may include pyrite, aragonite, calcite, dolomite, hematite, titanium oxide, and other minerals. For stromatolites, the nearly penecontemporaneous mineralization of the mats with carbonate supports the preservation. Modern stromatolites may include aragonite and calcite (Reid et al., 2000) or even dolomite (Vasconcelos and McKenzie, 1997) and gypsum (Douglas et al., 2008).

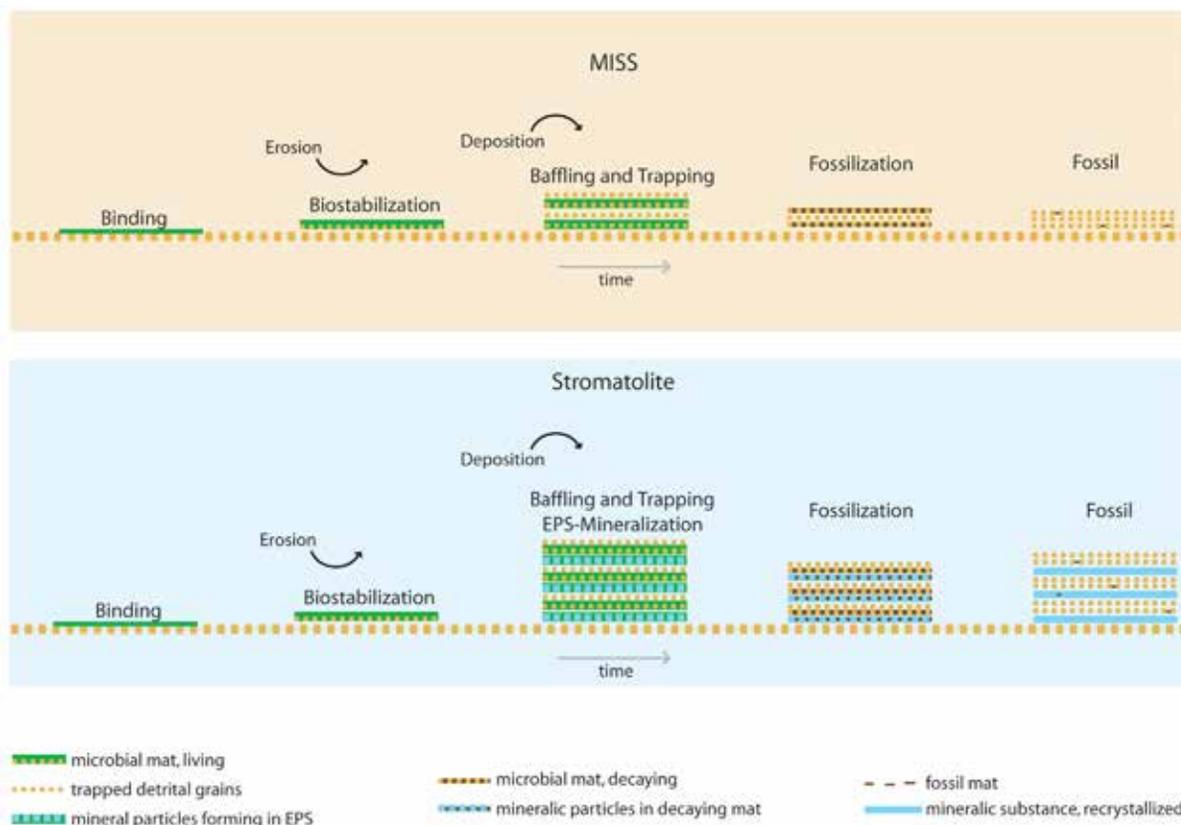


Figure 2. Formation of microbially induced sedimentary structures (MISS) versus stromatolites. Top: The microbial mat overgrows the sedimentary surface and incorporates some of the sedimentary grains. The process of individual microbes actively assembling to form a microbial mat fabrics is called “binding.” During episodes of erosion, the microbial mat biostabilizes its substrate; during episodes of deposition of sediment, baffling and trapping accumulates sedimentary particles on the microbial mat surface. Bottom: In stromatolites, another process is added. Here, mineral particles (usually carbonates) form within the extracellular polymeric substance (EPS-mineralization). In the formation of MISS, the processes of binding, biostabilization, baffling, and trapping elevate the mat-covered sedimentary surface somewhat; the amount of precipitated minerals typical for stromatolites contributes significantly to their positive topography. Later, the MISS- or stromatolite-forming microbial mats fossilize—that is, the organic matter is replaced by minerals. In stromatolites, however, the EPS-precipitated mineral particles now recrystallize and contribute to the layering (lamination) characteristic for most stromatolites. MISS commonly lack this lamination. Note that there are also stromatolites predominantly formed by mineral precipitation with no or very minor detrital sediment in them.

TEMPORAL DISTRIBUTION OF STROMATOLITES AND MISS AND THEIR SIGNIFICANCE

Both MISS and stromatolites are among the oldest evidence of life on Earth. Their temporal distribution ranges from the Early Archean to the present day. It must be pointed out that establishing the biogenicity of the most ancient MISS and stromatolites is not straightforward and relies primarily on multiple lines of evidence and comparisons with modern and other fossil analogs (Awramik and Grey, 2005). The occurrence of many, time-restricted, distinctive morphologies that have been given binomial names makes stromatolites helpful tools in biostratigraphic zonation, particularly in the Proterozoic (Cloud and Semikhatov, 1969; Grey et al., 2011). More than 1,100 taxa of stromatolites have been described in the literature. Stromatolite taxa are established based on a combination of features, including the overall shape, the nature and geometry of laminae, and lamina microstructure. These named stromatolites have a “morphological theme,” meaning there is similarity among nearest neighbor stromatolites in the biostrome or bioherm. Stromatolites show greatest morphological diversity in the Proterozoic, particularly the late Mesoproterozoic (Awramik and Sprinkle, 1999) (Fig. 3). This diversity pattern likely reflects unique combinations of microbial biology (genetics), interactions with non-microbial mat organisms, and conditions on Earth.

Prokaryotes that build microbialites exist in biofilm cooperatives, not as solitary organisms. Although many can survive outside of the community, it is the cooperative that they create in which they increase their survival possibilities, strategically manipulate their environment, and develop survival strategies by chemical communication and quorum sensing (Noffke et al., 2013). Chemical clues for gene expression have been recognized in bacteria in biofilms that change the structure of the biofilm (Davies et al., 1998). Therefore, it is not the individual microbe that controls structure formation; it is the entire biofilm and all genetic information and resulting phenotypes that form that complex consortium. At some point in the evolution of prokaryotes (bacteria and archaea), EPS caused the precipitation of mineral particles. Stromatolites were born. Structures we would call stromatolites were described as early as the sixteenth century (Krumbein et al., 2003) and have been given binomial names since 1883 (Hall, 1883). MISS seem not to have changed in morphology over time. Erosional remnants and pockets, polygonal oscillation cracks, and mat chips (Figs. 1D–1F) and a multitude of other MISS are nearly identical from the early Archean to today. MISS might be Earth-historically older than stromatolites, but because the MISS-producing biofilms never evolved EPS-controlled mineral precipitation, they never produced the diversity of their relatives. However, the oldest stromatolites and MISS infer that the highly organized, cooperative way of life in prokaryotes had already evolved by the time of Earth’s oldest sedimentary record.

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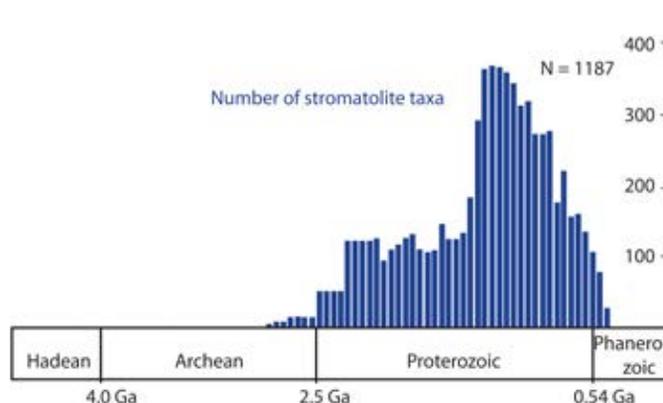


Figure 3. Diversity of taxa (“forms,” in the literature, which are roughly equivalent to form species) of stromatolites through time. This graph plots the number of forms per 50-million-year interval and is redrawn from Fig. 2 in Awramik and Sprinkle (1999) using the same dataset. The high diversity of stromatolites during the Mesoproterozoic, 1600 to 1000 Ma, is remarkable.

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Suzanne Mahlburg Kay

PRESIDENTIAL WELCOME

On the occasion of the 125th Anniversary of The Geological Society of America, we invite you to join us at the annual meeting of the Society in Denver, Colorado, USA, from the 27th to 30th of October. We will commemorate the anniversary of the organizational meeting of the Society at Cornell University in Ithaca, New York, USA, on 27 December 1888. At that time, 13 of the 100 prominent geologists who had voted in August 1888 to form a geological society met to formalize the American Geological Society and elect James Hall as the first president. This was followed by the first meeting with technical sessions in 1889, the name was changed to the Geological Society of America, and the decision was made to schedule annual meetings after the summer field season, as is still done today. By the 28–30 December 1932 meeting at Harvard University in Cambridge, Massachusetts, USA, more than 400 prominent geologists met to listen to scientific presentations, attend a banquet with a presidential address, participate in a “smoker,” go on field trips, and discuss educational and outreach themes.

As in those days, and as the Society has grown to nearly 26,000 members, a primary objective of the GSA remains the organization of an annual meeting at which the most recent advances in the geosciences are celebrated, awards are given, and colleagues join together for scientific discussions and fellowship. At this year’s 125th anniversary meeting, we will particularly emphasize the accomplishments of the geological sciences and the Society over the past 50 years as we look to the future. Some highlights include a record number of technical and Pardee sessions as well as special events such as the presentation of the new symphony, *Formations*, by the Boulder Philharmonic and a gala black-tie dinner. A 125th anniversary wine and other traditional and special events will also be part of the celebration.

As a Society, we look forward to a future in which GSA members continue to explore and share their understanding of the fundamental questions of the geosciences through curiosity and societally driven research on a national and international level. In this way, we share the goal of also making advances in understanding global resources, geohazards, and the global environment.

Suzanne Mahlburg Kay, Cornell University

GSA ANNUAL MEETING & EXPOSITION
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Mount Sneffels near Ridgway and Telluride; photo by Matt Inden/Miles. Used with permission from Colorado Tourism Office.

<http://community.geosociety.org/2013AnnualMeeting/>

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The GSA Foundation is proud to continue its work in support of GSA and its programs.

*Denotes in-kind contribution

2013 GSA MEDAL & AWARD RECIPIENTS



Steven M. Stanley



Richard W. Carlson



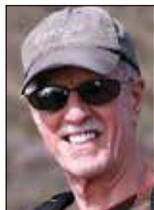
Naomi E. Levin



Scott D. Sampson



Reginal W. Spiller



Jon Olsen



Stephen G. Pollock



Ginger Williams



Whitney M. Behr



Edward Burtynsky



Peter A. Scholle

PENROSE MEDAL

Steven M. Stanley, University of Hawaii

ARTHUR L. DAY MEDAL

Richard W. Carlson, Carnegie Institution of Washington

YOUNG SCIENTIST AWARD (DONATH MEDAL)

Naomi E. Levin, Johns Hopkins University

GSA PUBLIC SERVICE AWARD

Scott D. Sampson, Denver Museum of Nature & Science

RANDOLPH W. "BILL" AND CECILE T. BROMERY
AWARD FOR THE MINORITIES

Reginal W. Spiller, Azimuth Energy LLC

GSA DISTINGUISHED SERVICE AWARD

Jon Olsen, The Geological Society of America
Stephen G. Pollock, University of Southern Maine
Virginia (Ginger) Williams, The Geological Society of America

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Peter A. Scholle, Scholle Petrographic LLC

GSA's 2013 HALL of FAME:

Celebrating 125 Years of Geoscience

Pause in the bustle of the Annual Meeting to visit the Hall of Fame in the Convention Center and acknowledge your well-deserving and hard-working colleagues, mentors, and students. Take a moment to watch our honorees scroll by on this digital display and be sure to congratulate these colleagues or students when you see them!

ACTION Items

Registration **Early registration deadline:** 23 Sept. **Cancellation deadline:** 30 Sept.

REGISTRATION FEES (in U.S. dollars)	Early (June–23 Sept.)		Standard & On-Site (after 23 Sept.)	
	Full Mtg	One Day	Full Mtg	One Day
Member professional	\$345	\$225	\$425	\$255
Member professional (70+ years old)	\$260	\$160	\$345	\$185
Nonmember professional	\$460	\$300	\$530	\$320
Member student	\$115	\$75	\$150	\$85
Nonmember student	\$155	\$99	\$190	\$110
K–12 professional		\$55		\$65
High school student		\$40		\$40
Guest or Spouse		\$85		\$90
Field Trip or Short Course only		\$40		\$40
Low Income Country*		50%		50%

* GSA offers a 50% discount on annual meeting registration fees for individuals who are both residing in and are citizens of “Low or Low-Middle Income Economies” as classified by the World Bank. Online registration is not available for “Low or Lower Middle Income Economy” registrants. Please fill out a printed version of the registration form (see the meeting website) and mail it to GSA, 3300 Penrose Place, Boulder, Colorado, 80301, USA; or FAX to +1-303-357-1070.

WHEN YOU REGISTER, DON'T FORGET TO...

- Register for tours, special events, field trips, and workshops;
- Apply for the Student Travel Grant (by 23 September);
- Help a member participate in the GSA Annual Meeting by donating to the Student Travel Fund on your registration;
- Make your hotel reservation;
- Book your travel; and
- Invite a colleague to attend!

GREENING OUR MEETINGS

In furtherance of GSA's mission to promote Earth stewardship, GSA works continuously to minimize the environmental impacts associated with the planning and execution of all our meetings. Your participation is a key component in this effort—learn more via the Sustainability link under the About tab for the annual meeting—including tips for green(er) travel to and during the meeting.

HOUSING

Deadline: 30 Sept.

Make your reservation prior to 30 Sept. to guarantee the GSA group rates. After 30 Sept., continue to work with **Visit Denver/GSA Housing Bureau**. We will assist you in making a hotel reservation but cannot guarantee the rates.

Reservations can be made online, by phone, or by fax. Making a reservation online provides you with the most up-to-date availability

and an immediate confirmation. The GSA group rates include Internet in the guest rooms—see the GSA website for details.

HOW DOES GSA PROTECT MY ROOM RESERVATION?

We sign contracts with each hotel in the official GSA room block. Each hotel agrees to provide a room for each reservation made through Visit Denver/GSA Housing Bureau. In the event the hotel is unable to honor a reservation, the hotel must make the following arrangements:

1. Provide you with alternate accommodations at a comparable hotel, first using hotels that are part of our block;
2. Pay the first night's room and tax at the comparable hotel AND provide an amenity and note of apology from the hotel's general manager upon your return to the hotel;
3. Pay the transportation costs to the comparable hotel as well as return to the hotel the following day; and
4. Pay transportation costs for two (2) round trips per day to and from the comparable hotel and the convention center.

Your responsibility is to arrive on your scheduled arrival date. We advise you to double-check the arrival date on your hotel reservation at least one week before you leave to make sure it is the correct date. If you do not show up on the date of your scheduled arrival, then the hotel will release your room and you will be charged one night's room/tax. If you have travel delays and cannot arrive on your scheduled arrival date **contact the hotel directly** to let it know of the change.

GSA Foundation's 2013 **SILENT AUCTION**

This year's Silent Auction is joining GSA's 125th Anniversary GIVE 125 challenge, and we need your help to reach our goals! We're seeking items that broadly pertain to the geosciences. *Proceeds will support "On To the Future," a GSA initiative to bring 125 students from underrepresented groups to the annual meeting.*

- Help us build our "well-equipped geoscientist" area, from head to toe, classroom to field—with tools, field supplies, gear, software;
- Add to the collection of geologic specimens;
- Contribute to our selection of wine & wine accessories;
- People always appreciate gift certificates (e.g., Amazon, special events, trips, restaurants);
- GSA meeting attendees love books; and
- Geo-gifts, jewelry, and apparel donations are great for our pre-holiday meeting.



To make a donation, or if you have any questions, please contact Ann Crawford, acrawford@geosociety.org; +1-800-472-1988, ext. 1053, or +1-303-357-1053.



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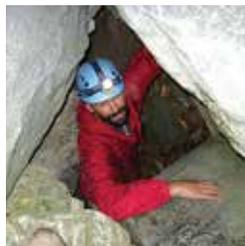
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- Contact with thousands of students soon to be entering the workforce;
- Visibility throughout the meeting, onsite and beyond; and
- Awareness of your company as a partner supporting GSA's programs and doing business in our members' communities.

NEW opportunities include the 125th Anniversary Gala, continuing our year-long celebration, and the Geoscience Career Program, connecting industry and students.

For a full menu of sponsorship opportunities visit www.geosociety.org/meetings/2013/ or contact Debbie Marcinkowski at +1-303-357-1047 or dmarcinkowski@geosociety.org for help in selecting the best way to showcase your company.



www.geosociety.org/meetings/2013/documents/13GSA_sponsorship.pdf

Things to **SEE & DO**

SATURDAY ICEBREAKER

5–7 p.m., Colorado Convention Center

Join your colleagues and friends on Saturday evening, 26 Oct., to catch up, plan your week ahead, and enjoy music, a special label beer, 125th Anniversary wine, and fun!

EXHIBITS OPENING RECEPTION

Sun., 27 Oct., 5–7 p.m., Colorado Convention Center, Halls E&F

Enjoy a special label beer or glass of 125th Anniversary wine while you explore the 2013 GSA Exhibits, and don't forget to find those special gifts, giveaways, and unique GSA 125th Anniversary items!

SUBARU OUTDOOR LIFE LECTURE

Mon., 28 Oct., 6:30–7:30 p.m.

Always one of the highlights of the meeting—this is your chance to hear from one of the most fascinating people in the world of geoscience and adventure. Previous years have featured Julie Brigham-Grette, who spoke about El'gytgyn Crater Lake; Ann Bancroft, the first known woman in history to cross the ice to the North and South Poles; Conrad Anker, who spoke about the film *The Wildest Dream: Conquest of Everest*; and Yvon Chouinard, author of *Climbing Ice* and founder and owner of Patagonia Inc. This year's lecturer has yet to be confirmed as of press time but is sure to live up to the standards set by previous speakers.

GUEST PROGRAM

Is your guest looking for something to do while you attend sessions? For a small fee, he or she can register to receive guest privileges, including the Guest Hospitality Suite, with complimentary refreshments, entertaining and educational seminars, and a local expert with information about the area.

LOCAL TOURS & ACTIVITIES

Need a break? Join your guest at one of these local tours. Fees for these events cover the costs of professional tour guides/facilitators, transportation, admission, materials, and gratuities. For event descriptions and more information, check out the meeting website.

101. **Georgetown Loop Railway:** US\$94; Sun., 27 Oct., 9:15 a.m.–3:45 p.m.
102. **Mine & Wine Tour:** US\$92; Mon., 28 Oct., 12:30–5 p.m.
103. **Watercolor & Wine:** US\$45; Mon., 28 Oct., 2:30–4:30 p.m.
104. **Bad Boys and Bawdy Girls:** US\$56; Tues., 29 Oct., 1–4 p.m.
105. **Best of Boulder Tour:** US\$100; Wed., 30 Oct., 9 a.m.–3 p.m. Includes lunch; please check the box on your online registration and let us know of any special dietary needs.
106. **Jewelry Making Workshop:** US\$58; Wed., 30 Oct., 9:30 a.m.–noon.

HALL OF MAPS

As part of GSA's 125th anniversary celebration, the Society will feature a map exhibit, including notable historic maps, state survey maps, and modern digital displays. Early geologic maps from Smith, Lyell, King, Hayden, Hitchcock, and more will be reproduced at their original sizes, giving you a look back in time at the origin and evolution of geologic mapping. State surveys from around the country will be providing geologic maps that showcase significant geologic features and the changes in mapping technology and geologic understanding through time. On the digital side, modern displays will showcase the latest in digital mapping techniques, including LiDAR, 3-D and 4-D maps, and Google map overlays.



DO YOU KNOW DENVER?

Many of Denver's best neighborhoods are located walking and/or biking distance from the convention center. Find your favorite at www.denver.org/metro/neighborhoods, plus see below for a few recommendations:

Improvements have transformed 14th Street into Denver's "Ambassador Street," welcoming visitors to the downtown area with an enhanced pedestrian experience. The Colorado Convention Center, the Theater District, and many new restaurants are located in the heart of "Ambassador Street." Some of the restaurants that you will notice almost as soon as you walk out of the convention center are Pizza Republica, Row 14, and Crave Dessert Bar & Lounge. Just around the corner from Crave you will find Snarf's and Organic Pizza Company. The Snarf's sandwich shop has long been a Boulder lunch fixture and has grown to include locations in Denver, Chicago, and St. Louis. The Organic Pizza Company is another native small business that focuses on organic and local products.

If you feel like exploring on a B-Cycle bike, peddle over to Denver's LoHi (Lower Highlands) and CPV (Central Platte Valley) neighborhoods. The neighborhoods are easily accessible thanks to the three bicycle- and pedestrian-only bridges connecting downtown Denver to the northwest neighborhoods (Millennium Bridge, Platte River Bridge, and Highland Bridge). You will not be disappointed with the parks, restaurants, and boutique shopping. You can even stop by the REI Denver flagship store. (Cab fare from downtown to Highlands is US\$8–US\$12.)

Staying in **TOUCH**

GSA'S CONNECTED COMMUNITY

GSA launched its new Connected Community for members and friends this year. GSA's Connected Community empowers Annual Meeting attendees to easily interact and stay connected before, during, and after the Annual Meeting. Your meeting registration automatically makes you a part of this group.

With the Connected Community you can:

- Search and connect with other attendees you meet so that you can **stay in touch**;
- Organize meet-ups and activities;
- Join in discussions and **keep topical conversations going beyond the meeting**;
- **Join groups** of like-minded people who want to work together to improve and innovate;
- **Post your presentations, pictures, documents, videos, or other content** that you feel will help other participants in the GSA Community;
- **And More...**

We encourage you to activate your profile now so others can connect with you as the registration list grows. Learn more on the meeting website under the Community and Help tabs. If you are logging in to GSA's Connected Community for the first time, please follow the online instructions on how to log in.

As GSA members and friends transition to using the Connected Community, we still have the following old stand-bys available:

ROOMMATES & RIDES

Meet new people, coordinate your schedules, and plan activities while in Denver. You can even save money by sharing travel and lodging expenses.

It's easy and it's free! Go to community.geosociety.org/2013AnnualMeeting/Community/BulletinBoard/ to get started.

PERSONAL SCHEDULER

Simplify your time during the annual meeting by taking advantage of the free Personal Scheduler. The Personal Scheduler is designed so that you may easily browse all events scheduled for this meeting, create your own schedule of events, record notes, and download to your mobile device or print for easy reference. This is a simpler version of the mobile meeting app, with fewer features.

MOBILE MEETING

Everything you need to know about the meeting (updated in real time) at your fingertips!

Native App Version supports:

- Android version 2.3.3 and above;
- iOS version 5 and above;
- Runs on Android tablets 3.0 or higher and on iPad.

Don't have a smartphone?

The web version of the app will run on your computer. Please visit www.geosociety.org/mobilemeeting/ for more information.

View the entire Technical Program—Locate the talk you want to hear and add it to your calendar.

Exhibits—See who is exhibiting and find them on the floor plan.

Activities—Select events to attend and add them to your phone's calendar.

Calendar—Receive important alerts and reminders.

Tips

- After you install the app, open it, and data will start downloading.
- Download time is affected by your reception, signal strength, and the type of mobile device.
- Once the app is installed on your phone it is native—so you can browse the information in airplane mode.
- The app will automatically download any new or changed data each time you open it.
- The calendar events are added to the device's calendar

SOCIAL MEDIA

Blog Roll

Let everyone know about your meeting-related blog posts! Add your info to the Blog Roll at <http://bit.ly/19FsxPo>. Also, check out GSA's blog, *Speaking of Geoscience*TM, at <http://geosociety.wordpress.com>, and learn how YOU can add to the discussion.



Facebook

Check out GSA's vibrant Facebook page and join more than 20,000 fans worldwide at www.facebook.com/GSA.1888.



LinkedIn

GSA manages an active LinkedIn group to help you network and stay connected with your professional peers. Go to LinkedIn.com and search for "The Geological Society of America."



Twitter

GSA is [@geosociety](https://twitter.com/geosociety) on Twitter. Get up-to-the-second meeting news by joining this global audience of more than 9,000 geoscientists, students, agencies, and geoscience companies who follow GSA and by watching this year's meeting hashtag, #GSA125. Let others know you are tweeting about the meeting by adding your twitter "handle" to our Twitter Roll at <http://bit.ly/17YidVI>. When you tweet the meeting, your message helps create a rolling narrative and stretches the meeting's virtual boundaries.

STUDENTS!

INFORMATION AND ACTIVITIES

Please be sure to check out the students Web page, <http://community.geosociety.org/2013AnnualMeeting/Conference/StudentInfo>, for the most up-to-date information on events scheduled for YOU! Also, see this issue's "Careers & Mentoring" articles, p. 22–23.

STUDENT VOLUNTEERS

GSA student members: Get free meeting registration when you volunteer for ten hours **PLUS** a US\$25 stipend for every five hours worked **PLUS** get an insider's view of the meeting! Sign up on the meeting website (click on Conference, then Student Info) and then register for the meeting as a student volunteer.

GRANT ASSISTANCE

Need help getting to the Annual Meeting? Don't forget to apply for a grant from a GSA Section or Division! Various groups are offering grants to help defray your costs for registration, field trips, travel, etc. Check out the meeting website for application and deadline information. Note: Eligibility criteria and deadline dates may vary by grant.

BEST STUDENT GEOLOGIC MAP COMPETITION

Submissions accepted through **6 Sept.**

Please join us at the inaugural Best Student Geologic Map Competition. The competition will highlight student research from around the world that utilizes field mapping and the creation of geologic maps as a major component. The map display will begin on Tues., 29 Oct., 5–6:30 p.m. in the Poster Session area of the Exhibit Hall. Cash bar provided. Submission instructions, awards, and map judging criteria are online.

A NIGHT AT THE MUSEUM: A RECEPTION FOR STUDENTS

Tuesday, 29 Oct., 7–9:30 p.m., Denver Museum of Nature & Science. Buses leave from Lobby F of the Colorado Convention Center at 6:45 p.m. and return at 9:45 p.m. Fee: US\$10.

Enjoy an evening with your peers at the Denver Museum of Nature & Science. The museum is opening its doors for a fun-filled evening just for students. Explore the Prehistoric Journey, Space Odyssey, and Gems and Minerals exhibits, and mingle in the Southeast Atrium area. Light hors d'oeuvres and a cash bar available. Be sure to register for "Night at the Museum" when completing your meeting registration online.

PRESIDENT'S STUDENT BREAKFAST RECEPTION



Suzanne Mahlburg Kay

When: Sunday, 27 Oct., 7–8:30 a.m.

Location: Colorado Convention Center

Sponsored by



Hosted by GSA



GSA President **Suzanne Mahlburg Kay** invites all students registered for the meeting to attend a free breakfast buffet sponsored by ExxonMobil Corporation. **Sue** and members of GSA leadership, along with ExxonMobil staff members, will be on hand to answer questions and address student issues. Take this opportunity to network with fellow students, meet the officers of GSA, and recognize the ExxonMobil Field Camp Scholar Awardees!

CAMPUS CONNECTION

Bringing Students and Schools Together

GSA's Campus Connection (formerly Graduate School Information Forum) provides an excellent opportunity for students to meet face to face with representatives from top U.S. geoscience schools. Last year, 68 schools participated in the four-day event, saving students time and travel expenses and giving the schools a chance to meet with some of the best student geoscientists in the world in a relaxed, informal setting. For a preliminary list of schools, see p. 43.

The new Campus Connection will be located in the Exhibit Hall. The Poster Sessions will be on one side and just prior to entering the educational area, there will be another new feature: The Quad—a lounge especially designed for GSA's student participants. As on most campuses, The Quad will be a gathering point for networking opportunities. Check this out online on the Annual Meeting Expo page.

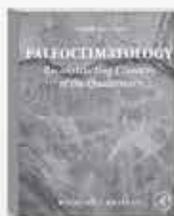
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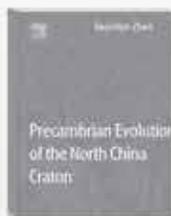
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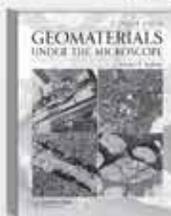
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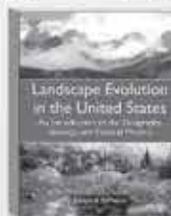
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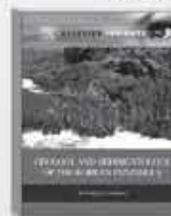
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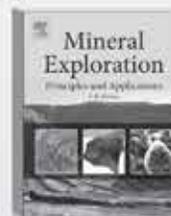
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Lone Star Rising Scholarship

A national scholarship for women seeking to enter the workforce in a geoscience-related field, up to \$3000. For more information, go to www.awg.org/eas/scholarships.htm

Applications due: Oct. 31, 2013.

Happy 125th Anniversary GSA!

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Happy 125th Anniversary GSA!



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Careers & MENTORING

K-12 NETWORKING & EDUCATIONAL EVENTS

Field Trips

- Trip 415. **Discovering Treasures for Educators: Behind the Scenes in Earth Sciences at the Denver Museum of Nature & Science.**
- Trip 418. **Ancient Denvers: A Journey through the Front Range's Geologic History.**

Short Courses

Attend one (A or B) and get the second FREE (C or D)! See the meeting website for details.

- 520A. **Teaching Controversial Issues 1: Climate and Energy.**
- 520B. **Yellowstone National Park as a Hotbed for Inquiry—For Teachers.**
- 520C. **Teaching Controversial Issues 2: Evolution of Life and Earth.**
- 520D. **Introduction to Critical Zone Science and Observatories.**

GEOLOGY IN INDUSTRY

This is NOW part of GSA's Geoscience Career Program (see p. 23). Sun., 27 Oct., 11:30 a.m.–1 p.m.

Undergraduate and graduate students will enjoy a FREE lunch with a panel of mentors representing various industries. These mentors will answer questions, offer advice about preparing for a career in industry, and comment on the prospects for current and future job opportunities with their companies.

WOMEN IN GEOLOGY

Sun., 27 Oct., 5–6:30 p.m.

Addressing key issues faced by women in geology, this informal gathering begins with brief remarks by women geoscientists, followed by time for networking, sharing ideas, and getting to know other women geoscientists and geosciences educators. Appetizers provided.

GEOLOGY IN GOVERNMENT

Mon., 28 Oct., 11:30 a.m.–1 p.m.

This popular program provides a FREE lunch for undergraduate and graduate students with a panel of mentors representing a variety of government agencies. These mentors will answer questions, offer advice about preparing for a career in government, and comment on the prospects for current and future job opportunities with their agencies. Also, come learn more about GSA's GeoCorps program!

STUDENT NETWORKING LUNCHEON

Tues., 29 Oct., 11:30 a.m.–1 p.m.

This luncheon for undergraduate and graduate students is supported by industry donations and organized by GSA, the American Geosciences Institute (AGI), and the Prospectors & Developers Association of Canada (PDAC). This is an exciting opportunity to network with 40+ geoscience professionals! They

will answer questions, offer advice about career plans, and comment on job opportunities within their fields. Pre-registration is necessary, and you must bring your luncheon ticket to be admitted.

JOHN MANN MENTORS IN APPLIED HYDROGEOLOGY PROGRAM

Tues., 29 Oct., 11:30 a.m.–1 p.m.

This program underwrites the cost for 25 students to attend the Hydrogeology Division Luncheon and Awards Presentation and meet some of geoscience's most distinguished hydrogeologists. Students eligible for this honor are those who have (1) indicated a professional interest in hydrology/hydrogeology on their GSA membership application, and (2) registered for the Annual Meeting by 23 Sept. The first 25 students who respond to an e-mail invitation on 25 Sept. based on these criteria will receive FREE tickets for the luncheon.

DIVERSITY IN THE GEOSCIENCES SOCIAL RECEPTION

Tues., 29 Oct, 5:30–7 p.m.

The GSA Diversity in the Geosciences Committee and the NSF's Opportunities for Enhancing Diversity in the Geosciences would like to invite you to attend a relaxing forum for socializing, sharing ideas, and meeting other geoscience community members interested in diversity issues. The 2013 On To The Future Scholars and the seven undergraduate Subaru Minority Scholarship Awardees will be recognized. Appetizers and cash bar provided.

GSA'S EMPLOYMENT SERVICE CENTER BRINGS IT ALL TOGETHER

EMPLOYERS: Looking for **Qualified Candidates** in the Geosciences?

The **GSA Employment Service Center** offers a database of candidates seeking positions in more than 30 geoscience specialties.

- Search online by specialty, experience, location, and more
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- **Interview service** at GSA's 2013 Annual Meeting & Exposition in Denver this 27–30 October

GSA will provide an interview booth, appointment scheduling, posting of your open position(s), and access to our applicant database.

JOB SEEKERS: Looking for **Employment** in the Geosciences?

Post your online profile and résumé now. This is a FREE service to all GSA members.

www.geosociety.org/Employment_Service/

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Boost Your CAREER!



GEOSCIENCE CAREER PROGRAM

GSA's new Geoscience Career Program will connect industry and students in a day of progressive sessions, including a student workshop to prepare for job searches; a morning session for students to discuss their research with sponsoring companies; and the popular Geology in Industry lunch panel. In the afternoon, students will have a chance to learn about the companies, their unique cultures and work environments, and the types of geoscience careers available. The program concludes with an evening reception for student research presenters, sponsoring corporations, and recently graduated GSA members.

All program attendees must register.

For a full program description and registration, go to www.geosociety.org/GeoscienceCareerProgram/.

For details on corporate participation, contact Debbie Marcinkowski, +1-303-357-1047, dmarcinkowski@geosociety.org.

For information on student participation, contact Jennifer Nocerino, +1-303-357-1036, jnocerino@geosociety.org.

ON TO THE FUTURE

On To the Future (OTF) is a grassroots initiative of The Geological Society of America to provide partial funding for 125 diverse students to attend their first GSA Annual Meeting, this year in Denver, Colorado, USA.

Many GSA members describe their first GSA meeting as an exciting focal point in their professional development. It is the perfect situation for a student to gain exposure to the array of geoscience research and career options. GSA is also adding significant programs that facilitate effective mentoring relationships and networking opportunities. The personal connection accelerates the process of becoming an engaged and involved member of a scientific and professional community and is an essential catalyst in transforming a student into a professional.

As society is becoming so very diverse, it is only fitting to be able to support this same opportunity for 125 diverse students.

The OTF Scholars will participate in a number of gatherings throughout the meeting, where they will have an opportunity to network, hear about opportunities for their future career paths, and meet key GSA members. The scholars will be encouraged to get the most out of their time at the meeting, and we hope that other members in attendance will have an opportunity to welcome them and share their science and stewardship of our profession.

For more information, please contact **Gary Lewis**, Director, GSA Education & Outreach, glewis@geosociety.org.

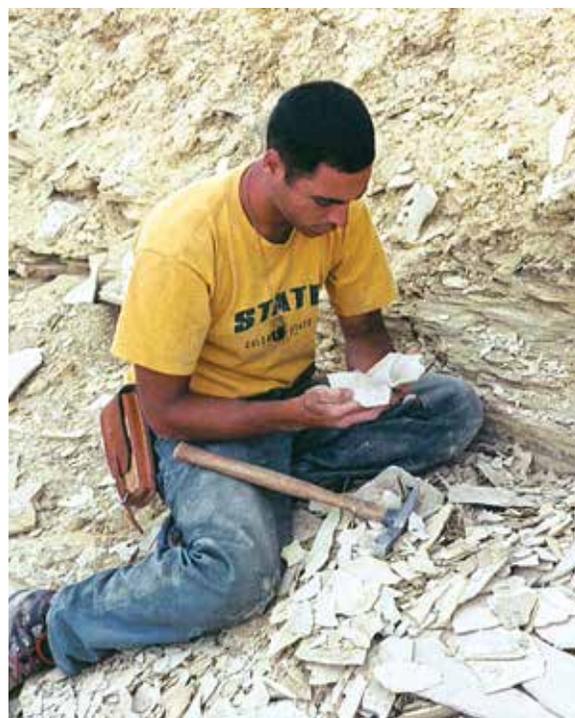
NOTICE OF GSA COUNCIL MEETINGS

GSA Annual Meeting & Exposition Denver, Colorado, USA

Day 1: Saturday, 26 Oct., 8 a.m.–noon, Hyatt CCC, Centennial Ballroom G

Day 2: Wednesday, 30 Oct., 8 a.m.–noon, Hyatt CCC, Mineral Hall F

All GSA members are invited to attend the open portions of these meetings.





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Getting to DENVER



Denver skyline at dusk. Photo by Bob Ashe. Denver Metro Convention & Visitors Bureau.



BY PLANE Denver International Airport (DIA [official airport acronym: DEN], www.flydenver.com) is the only major hub airport within a 500-mile radius, serving as the gateway to Colorado and the Rocky Mountain West. DIA is located 23 miles north-east of downtown Denver. For travel discounts on United Airlines, you may book online at www.united.com and enter ZQ5N647343 in the Offer Code box when searching for your flights. If booking through a travel professional or United Meetings at +1-800-426-1122, please give them the following information: Agreement Code: 647343 and Z Code: ZQ5N. Ground transportation options between the airport and downtown include RTD SkyRide Public Bus, Commercial Shuttle/ SuperShuttle, and taxi service. Costs range from \$11 to \$55 one-way.

BY CAR Carpool, vanpool, or schoolpool to save money, gas, and the environment! Contact colleagues through the GSA's Connected Community or online bulletin board (see p. 17). Colorado is bordered by seven other states and is roughly 340 miles from the center of the contiguous United States. With 25 Scenic and Historic Byways, it's not hard to find an enjoyable road to travel in Colorado. Wander off the major north-south (I-25) and east-west (I-70) thoroughfares to see the real Colorado and geologic points of interest along the way.

BY BUS Greyhound express routes include extra legroom, free Wi-Fi, and power outlets; visit www.greyhound.com to see if your city lies along one of these routes. The downtown Greyhound bus station is at Arapahoe and 19th Street, about eight blocks from the Colorado Convention Center and three blocks from the free 16th Street shuttle.

BY TRAIN Amtrak, the U.S. national rail operator, connects America in safer, greener, and healthier ways. Experience one of the most beautiful train trips in all of North America—the California Zephyr! The Zephyr runs daily between Emeryville/Bay Area and Chicago, with a stop in Denver. For schedules and tickets, go to www.amtrak.com. The Denver Amtrak Station has temporarily relocated to 1800 21st Street. Amtrak will return to Union Station in spring of 2014 as a bustling mixed-use, transit-oriented hub. The Zephyr runs daily between Chicago and San Francisco with a stop in Denver. Learn more at www.amtrak.com and www.denverunionstation.org.

Denver **TRANSPORTATION**

ONCE YOU ARRIVE

RTD SkyRide is the convenient, affordable bus service to and from Denver International Airport (DIA). You can catch SkyRide buses on level 6 across from doors 605 and 607 (east side) at DIA. For information on RTD routes, schedules, and fares, call 1+303-299-6000 or go to www.rtd-denver.com/skyride.shtml. The SkyRide information counter is located in the ground transportation area on the west side of the airport terminal. RTD informational kiosks are also available in the main terminal behind the rental counter. Fares are US\$7, US\$9 or US\$11, depending on destination, and drivers assist with luggage.

SuperShuttle is the nation's leading shared-ride airport shuttle service and one of the easiest and most cost-effective airport shuttle services from DIA to your hotel. You can book online at <http://groups.supershuttle.com/geo.html>; use discount code GEO13 for a discounted fare on the shuttle between DIA and the hotels in downtown Denver.

Taxis are available at DIA on the east and west sides of the airport, right outside of Baggage Claim on Island 1. Check with a taxi company or with a driver at the airport for fares and destinations served. Taxis are regulated and charge flat fares for four zones within the Denver Metro area. The one-way fare to downtown Denver is approximately \$55.15. For additional information go to www.flydenver.com/taxi.

Avis Car Rental: GSA has partnered with Avis to provide rental cars at a discounted rate. If you wish to reserve a car, please contact Todd Alexander at +1-800-525-7537, ext. 35003, or the Avis Meetings and Convention Department at +1-800-525-7537. They can ensure that you maximize your rental dollars. Please mention AWD #D016756 when you call. Online reservations can be made through www.avis.com. For parking rates, please contact your hotel directly.

WHILE IN DENVER

For a guide to getting around Denver without a car, go to www.denver.org/transportation/get-around-denver-without-car.

B-Cycle is the first large-scale bike-sharing system in the United States. B-cycle is a green, cost-effective, and convenient way to explore Denver and its neighborhoods, with 83 stations and more than 700 shiny red bicycles across the city. Daily passes are just US\$8, and all rides under 30 minutes are free! If you want to get outside the city, the area offers 850 miles of paved, off-street bike trails. For additional information, go to <http://denver.bicycle.com/>.

The 16th Street Shuttle uses eco-friendly hybrid buses that offer free shuttle service up and down the 16-block tree-lined retail core of downtown Denver. They stop on every corner in the heart of downtown from early morning to late evening.

Walking: Denver is the fourth most walkable city in the nation, according to the Brookings Institute. The central business district, which includes the convention center and hotels in the GSA room block, is one of the most walkable neighborhoods, with access to restaurants, brewpubs, and museums.

Pedicabs are those three-wheeled pedal cabs that are powered by people. Denver requires all legitimate pedicabs to display a small city-issued license plate on the rear of the three-wheeled vehicles. One such company, Mile High Pedicabs (www.milehighpedicabs.com/) is a member of the Denver Metro Convention and Visitors Bureau and their drivers are licensed, trained, and insured. If you see a pedicab, simply talk to the driver about where you want to go. The driver is an independent contractor and can negotiate the fare with you. Generally the suggested rate is \$2 per block, and tipping is appreciated.

Light Rail is the way to go if you would like to explore areas outside of downtown Denver. The new W line heads west toward Golden, the E and F lines take you south to Park Meadows, and the C and D lines go southwest to Littleton. Plan your trip on the RTD Light Rail at www.rtd-denver.com or in person by visiting one of the transit stations (downtown locations: Market Street Station at 16th and Market Street; Civic Center Station at 16th and Broadway).

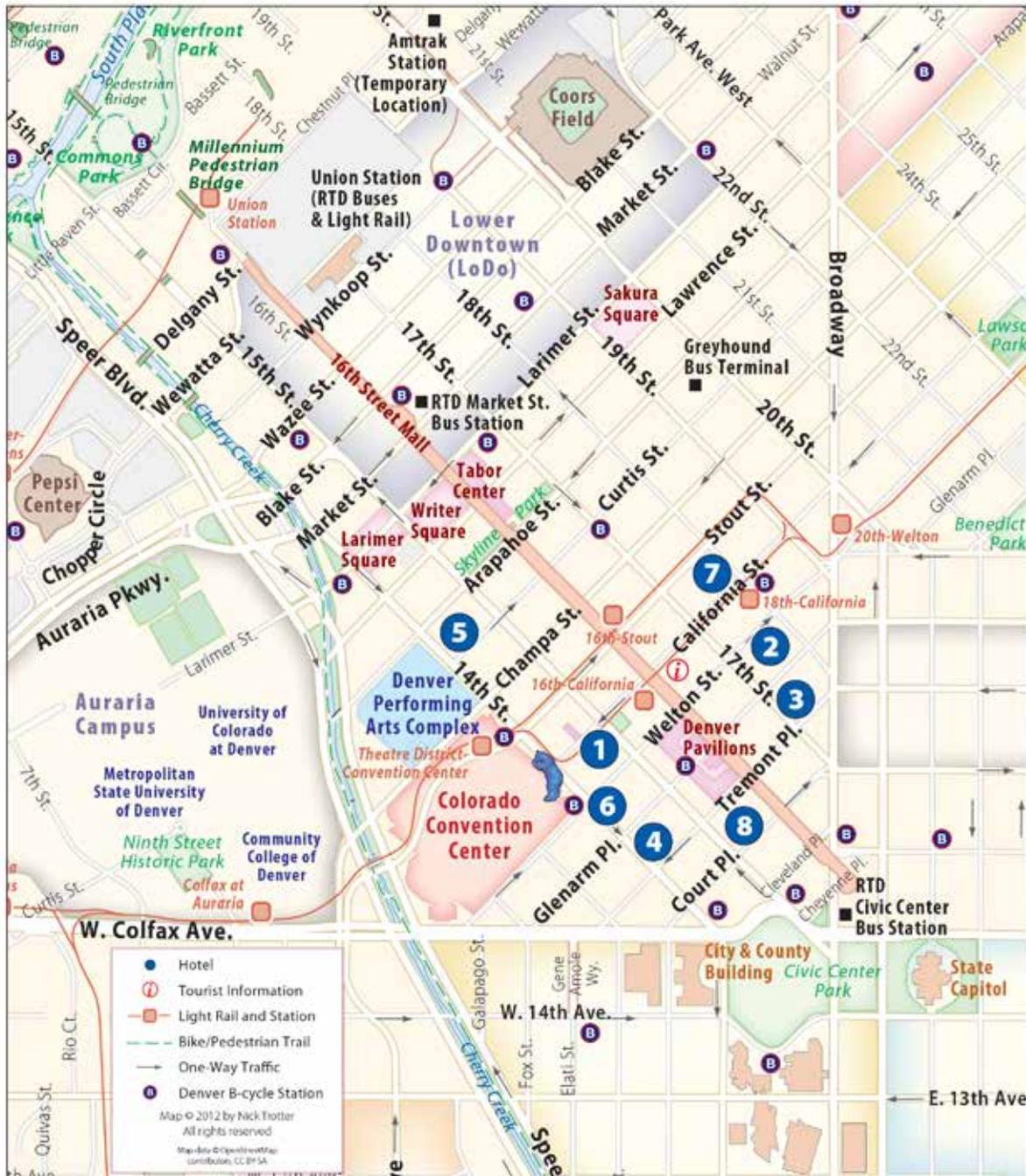
Did you know? While at the meeting, if you are unable to walk from the hotels in GSA's room block to the Colorado Convention Center, we will reimburse you for your taxi fare. Please bring your receipt and stop by the Annual Meeting Office for assistance.

The 15th step on the west side of the Colorado State Capitol is exactly 5,280 feet above sea level – one mile high. The carving in the steps is actually the wrong spot. The correct mile high spot is two steps higher and indicated by a brass marker. Photo by David Falconer. Denver Metro Convention & Visitors Bureau.



MAP of Downtown DENVER

- | | |
|--|---------------|
| 1 Hyatt Regency at CCC (HQ) | \$206 sgl/dbl |
| 2 Grand Hyatt Denver (Co-HQ) | \$179 sgl/dbl |
| 3 Comfort Inn Downtown | \$139 sgl/dbl |
| 4 Crowne Plaza Denver | \$149 sgl/dbl |
| 5 The Curtis, a Doubletree Hotel by Hilton | \$157 sgl/dbl |
| 6 Hilton Garden Inn Downtown Denver | \$169 sgl/dbl |
| 7 Denver Marriott City Center | \$179 sgl/dbl |
| 8 Sheraton Denver Downtown Hotel | \$179 sgl/dbl |





Celebrating Advances in Geoscience

Written by giants in their fields, these volumes are being prepared in honor of the 125th anniversary of GSA's founding in 1888. These comprehensive books cover advances in the geosciences over the past 50 years.

THREE MUST-HAVE SPECIAL PAPERS

SPECIAL PAPER 500

The Web of Geological Sciences: Advances, Impacts, and Interactions

edited by Marion E. Bickford

Special Paper 500 addresses advances from 1963 until 2013 in most of the important subdisciplines of the geosciences. What a 50 years they have had! The past 50 years have seen, among many other things, the development and understanding of plate tectonics, the exploration of the Moon and Mars, the development of new technologies, including digital computing and micro-analytical instruments, as well as advanced geophysical techniques. This volume—certain to become a classic—will be of great interest to professional scientists and will be particularly useful for students.

SPECIAL PAPER 501

The Impact of the Geological Sciences on Society

edited by Marion E. Bickford

Special Paper 501 examines the impact of the geosciences on society during the period 1963 to 2013. The past 50 years have seen, to mention only a few, new understandings of the origin of hydrocarbons and new technologies for their extraction; the need, in the electronics sector in particular, for new metals, including the rare-earth elements; and the global need for water resources and ways to keep water supplies uncontaminated. As populations have grown around the world, the effects of geologic hazards, notably earthquakes, tsunamis, and volcanic eruptions, have become increasingly devastating, accentuating the need to predict their occurrence. This volume focuses on the importance of the geosciences in informing public policy.

SPECIAL PAPER 502

Rethinking the Fabric of Geology

edited by Victor R. Baker

Special Paper 502: *Rethinking the Fabric of Geology* addresses changes in the philosophical directions of the geosciences and is essentially a follow-up to the 1963 publication of *The Fabric of Geology*, edited by Claude C. Albritton Jr. Its ten chapters cover philosophical aspects and debate, geological mapping, modeling prediction as well as quantitative modeling, and the changing nature of geology. The chapters in this volume will provoke many coffee-room discussions and invite students and professionals alike to think deeply about our science!

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Short COURSES

Early registration deadline: 23 September

Registration after 23 September costs an additional US\$30.

Cancellation deadline: 30 September

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

Can I take a short course if I am not registered for the meeting? YES! You're welcome to—just add the meeting nonregistrant fee (US\$40) to your course enrollment cost. Should you then decide to attend the meeting, your payment will be applied toward meeting registration.

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

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

See www.geosociety.org/meetings/2013/courses.htm or contact Jennifer Nocerino at jnocerino@geosociety.org for course abstracts and additional information.



Two-Year College Faculty: Thanks to Subaru of America, Inc., 45 two-year college professors (at least half-time) who attend any one short course will be reimbursed US\$100! For more information, please contact Davida Buehler at dbuehler@geosociety.org.

- 501. **Introduction to Terrestrial Laser Scanning (Ground-Based LiDAR) for Earth Science Research.** Fri., 25 Oct., 8 a.m.–5 p.m. US\$54; includes lunch. Limit: 20. CEU: 0.8.
- 502. **Sequence Stratigraphy for Graduate Students.** Fri.–Sat., 25–26 Oct., 8 a.m.–5 p.m. US\$25. Limit: 55. CEU: 1.6. *Upon completion of the course, participants will receive a US\$25 coupon redeemable at the onsite GSA bookstore.*
- 503. **Field Safety Leadership.** Fri.–Sat., 25–26 Oct., 8 a.m.–5 p.m. US\$25; includes continental breakfast and lunch. Limit: 24. CEU: 1.6. *Upon completion of the course, participants will receive a US\$25 coupon redeemable at the onsite GSA bookstore.*
- 504. **Introduction to Petroleum Structural Geology.** Fri.–Sat., 25–26 Oct., 8 a.m.–5 p.m. US\$25; includes continental breakfast and lunch. Limit: 30. CEU: 1.6. *Upon completion of the course, participants will receive a US\$25 coupon redeemable at the onsite GSA bookstore.*
- 505. **Structural and Stratigraphic Concepts Applied to Basin Exploration.** Fri.–Sat., 25–26 Oct., 8 a.m.–5 p.m. US\$25; includes continental breakfast and lunch. Limit: 30. CEU: 1.6. *Upon completion of the course, participants will receive a US\$25 coupon redeemable at the onsite GSA bookstore.*
- 506. **Volcanic Crisis Awareness.** Fri., 25 Oct., 8 a.m.–5 p.m., and Sat., 26 Oct., 8 a.m.–noon. US\$25. Limit: 30. CEU: 1.2. *Upon completion of the course, participants will receive a US\$25 coupon redeemable at the onsite GSA bookstore.*
- 507. **Effective Strategies for Teaching Diverse College Students.** Fri.–Sat., 25–26 Oct., 9 a.m.–5 p.m. US\$25. Limit: 40. CEU: 1.4.
- 508. **Helping Students Succeed in Geoscience Courses at Two-Year Colleges.** Sat., 26 Oct., 8 a.m.–4 p.m. US\$25; includes lunch. Limit: 48. CEU: 0.8.
- 509. **Near-Surface Geophysics for Non-Geophysicists.** Sat., 26 Oct., 8 a.m.–5 p.m. US\$110; includes course materials. Limit: 40. CEU: 0.8.
- 510. **Three-Dimensional Geologic Mapping.** Sat., 26 Oct., 8 a.m.–5 p.m. US\$75, includes lunch. Limit: 65. CEU: 0.8.
- 511. **Introduction to the Theory and Methods of (U-Th)/He Thermochronology.** Sat., 26 Oct., 8 a.m.–5 p.m. US\$75; includes lunch. Limit: 30. CEU: 0.8.
- 512. **Using Laser Ablation Split Stream (LASS) Geochronology and Petrochronology to Address Tectonic and Petrologic Questions.** Sat., 26 Oct., 8 a.m.–5 p.m. US\$25; includes lunch. Limit: 25. CEU: 0.8.
- 513. **Laser Ablation ICP-MS: An Overview of the Technique and a Look at New Advances in Quantitative Microanalyses for Geological, Biological, and Environmental Applications.** Sat., 26 Oct., 8 a.m.–5 p.m. US\$140, includes continental breakfast and lunch. Limit: 40. CEU: 0.8.
- 514. **Modern Digital Geologic Mapping Techniques.** Sat., 26 Oct., 8 a.m.–5 p.m. US\$102; includes lunch. Limit: 25. CEU: 0.8.
- 515. **Fundamentals of Mudrock Chemostratigraphy: Handheld XRF Analysis, Calibration, and Interpretation.** Sat., 26 Oct., 8 a.m.–5 p.m. US\$20. Limit: 84. CEU: 0.8.
- 516. **Introducing ImageRover: Free Software for the 3-D Visualization and Analysis of Mars Field Data Using MER Images.** Sat., 26 Oct., 8 a.m.–noon. US\$25. Limit: 50. CEU: 0.4. *Upon completion of the course, participants will receive a US\$25 coupon redeemable at the onsite GSA bookstore.*
- 517. **Optical Properties of Minerals in Thin Section: Quantitative Methods in Birefringence.** Sat., 26 Oct., 8 a.m.–noon. US\$40. Limit: 30. CEU: 0.4.
- 518. **Modernizing the Seismology in Your 100- and 200-Level Geoscience Courses.** Sat., 26 Oct., 8 a.m.–noon. US\$25. Limit: 25. CEU: 0.4. *Upon completion of the course, participants will receive a US\$25 coupon redeemable at the onsite GSA bookstore.*
- 519A. **Teaching Geoscientific Thinking: What Does It Mean and How Do I Do It?** Sat., 26 Oct., 8 a.m.–noon. US\$55 for one course—or get two-for-one!—US\$55 for combined courses (add 519C or 519D). Limit: 40. CEU: 0.4.
- 519B. **Teaching and Learning about Climate in Geoscience Classrooms.** Sat., 26 Oct., 8 a.m.–noon. US\$55 for one course—or get two-for-one!—US\$55 for combined courses (add 519C or 519D). Limit: 40. CEU: 0.4.
- 519C. **Integrating Sustainability into Geoscience Courses.** Sat., 26 Oct., 1–5 p.m. US\$55 for one course—or get two-for-one!—US\$55 for combined courses (add 519A or 519B). Limit: 40. CEU: 0.4.



- 519D. **Teaching Energy: Important, But Unfamiliar, Concepts, Emerging Themes & Grand Challenges.** Sat., 26 Oct., 1–5 p.m. US\$55 for one course—or get two-for-one!—US\$55 for combined courses (add 519A or 519B). Limit: 40. CEU: 0.4.
- 520A. **Teaching Controversial Issues 1: Climate and Energy.** Sat., 26 Oct., 8 a.m.–noon. US\$20 for one course—or get two-for-one! —US\$20 for combined courses (add 520C or 520D). Limit: 35. CEU: 0.4.
- 520B. **Yellowstone National Park as a Hotbed for Inquiry—For Teachers.** Sat., 26 Oct., 8 a.m.–noon. US\$20 for one course—or get two-for-one!—US\$20 for combined courses (add 520C or 520D). Limit: 30. CEU: 0.4.
- 520C. **Teaching Controversial Issues 2: Evolution of Life and Earth.** Sat., 26 Oct., 1–5 p.m. US\$20 for one course—or get two-for-one!—US\$20 for combined courses (add 520A or 520B). Limit: 35. CEU: 0.4.
- 520D. **Introduction to Critical Zone Science and Observatories.** Sat., 26 Oct., 1–5 p.m. US\$20 for one course—or get two-for-one!—US\$20 for combined courses (add 520A or 520B). Limit: 20. CEU: 0.8. *Participants are required to bring their own laptops.*
- 521. **U-Pb geochronology and Hf Isotope Geochemistry Applied to Detrital Minerals.** Sat., 26 Oct., 9 a.m.–5 p.m. US\$45, includes lunch. Limit: 40. CEU: 0.7.
- 522. **New Tools for Teaching Earth History: Global Geology .com, Ancient Earth App, and The PALEOMAP PaleoAtlas for ArcGIS.** Sat., 26 Oct., 9 a.m.–5 p.m. US\$75, includes lunch. Limit: 30. CEU: 0.7. *Participants are required to bring their own laptops or tablet computers. Complimentary Wi-Fi will be provided.*
- 523. **Mars for Earthlings: Introductory Earth-Mars Teaching Resources for Higher Education.** Sat., 26 Oct., 1–5 p.m. US\$25. Limit: 30. CEU: 0.4. *Upon completion of the course, participants will receive a US\$25 coupon redeemable at the onsite GSA bookstore.*
- 524. **Getting Started in Undergraduate Research for New, Future, and Current Faculty.** Sat., 26 Oct., 1–5 p.m. US\$35. Limit: 20. CEU: 0.4.
- 525. **Communicating Science: Tools for Scientists.** Sat., 26 Oct., 1–5 p.m. US\$25. Limit: 30. CEU: 0.4. *Upon completion of the course, students will receive a US\$10 coupon redeemable at the onsite GSA bookstore.*
- 526. **Integrating GPS, LiDAR, InSAR, and Other Geodesy Data into Undergraduate Courses.** Sat., 26 Oct., 1–5 p.m. US\$20. Limit: 30. CEU: 0.4.
- 527. **High Relief Clinoforms in the Colville Foreland Basin, Arctic Alaska.** Thurs., 31 Oct., 8:30 a.m.–4:30 p.m. US\$80. Limit: 30. CEU: 0.7.

Associated Society **SHORT COURSES**

Society of Economic Geologists (SEG)

Modeling Structural Evolution to Improve Geological Models for Exploration and Mine Development. Thurs.–Fri., 24–25 Oct., 8 a.m.–5 p.m. Limit: 40. **Instructors:** Jennifer Ellis, Midland Valley; Gareth Johnson, Midland Valley. Register at www.segweb.org/events.

FEEs (in U.S. dollars)

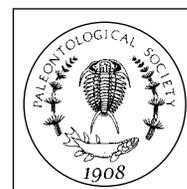
	Early Reg. (Through 30 Sept.)	Late Reg (After 30 Sept.)
Members	\$895	\$995
Non-Members	\$995	\$1,095
SEG Member Students	\$495	\$545
Non-Member Students	\$545	\$595



Note: GSA will not be handling registration for these courses. Please use the contact information provided online to learn more and to register.

Paleontological Society

Ecosystem Paleobiology and Geobiology. Sat., 26 Oct., 9 a.m.–5 p.m. FREE, with no registration needed and no course attendance limit. **Instructors:** Andrew Bush, University of Connecticut; Sara Pruss, Smith College; Jonathan Payne, Stanford University. Learn more at www.paleosoc.org.



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American Institute
of Professional
Geologists (AIPG)

www.aipg.org



Booth #946

Sigma Gamma
Epsilon (SGE)

www.sigmagammapsi.com



Booth #355

Paleontological
Society (PS)

www.paleosoc.org



Booth #1111

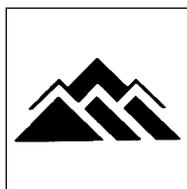
The Clay Minerals
Society (CMS)

www.clays.org/



International
Association of
Hydrogeologists (IAH)

www.iah.org



Booth #106

National Association
of Geoscience Teachers
(NAGT)

<http://nagt.org/index.html>



Booth #1106

Mineralogical
Association of Canada
(MAC)

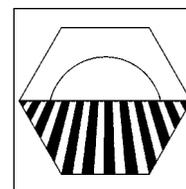
www.mineralogicalassociation.ca



Booth #1133

Association of Earth
Science Editors (AESE)

www.aese.org/



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www.soils.org/

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Upcoming AWG Events

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AWG Networking Breakfast

Women in AEG AWG Breakfast

AWG at AEG, Seattle, Washington

AWG and AEG Breakfast, September 2013



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Scientific **FIELD TRIPS**

Field-Trip Co-Chairs: Lon Abbott, lon.abbott@colorado.edu; Greg Hancock, gshanc@wm.edu.

GSA Contact: Beth Engle, bengle@geosociety.org.

Please contact trip leaders directly if you have questions about trip details; leader contact information and expanded trip descriptions are listed on the meeting website. All trips begin and end at the Colorado Convention Center in Denver unless otherwise indicated.

402. **Early Mesozoic Sandstones in Utah's Canyon Country: Signatures of Subsurface Microbes, Reducing Fluids, and Jurassic Earthquakes.** Wed.–Sat., 23–26 Oct. US\$445. Trip starts in Grand Junction, Colorado, and ends in Denver.
403. **Making the Case for the Picuris Orogeny: Evidence for a 1.5 to 1.4 Ga Orogenic Event in the Southwestern United States.** Wed.–Sat., 23–26 Oct. US\$436.
404. **The Laramie Anorthosite Complex and Its Contact Relationships.** Wed.–Sat., 23–26 Oct. US\$373.
405. **Colorado Geology Then and Now, 1901 to 2013: Following the Route of the Societies' 1901 Trip through Central Colorado—Evolution of Geological Thought and Discovery.** Thurs.–Sat., 24–26 Oct. US\$340.
406. **Origin and Evolution of the Upper Colorado River System: Evaluating the Competing Roles of Neogene Tectonism and Drainage Integration.** Thurs.–Sat., 24–26 Oct. US\$343.
407. **Sevier Fold-Thrust Belt to Laramide Foreland Transect: Exploring the Evolution of a Complex Orogenic System.** Thurs.–Sat., 24–26 Oct. US\$368. This trip begins in Salt Lake City and ends in Denver.
408. **There's More to This Than Meets the Eye: Human-Induced Changes in Hydrology, Geomorphology, and Biogeochemistry in High-Elevation Watersheds of the Southern Rockies.** Fri., 25 Oct. US\$105.
409. **Laramide Basin CSI: Comprehensive Stratigraphic Investigations of Paleogene Sediments in the Colorado Headwaters Basin, North-Central Colorado.** Fri.–Sat., 25–26 Oct. US\$212.
410. **Coal Geology and Mining History of the Raton Mesa Coal Region.** Fri.–Sat., 25–26 Oct. US\$220.
411. **Geological Photography: Capturing and Processing Geologic Images with Digital Camera and Gigapan.** Fri.–Sat., 25–26 Oct. US\$162.
412. **Gully Erosion along the West Bijou Escarpment, Colorado High Plains.** Sat., 26 Oct. US\$87.
413. **Geology along the Rocky Mountain Front Range, Morrison to Golden, Including Structure, Stratigraphy, Paleontology, Volcanology, and Economic Geology (pre-meeting).** Sat., 26 Oct. US\$107.
414. **Rocky Mountain Unsaturated Zones—Exploring Fire-Earth-Sky Connections.** Sat., 26 Oct. US\$68.
415. **Discovering Treasures for Educators: Behind the Scenes in Earth Sciences at the Denver Museum of Nature & Science.** Sat., 26 Oct. US\$64.
416. **Lessons Learned from the 1982 Lawn Lake Dam Failure Flood and the 1976 Big Thompson Canyon Flood, Colorado.** Sat., 26 Oct. US\$95.
417. **The Role of Bioturbation in Producing the Mima-Type, Mima-Like, and Various Related Mounds and Heaps in the Greater Denver-Boulder Area, Colorado.** Sat., 26 Oct. **CANCELED**
418. **Ancient Denvers: A Journey through the Front Range's Geologic History.** Sun., 27 Oct. US\$88.
419. **A Survey of the Depositional Environments, Paleoflora, and Paleofauna of the Western Interior Seaway Greenhorn Cyclothem in the Comanche National Grassland, Southeastern Colorado.** Mon., 28 Oct. US\$108.
420. **Tour of the Bureau of Reclamation Laboratories, Denver Federal Center.** Mon., 28 Oct. US\$57.
421. **Kirk Bryan Field Trip: Critical Zone Evolution: Climate and Exhumation.** Wed., 30 Oct. US\$85.
422. **Seismogenic Fault-Zone Processes and Heterogeneity Recorded by Pseudotachylite: New Insights from the Homestake Shear Zone, Colorado.** Thurs., 31 Oct. US\$96.
423. **Geology along the Rocky Mountain Front Range, Morrison to Golden, Including Structure, Stratigraphy, Paleontology, Volcanic, and Economic Geology (post-meeting).** Thurs., 31 Oct. US\$107.
424. **Proterozoic Metamorphism and Deformation in the Northern Colorado Front Range.** Thurs., 31 Oct. US\$102.
425. **History of Paleontology at the Florissant Fossil Beds National Monument.** Thurs., 31 Oct. US\$105.
426. **Strata, Structures, and Enduring Enigmas—A 125th Anniversary Overview of Colorado Springs Geology.** Thurs.–Fri., 31 Oct.–1 Nov. US\$187.
427. **New Views on Late Paleozoic Climate and Tectonics in the Ancestral Rocky Mountains.** Thurs.–Sat., 31 Oct.–2 Nov. US\$351.

Associated Society **FIELD TRIP**



Society of Economic Geologists (SEG)

Colorado Porphyry-Molybdenum Deposits and Leadville District. Thurs.–Sat., 24–26 Oct.

Leaders: Ralph Stegen, Freeport-McMoRan; Tommy Thompson, University of Nevada. Register via the SEG website, www.segweb.org/events.

FEES (in U.S. dollars)

	Early Reg. (1 Aug.–15 Sept.)	Late Reg. (After 15 Sept.)
Members	\$795	\$895
Non-Members	\$895	\$995
Member Students	\$395	\$445
Non-Member Students	\$445	\$495

Note: GSA will not be handling registration for this field trip, but you can read the trip description and leader bios on the GSA meeting website.

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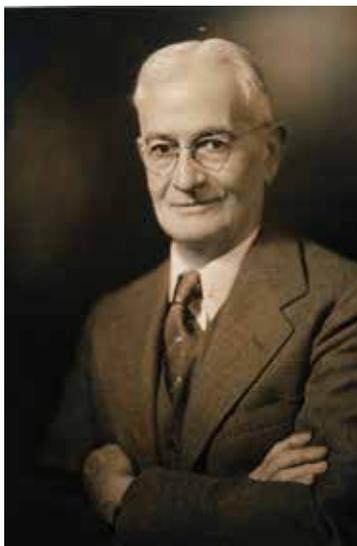
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PARDEE KEYNOTE Symposia



SUNDAY

27

8 a.m.–noon

P1. 125 Anniversary Pardee Symposium: 125 Years of Exploration and Geoscience with GSA and the National Geographic Society: Celebrating the Rich History of Geoscientist Explorers Who Have Broadened Our Horizons and Knowledge of Our World.

P10. Paleotopography.

1–5 p.m.

P5. Evolution of the North American Cordilleran Lithosphere.

P6. Energy and Health: The Emergence of Medical Geology in Response to the Shale Gas Boom.

MONDAY

28

8 a.m.–noon

P3. 125 Anniversary Pardee Symposium: In the Footsteps of Geology Giants.

P9. From the Sahara to Mars and Beyond: The History and Future of Aeolian Research.

1–5 p.m.

P8. Fossil Fuel Production, Economic Growth, and Climate Change.

TUESDAY

29

8 a.m.–noon

P4. 125 Anniversary Pardee Symposium: Quaternary Geology and Geomorphology: Past, Present, and Future.

P13. “Water, Water, Everywhere...” in the Solar System.

1–5 p.m.

P12. Resourcing Future Generations: What Needs to Be Done in the Near Term to Meet Demand for the Mineral Resources Needed in the Long Term?

WEDNESDAY

30

8 a.m.–noon

P2. 125 Anniversary Pardee Symposium: Advances in Understanding Earth Structure and Process from EarthScope.

1–5 p.m.

P7. Back to the Future: Eocene–Early Oligocene Climatic Response to Geological Processes and Implications for the Future Earth.

P11. Rare Earth Elements: Minerals, Mines, Magnets (and More).

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 papers covering a broad range of topics.



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SPECIAL Sessions

The following special sessions extend and enhance opportunities for diverse learning and presentation modes within the technical program. Each session is structured by the individual organizer(s) to best fit their purpose, in order to provide an interesting and unique session for the meeting attendees.

A Life in Earth History from Tectonics to Climate: The Scientific Legacy of Paul F. Hoffman

Organizers: Robert S. Hildebrand, Francis A. Macdonald, Samuel A. Bowring, and Galen P. Halverson

This session will focus on recent advances in crustal, climate, and biogeochemical evolution, from tectonics to Snowball Earth, and their interactions.

Special Session: Accomplishments, Challenges, and Frontiers in Soil Geomorphology: In Memory of Donald L. Johnson

Organizers: Randall Schaetzl, Jennifer Horwath Burnham, and Daniel R. Muhs

The late Donald L. Johnson was one of the pioneers of soil geomorphology and the application of its principles to Quaternary research, geoarchaeology, and soil-landscape evolution. His interdisciplinary approach to soil geomorphology, in the classic natural history tradition of Charles Darwin, brought together key concepts from pedology, ecology, botany, and zoology, as well as traditional earth-science fields. Speakers who are stimulated by this type of interdisciplinary approach to soil geomorphology are invited to present papers that showcase exciting new results as a tribute to Johnson's innovative research style. Abstracts on topics that he was especially passionate about—bioturbation, stone lines, soil evolution, and pedogenic theory—are particularly encouraged.

CRvolution 2: Cenozoic Landscape Evolution of the Colorado Plateau–Rocky Mountain Region and the Carving of Grand Canyon

Organizer: Karl E. Karlstrom

The western U.S. field laboratory, because of its spectacular exposure, has been at the forefront of the scientific breakthroughs in geomorphology, stratigraphy, paleontology, and tectonics for more than a century (Dutton, 1882). The century-long debate about the evolution of the continental-scale Colorado River system and the carving of Grand Canyon is poised for resolution! This session is a step toward that breakthrough and complements an ongoing GSA *Geosphere* theme volume on CRvolution.

Cutting Edge Applied Geoscience in Exploration: The Best of AAPG

Organizers: Robbie Gries and Paul Weimer

Three-dimensional seismic visuals, innovative structural geological applications, amazing application of the newest stratigraphic thinking—these concepts and more have captured presentation awards from a cadre of peers at the annual meetings of the American Association of Petroleum Geologists (AAPG).

This session is designed to expose GSA attendees to the latest in applied geoscience for the advancement of resource development.

GSA 125th Anniversary Books: I, *The Web of Geological Sciences: Advances, Impacts, and Interactions*; II, *The Impact of Geological Sciences on Society: Authors Present Summaries of Their Articles*

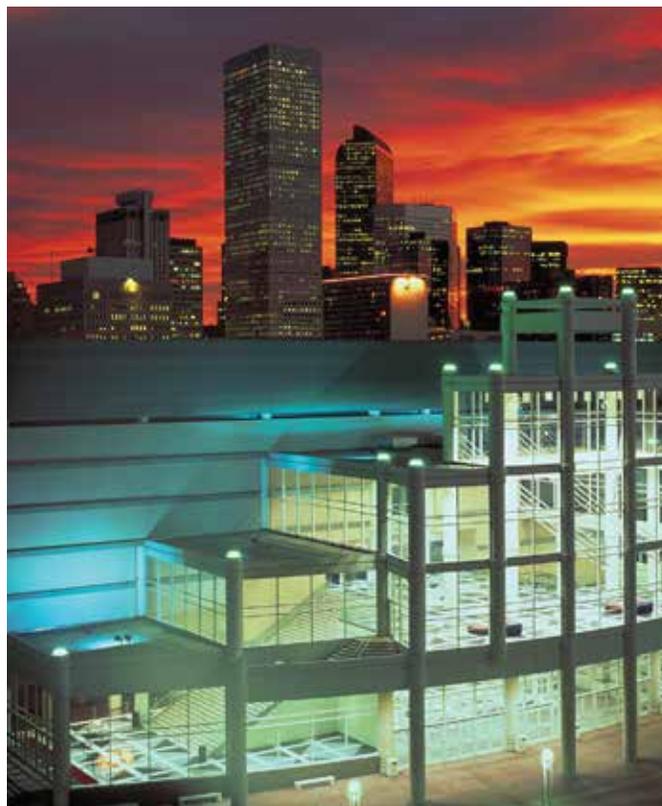
Organizer: M.E. Bickford

In this session, authors of invited articles for two GSA Special Papers commissioned for GSA's 125th Anniversary celebration will present summaries of their articles.

Process Geomorphology and the Legacy of Dale F. Ritter: Linkages within the Natural and Human Landscape

Advocates: R. Craig Kochel, Jerry R. Miller, and Dru Germanoski

This special session will assemble leading scientists and educators whose work highlights the theme of *Process Geomorphology*, building upon the legacy of process and dynamics in geomorphic systems championed by Dale F. (Dusty) Ritter. Based on his pioneering research on glaciofluvial processes and landforms, Dusty mentored hundreds of students and provided a focus for the field with his first edition of *Process Geomorphology* in the 1970s. This session will focus on research on a broad range of geomorphic topics, including glaciofluvial systems, applied environmental geomorphology, and process linkages that exist within watersheds, and, where possible, will highlight student-professor collaborations.



Colorado Convention Center. Photo by Bob Ashe. Denver Metro Convention & Visitors Bureau.

EVERYONE NEEDS A *FIELD* ASSISTANT — FIND YOURS AT **GSA** THIS YEAR!

GSA has partnered with Colorado's own Left Hand Brewing Company to bring you GSA's 125th Anniversary labeled brew: "**Field Assistant.**" Grab a bottle to enjoy during the Saturday Icebreaker, Sunday Exhibits Opening Reception, or during the afternoon beer receptions, Mon.–Wed., 5–6:30 p.m., while you peruse the Poster Sessions. Special commemorative "Field Assistant" items will be available for purchase in the GSA Bookstore.



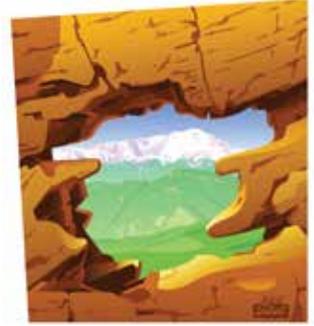
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Celebrating GSA's 125th Anniversary



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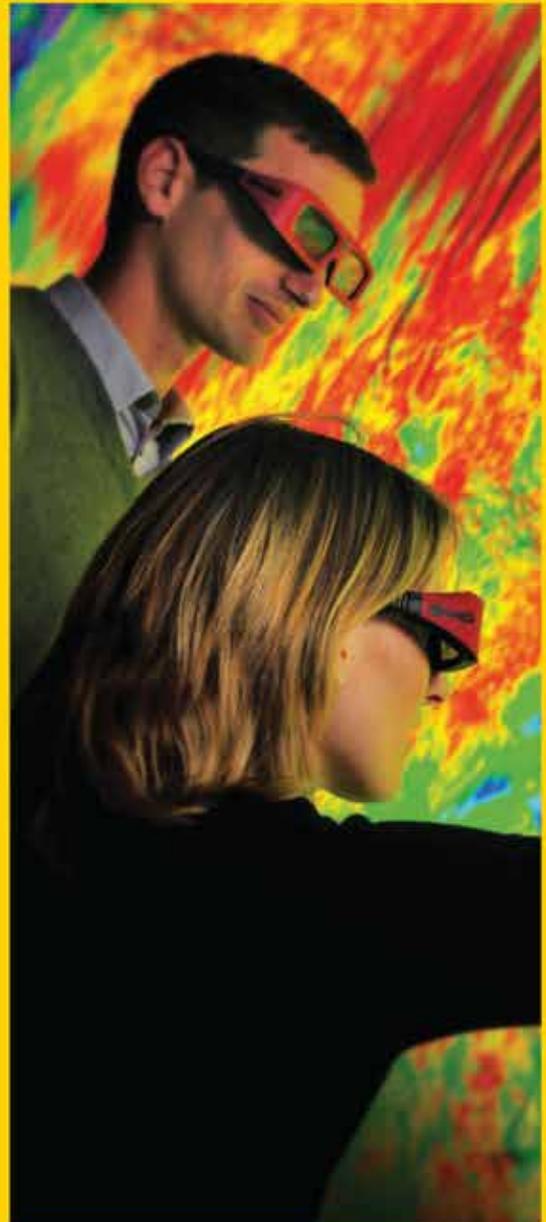
You can join us either through our Shell Graduate Program or through our Assessed Internship Program. Our Shell Graduate Program is a developmental framework that prepares you for a professional career by enabling you to build your skills through hands-on roles and challenging assignments. Through our Assessed Internship Program, you will get involved in real projects that will help enhance your development.

Geosciences opportunities are available in the following areas:

- Geology
- Geophysics
- Geochemistry
- Petrophysics
- Production Technology
- Well Engineering
- Reservoir Engineering
- Process Engineering
- Research & Development (R&D)
- Information Technology (IT)

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**EXHIBITORS** by Category *(as of press time)***COMPUTER SOFTWARE**

International Centre for
Diffraction Data
Mappt

ENVIRONMENTAL

British Geological Survey
Environmental Isotope Lab,
University of Waterloo
WKU Hoffman Environmental
Research Institute

**GEMS/MINERALS
DEALERS, JEWELRY/
GIFTS**

Cornerstone Minerals
Crystals Unlimited
Finesilver Designs / Jewelry
Gems & Crystals Unlimited
Geographics
IKON
Komodo Dragon
Natural Creations Ltd.
Natural Earth Craft LLC
Nature's Own
Xeno Designs

**GENERAL EDUCATIONAL
PRODUCTS**

Little River Research & Design
Ward's Science

**GEOGRAPHIC SUPPLIES
AND RELATED
EQUIPMENT**

Estwing Mfg. Co.
Forestry Suppliers Inc.
Rite in the Rain

**GEOLOGICAL SOCIETY OF
AMERICA**

GSA Archaeological Division
GSA Environmental and
Engineering Geology
Division
GSA Geoinformatics Division
GSA Geology and Public Policy
GSA Geology and Society
Division
GSA Geophysics Division
GSA Geoscience Education
Division
GSA History and Philosophy of
Geology Division

GSA Headquarters Services
GSA Hydrogeology Division
GSA Limnogeology Division
GSA Mineralogy,
Geochemistry, Petrology, and
Volcanology Division
GSA Planetary Geology
Division

**GEOLOGICAL AND
GEOPHYSICAL
INSTRUMENTATION**

Apex Marketing
Applied Field Data Systems Inc.
ASC Scientific
BigC: Dino-Lite Scopes
Bruker Corporation
Brunton
elementar Americas Inc.
Gatan Inc.
Geophysical Survey Systems
Inc.
HORIBA Scientific
IDS North America Ltd.
IsotopX Inc.
IXRF Systems Inc.
Leica Microsystems Inc.
Mala Geoscience USA Inc.
Martin Microscope
Optech Inc.
RIEGL USA
Rigaku Americas Corporation
SciAps Inc.
Sensors & Software Inc.
Spectral Evolution
Thermo Scientific
TSI Inc.
UNAVCO

**GOVERNMENT AGENCIES
(FEDERAL, STATE, LOCAL,
INTERNATIONAL)**

EARTHTIME
NASA
National Park Service
National Science Foundation
U.S. Forest Service
U.S. Geological Survey

OTHER

2014 GSA Annual Meeting—
Vancouver, BC, Canada
35th International Geological
Congress (IGC) Foundation

Consortium of Universities
for the Advancement of
Hydrologic Sciences Inc.
(CUAHSI)
Critical Zone Observatories
Esri
Geocognition Research Lab
IRIS Consortium
Space Science Institute
STEPPE—Coordinating Office
for Research on Sedimentary
Crust, Deep-Time & the
Earth-Life System
Subaru of America Inc.

**PROFESSIONAL
SOCIETIES AND
ASSOCIATIONS**

American Association of
Petroleum Geologists
AASP - The Palynological
Society
American Geophysical Union
American Geosciences Institute
American Institute of
Professional Geologists
American Meteorological
Society
American Quaternary
Association
Association for Women
Geoscientists
Association of Earth Science
Editors
Association of Environmental
& Engineering Geologists
Colorado Scientific Society
Council on Undergraduate
Research
Cushman Foundation
Environmental and
Engineering Geophysical
Society
European Geosciences Union
Geochemical Society
Geological Association of
Canada
Geoscience Information
Society
GeoScienceWorld
IMA2014
International Association for
Geoscience Diversity
International Association of
Geochemistry

International Union of
Geological Sciences
Max Planck Institute for
Chemistry
Mineralogical Association of
Canada
Mineralogical Society of
America
Minerals Education Coalition
/ Society for Mining,
Metallurgy & Exploration
National Association of
Geoscience Teachers
National Association of State
Boards of Geology
National Cave & Karst Research
Institute
National Ground Water
Association
National Speleological Society
Paleontological Research
Institution
Paleontological Society
Prospectors & Developers
Association of Canada
SEPM (Society for Sedimentary
Geology)
Sigma Gamma Epsilon
Society for the Preservation of
Natural History Collections
Society of Economic Geologists
Society of Exploration
Geophysicists &
Geoscientists *without
Borders*®
Soil Science Society of America
The Clay Minerals Society
Western Interior
Paleontological Society /
Friends of Dinosaur Ridge

**PUBLICATIONS, MAPS,
FILMS**

Cambridge University Press
Cengage Learning
Colorado Plateau Geosystems
Inc.
Columbia University Press
Copernicus Meetings & Open
Access Publications
Elsevier
FriendShip Publications
Geologic Data Systems
Geological Society of London
Kendall Hunt Publishing Co.
McGraw-Hill Education

Micropaleontology Project
 Mountain Press Publishing Co.
 Nature Publishing Group
 Oxford University Press
 Pearson
 Springer
 Taylor & Francis – CRC Press
 Treatise on Invertebrate
 Paleontology
 University of California Press
 University of Chicago Press
 W.H. Freeman
 W.W. Norton
 Waveland Press
 Wiley

SERVICES (EXPLORATION, LABORATORIES, CONSULTING, AND OTHERS)

Beta Analytic
 DirectAMS Radiocarbon
 Dating Services
 DOSECC Exploration Services
 GNS Science/Rafter
 Radiocarbon
 Integrated Ocean Drilling
 Program – U.S.
 Isotope Tracer Technologies
 Midland Valley Exploration Ltd.
 Ruen Drilling Inc.

STATE SURVEYS

Association of American State
 Geologists

UNIVERSITIES/SCHOOLS

Schools in boldface will
 be located in the *Campus
 Connection* area of the Exhibit
 Hall (formerly the Graduate
 School Information Forum).
**Auburn University Dept. of
 Geology and Geography**
Ball State University
 Baylor University Geology
 Dept.
**Black Hills Natural Sciences
 Field Station / South
 Dakota School of Mines and
 Technology**
Boise State University
**Central Washington
 University**

Colorado School of Mines
**Colorado School of Mines,
 Dept. of Geology &
 Geological Engineering**
 Cornell University
**Cornell University Earth and
 Atmospheric Sciences**
 EarthScope
East Carolina University
**Florida International
 University**
 Geological Institute of
 America
**Georgia State University Dept.
 of Geosciences**
 Groundwater Australia—
 National Centre for
 Groundwater Research &
 Training
 Illinois State University
**Indiana University–Purdue
 University Indianapolis**
**Indiana University–
 Bloomington**
**Iowa State University
 Dept. of Geological and
 Atmospheric Sciences**
 John D. Cooper Archaeological
 & Paleontological Center
 Kansas State University
**Michigan Tech University
 Dept. of Geological &
 Mining Engineering &
 Sciences**
 Mississippi State University
 Dept. of Geosciences
**Missouri State University
 GGP Dept.**
**Missouri University of Science
 and Technology**
**New Mexico Highlands
 University**
 NSF Antarctic Data
 Consortium
Oklahoma State University
Pennsylvania State University
Purdue University
**Rice University Earth Science
 Dept.**
San Diego State University
**Syracuse University Dept. of
 Earth Sciences**
 Texas A&M University
**Texas Tech University Dept. of
 Geosciences**
**The Ohio State University
 School of Earth Sciences**

EXHIBIT HALL HOURS

Sun., 27 Oct., 5–7 p.m.
 Mon.–Tues., 28–29 Oct., 9 a.m.–6:30 p.m.
 Wed., 30 Oct., 9 a.m.–2 p.m.

GSA EXHIBIT HALL OPENING RECEPTION

Sun., 27 Oct., 5–7 p.m.

The University of Texas at
 Austin Jackson School of
 Geosciences
**The University of Texas at
 Dallas Geosciences Dept.**
**University at Buffalo Dept. of
 Geological Sciences**
**University of Arkansas–
 Fayetteville**
**University of California,
 Davis, Geology Dept.**
**University of Connecticut
 Center for Integrative
 Geosciences**
**University of Delaware Dept.
 of Geological Sciences**
University of Idaho
**University of Illinois Dept. of
 Geology**
 University of Kansas
**University of Massachusetts–
 Amherst**
University of Michigan
 University of Nevada–Las
 Vegas
 University of Nevada–Reno
**University of North Carolina–
 Charlotte**
University of North Dakota
**University of Oklahoma
 ConocoPhillips School of
 Geology and Geophysics**
**University of South Carolina
 School of the Earth, Ocean
 and Environment**
**University of Southern
 California Dept. of Earth
 Sciences**
University of Toledo
**University of Wisconsin–
 Madison**

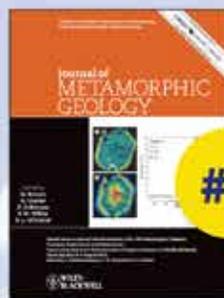
**University of Wisconsin–
 Milwaukee Dept. of
 Geosciences**
 University of Wyoming
**Vanderbilt University Dept.
 of Earth & Environmental
 Sciences**
 Virginia Tech Dept. of
 Geosciences
**Western Michigan University
 Dept. of Geosciences**
Wright State University

Wiley is a worldwide leading publisher of more than 75 geosciences journals spanning the entire spectrum, Wiley's authors, editors and affiliated societies are of the highest caliber publishing groundbreaking research in all subjects, including geology, geochemistry, mineralogy, and palaeontology.

The new partnership between Wiley and the American Geophysical Union, the world's leading society, came into effect in January 2013. The AGU has 62,000 members and publishes 19 journals and a book program as part of the Wiley portfolio. The AGU journal program is both extensive and of very high quality, accounting globally for 25% of journal articles and 40% of citations in the geosciences.

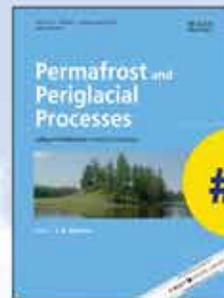
Geology

Wiley has more geology journals than any other publisher*, including 4 in the top 10. The 6 Wiley journals published 256 articles which were cited 12,867 times in 2012.



#2

Journal of Metamorphic Geology
IF 3.400
Ranked number 2

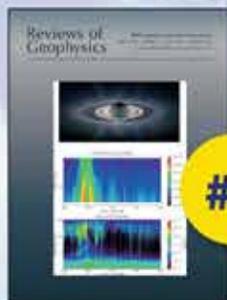


#4

Permafrost and Periglacial Processes
IF 3.049
Ranked number 4

Geochemistry and Geophysics

Nine Wiley journals in Geochemistry and Geophysics category*, including 4 in the top 20. The journals published 1,205 articles which were cited 33,588 times in 2012.

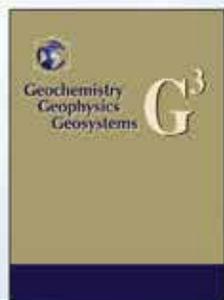


#2

Reviews of Geophysics
IF 13.906
Ranked number 2



Tectonics
IF 3.487



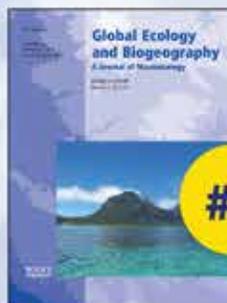
Geochemistry Geophysics Geosystems
IF 2.939



Meteoritics & Planetary Science
IF 2.800

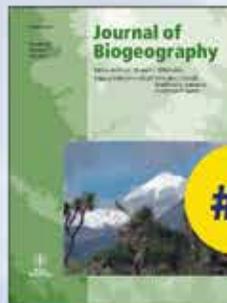
Physical Geography

Seven Wiley journals are in Physical Geography category*, including 5 in the top 20. The journals published 568 articles which were cited 26,999 times in 2012.



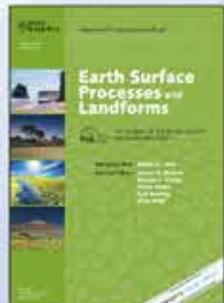
#1

Global Ecology and Biogeography
IF 7.223
Ranked number 1

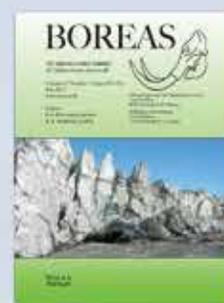


#2

Journal of Biogeography
IF 4.863
Ranked number 2



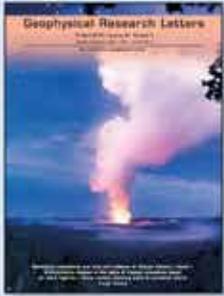
Earth Surface Processes and Landforms
IF 2.49



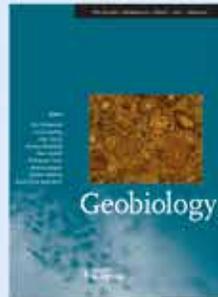
Boreas
IF 2.457

Geosciences, Multidisciplinary

21 Wiley journals ranked in the Geosciences, Multidisciplinary category*. The journals published 4,992 articles and with 273,923 cites, Wiley journals had the highest number of cites in 2012.



Geophysical Research Letters
IF 3.982



Geobiology
IF 3.042



Journal of Geophysical Research
IF 3.174



Basin Research
IF 2.912

Palaeontology

Five Wiley journals are ranked in the Palaeontology category *, including 3 in the top 5. The journals published 303 articles which were cited 13,924 times in 2012.



Paleocyanography
IF 3.296
Ranked number 1



Journal of Quaternary Science
IF 2.939
Ranked number 2

Astronomy and Astrophysics

Three Wiley journals are ranked in the Astronomy and Astrophysics category *. The journals published 303 articles which were cited more than 5610 times in 2012.

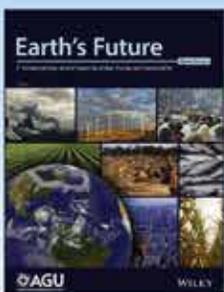


Space Weather
IF 1.370



Radio Science
IF 1.000

*ISI Subject Category, 2012 Journal Citation Reports® (Thomson Reuters, 2013)



NEW IN 2013

Earth's Future: A Transdisciplinary Journal Exploring Global Change and Sustainability

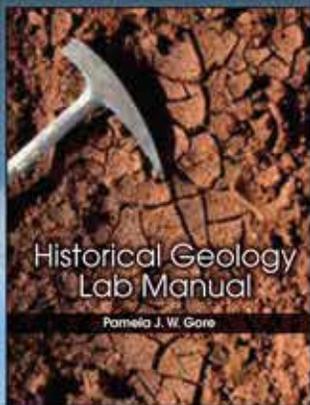
Editor in Chief: Guy Brasseur, Director Climate Service Center, Germany

earthsfuture.agu.org

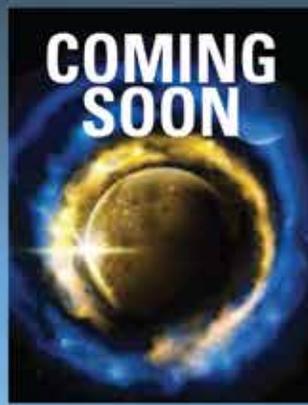
Open Access Journal

WILEY

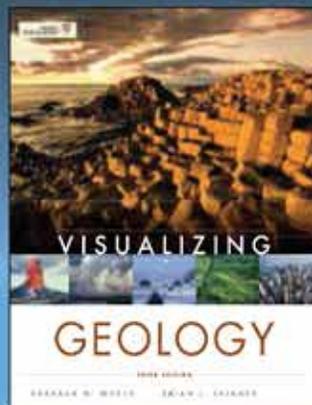
New Textbooks from Wiley



Historical Geology Lab Manual, 1st Edition
Pamela Gore
December 2013



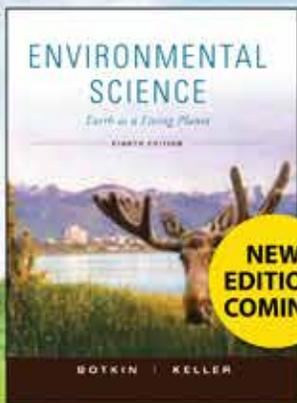
Physical Geology: The Science of Earth, 2nd Edition
Charles Fletcher
December 2013



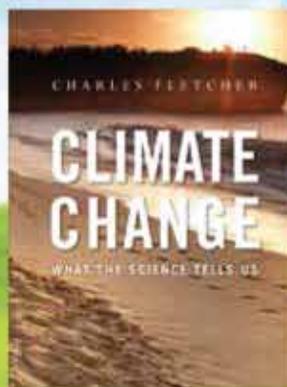
Visualizing Geology, 3rd Edition
Barbara W. Murck
April 2012



Visualizing Environmental Science, 4th Edition
Linda R. Berg, Mary Catherine Hager, David M. Hassenzahl
August 2013



Environmental Science: Earth as a Living Planet, 9th Edition
Daniel B. Botkin
April 2014



Climate Change, 1st Edition
Charles Fletcher
January 2013

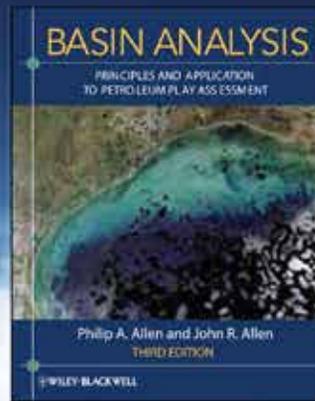
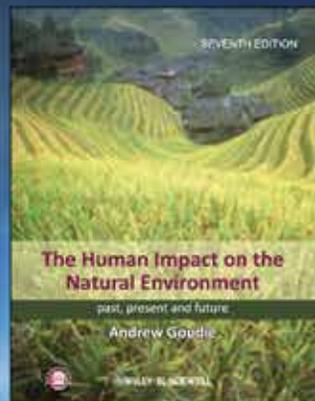
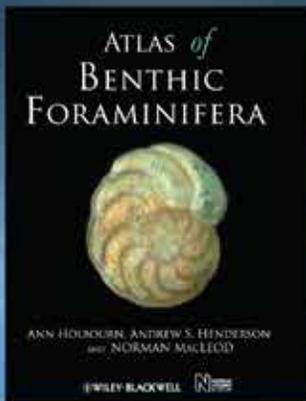


Earth Resources and Environmental Impact, 1st Edition
Kieran D. O'Hara
January 2014

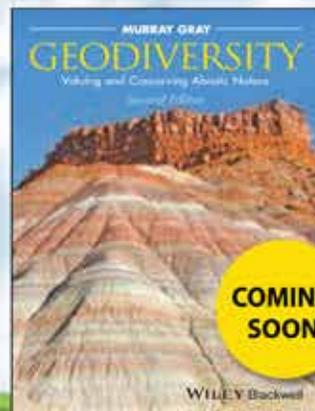
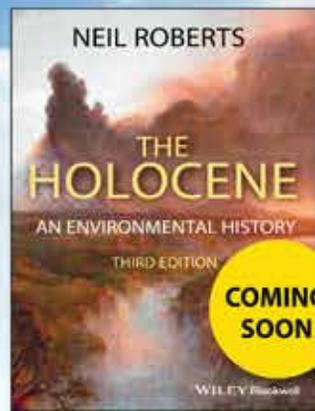
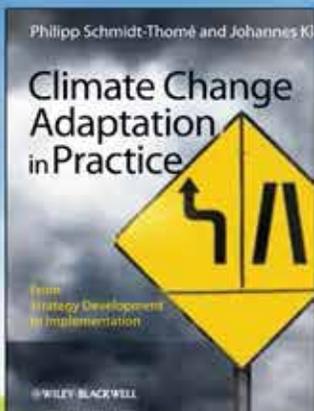
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www.wiley.com

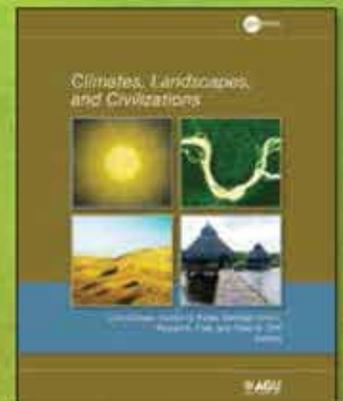
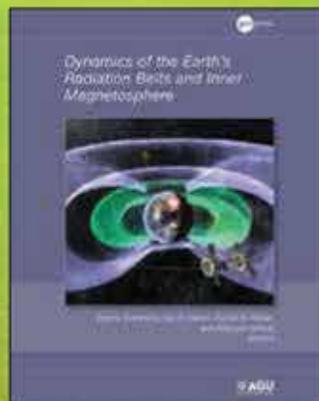
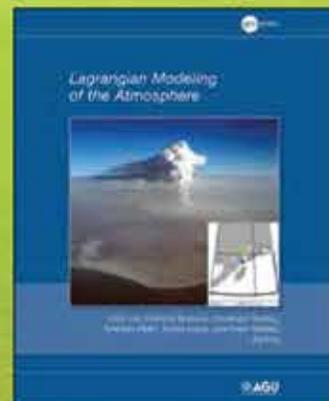
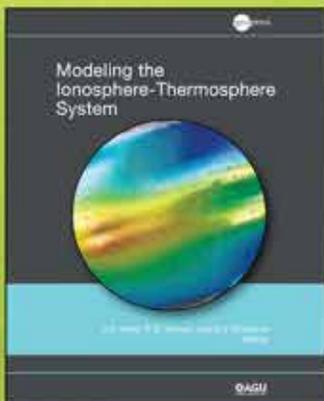
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Share Your Voice In GSA's Connected Community

This is the fourth installment in a series about GSA's new Connected Community. Past articles* have addressed how you can easily and securely log in through GSA's "single sign-on" system, set up your profile to make yourself visible in the Community, find contacts using a host of key variables, join or create interest groups, and extend the Annual Meeting experience beyond October. This month we'd like to talk about how and why you might use discussion forums (eGroups) in the Connected Community.

Your time is too valuable to waste in idle conversation that isn't relevant or valuable to you. GSA's Connected Community eGroups present an opportunity to find useful information from—and share ideas with—trusted colleagues, actually saving you time. GSA members are a select cohort of educated, focused, geoscience professionals. This is a Community for the earth science community. These are the people you'll want to engage with!

GSA eGroups combine the best of listserve and threaded discussion forum technology. They are the primary communications vehicle for large and small communities inside of GSA's Connected Community. Committees and interest groups can have private conversations, such as members of a field trip or researchers studying a common location, or users can participate in the Open Forum, which is an unsegmented exchange for everyone to use.

Are you looking for recommendations or have a question you'd like to ask your network? Using GSA eGroups, users can post, respond, or simply browse discussion threads. You'll receive an easy-to-read e-mail that contains a picture of the author linked to the author's profile, a link to the online archive where all postings are automatically stored, and a link to respond to either the author or the entire group.

Start new conversation topics or conduct research. Meeting presenters: Participate in discussion groups to showcase your session and generate interest in your topic. Consultants: Showcase your expertise and raise awareness on critical issues.

Take full advantage of the power of GSA's online resources, and join your colleagues today. Simply type community.geosociety.org into your web browser and click on "Help" for instructions on how to log in. You'll appreciate the growing collection of (archived and searchable!) information and data GSA eGroups generate.

▶ **HOT TIP:** Ask questions and post responses—it's quick and easy.

▶ **HOT TIP EXTRA CREDIT:** Customize your experience. Adjust your preference settings to include the receipt of real-time or daily digest postings, subscribe to RSS feeds, or opt for a mobile-friendly application.

Next month we'll talk about related Resource Libraries that add even more functionality to eGroup discussions.

Why would I use the Open Forum?

- Looking for a great value on lodging or a tasty pit stop recommendation from someone who has been working in your field location?
- Would you like an opinion on the efficacy of a new product you're considering?
- Have you heard of a great job opportunity?
- Did you find an extraordinary data link to share or a great classroom idea for your students?
- Wonder how other geoscience departments are managing issues?

Together we are smarter. Chances are someone knows the answer to your sticky problem. Or maybe you know the shortcut that someone else needs. The Connected Community can provide real solutions and immediate feedback to make your life easier.



We Believe in the Power of GSA's
Connected Community!
community.geosociety.org

*See the *GSA Today* website, www.geosociety.org/gsatoday/, for more articles about the Connected Community.

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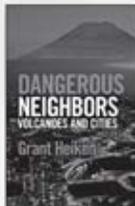
Roger Searle

\$80.00; Hb: 978-1-107-01752-8; 400 pp.

Dangerous Neighbors: Volcanoes and Cities

Grant Heiken

\$30.00; Hb: 978-1-107-03923-0;
204 pp.



Geochemical Rate Models

An Introduction to Geochemical Kinetics

J. Donald Rimstidt

\$80.00; Hb: 978-1-107-02997-2; 250 pp.

The Seismic Analysis Code

A Primer and User's Guide

George Helffrich, James Wookey, and
Ian Bastow

\$95.00; Hb: 978-1-107-04545-3; 176 pp.
\$55.00; Pb: 978-1-107-61319-5

Featured Textbooks

Earth Materials

Introduction to Mineralogy
and Petrology

Cornelis Klein and
Anthony Philpotts

\$200.00; Hb: 978-0-521-76115-4

\$99.00; Pb: 978-0-521-14521-3;
552 pp.

Essentials of Igneous and Metamorphic Petrology

B. Ronald Frost and
Carol D. Frost

\$125.00; Hb: 978-1-107-02754-1

\$65.00; Pb: 978-1-107-69629-7;
310 pp.

Second Edition!

Earth

Evolution of a
Habitable World

Jonathan I. Lunine

\$120.00; Hb: 978-0-521-85001-8

\$75.00; Pb: 978-0-521-61519-8;
327 pp.

Second Edition!

Dinosaurs

A Concise Natural History

David E. Fastovsky and
David B. Weishampel

\$72.00; Pb: 978-0-521-28237-6;

424 pp.

Modeling Volcanic Processes

The Physics and Mathematics
of Volcanism

Edited by Sarah A. Fagents,
Tracy K. P. Gregg, and
Rosaly M. C. Lopes

\$80.00; Hb: 978-0-521-89543-9; 431 pp.

Thermal Remote Sensing of Active Volcanoes

A User's Manual

Andrew Harris

\$160.00; Hb: 978-0-521-85945-5; 736 pp.

Antarctica

Global Science from a Frozen Continent

Edited by David W. H. Walton

\$55.00; Hb: 978-1-107-00392-7; 352 pp.

Prices subject to change.

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Linkages and Feedbacks in Orogenic Processes—A Conference Honoring the Career of Robert D. Hatcher Jr.

30 March–4 April 2014
Asheville, North Carolina, USA

CONVENERS:

Ryan Thigpen, *Western Hemisphere Exploration Team, BP America, Houston, Texas, USA, ryan.thigpen@bp.com*

Christopher Bailey, *Dept. of Geology, College of William & Mary, Williamsburg, Virginia, USA, cmbail@wm.edu*

Harold Stowell, *Dept. of Geological Sciences, University of Alabama, Tuscaloosa, Alabama, USA, hstowell@geo.ua.edu*

Richard Law, *Dept. of Geosciences, Virginia Tech, Blacksburg, Virginia, USA, rdlaw@vt.edu*

DESCRIPTION AND OBJECTIVES

This Penrose Conference will provide a forum to synthesize our understanding of orogenic systems, with specific emphasis placed on the consistent integration of multiple datasets that characterize process linkages and reconciliation of theoretical-numerical versus field-derived models. In collisional orogens, fundamental processes are inexorably linked, and as such, they exert higher-order controls on one another. For example, in many orogens, fault kinematics control the redistribution of heat-producing material and drive advection, which in turn sets up the thermal structure of the orogen. Thermal structure controls lithospheric rheology, which determines the nature and distribution of deformation and strain localization. The structural architecture governs fault kinematics, which act in conjunction with climate to focus erosional and exhumation processes. Therefore, explicit characterization of these links and their associated feedbacks are critical for understanding the evolution of orogenic systems.

Over the last decade, numerical and theoretical models of collisional systems have become increasingly complex, allowing explicit coupling of fundamental processes such as kinematics, mechanics, and thermal evolution at the whole orogen scale. At the same time, significant advancements have been made in the analysis of large multidisciplinary datasets and consequently, the solution space of enigmatic geologic problems has continued to shrink. To some degree, however, the progress achieved by this work is linked to our ability to reconcile what we observe in the field with model predictions, specifically with respect to the feedbacks between processes. We see this as an emerging knowledge gap, and will be using this

conference to bring together a critical mass of multidisciplinary researchers in order to address these questions.

This meeting will provide a forum for integration of fundamental orogenic process linkages and feedbacks at a variety of length and time scales. As such, we have organized six technical sessions representing four major process groups: (1) rheology and lithospheric strength; (2) thermal evolution and metamorphism; (3) kinematics, deformation, and strain localization; and (4) erosion, exhumation, and climate. Additionally, we will have two topical sessions focused on process rates and field integration/reconciliation of models. Each topical session will include talks and poster sessions. Presentations on studies that specifically address process linkage, including those that include numerical modeling of orogenesis or integrated field studies, are strongly encouraged.

PRELIMINARY AGENDA

This six-day meeting will start with an icebreaker in Asheville, North Carolina, USA, on the evening of Saturday, 29 March, and will be a balance of three days of field excursions and three days of talks and poster presentations. A two-day field trip that transects the southern Appalachian Valley and Ridge, Blue Ridge, and Inner Piedmont will commence at 8 a.m. on Sunday, 30 March. This area represents the primary study locale of Bob Hatcher's seminal career. Emphasis will be placed on examining the different structural styles, thermal effects, strain localization, and kinematics of multiple Paleozoic orogenies. The two-day excursion will start at the conference headquarters in Asheville and return on the following day, with an overnight stop in the Boone–Blowing Rock area. Another single-day mid-meeting field trip will examine the multiply reactivated Brevard fault zone and the extensive deformation and metamorphism in the Neocadian core of the southern Appalachians. The meeting will finish before lunch on Friday, 4 April.

ESTIMATED COSTS

The registration fee is estimated at US\$900–US\$1,100 and will cover the cost of the meeting, lodging (double occupancy), field trips, and most meals from 30 Mar.–4 Apr., including the conference dinner. Lunch will be provided each day on the field trips and during the meeting. **Not covered** is travel to and from Asheville, North Carolina, USA.

APPLICATIONS AND REGISTRATION

Application deadline: 1 Dec. 2013

Registration deadline: 1 Feb. 2014

The conference will be limited to 80 participants, and each participant will have to commit to attending the full six days of the conference. To apply, please contact the conveners at thigpe05@vt.edu with a letter of intent that includes a brief statement of interests, the relevance of your recent work to the themes of the conference, the subject of your proposed presentation, and contact information. Interested graduate students and early career faculty are strongly encouraged to apply. Once you have been selected to participate, you will be sent registration information.



Late winter view from the overlook at Camp Harrison looking west to the Blue Ridge. Grandfather Mountain, the high, snow-covered, jagged mountain in the distant left, along with Hawksbill, and Table Rock can be seen from the overlook on a clear day. Photo courtesy Arthur Merschat.

Association of Earth Science Editors
Annual Meeting



Native Resources: Building on the Bedrock of Geoscience Editing

October 10-12, 2013

Tulsa, Oklahoma

For details about the meeting
and AESE

www.aese.org

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SAGEEP 2014 March 16-20

Call for Session
Proposals

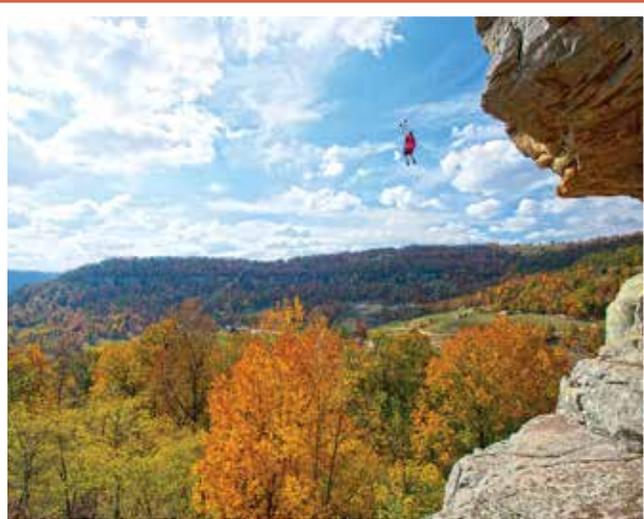
WWW.EEGS.ORG
SAVE THE DATES!

Preliminary Announcement & Call for Papers

SOUTH-CENTRAL

48th Annual Meeting of the South-Central Section,
GSA
Fayetteville, Arkansas, USA
17–18 March 2014

www.geosociety.org/sections/sc/2014mtg/



Horseshoe Canyon Ranch zipline near Jasper, Arkansas, USA; photo courtesy Arkansas Dept. of Parks & Tourism.

LOCATION

The 2014 South-Central Section meeting will be held at the University of Arkansas Global Campus and the Chancellor Hotel in Fayetteville, Arkansas, USA.

CALL FOR PAPERS

Abstract Deadline: 3 Dec. 2013

Technical Sessions

Please submit your abstract online at www.geosociety.org/Sections/sc/2014mtg/techprog.htm. A non-refundable submittal fee of US\$10/students and \$15/all others is required for each abstract submitted. If you cannot submit your abstract online, please contact Nancy Wright, +1-303-357-1067, nwright@geosociety.org.

Symposia Sessions

1. **Midcontinent Mississippian Surface and Subsurface Studies.** Christopher L. Liner, Univ. of Arkansas.

2. **Recent Induced/Triggered Seismicity in the Central and Eastern United States.** Scott Ausbrooks, Arkansas Geological Survey; Austin A. Holland, Oklahoma Geological Survey.
3. **Late Cretaceous Tectonics, Magmatism, and Sedimentation of the South-Central Region.** Bob Stern, Univ. of Texas at Dallas; Asish Basu, Univ. of Texas at Arlington; Peter Clift, Louisiana State Univ.

Theme Sessions

- T1. **Investigating Urban Karst Systems.** Douglas Gouzie, Missouri State Univ.; Marcus Gary, Aquifer Science.
- T2. **Karst Hydrogeology and Geomorphology.** Katherine Knierim, Univ. of Arkansas; Matt Covington, Univ. of Arkansas.
- T3. **Geothermal Energy and Its Significance as a Renewable Energy Resource.** Lea Nondorf, Arkansas Geological Survey; Bill Prior, Arkansas Geological Survey.
- T4. **Innovative Methodologies and Techniques in Geoscience Education.** René A. Shroat-Lewis, Univ. of Arkansas–Little Rock; Sandra Chandler, Arkansas Geological Survey.
- T5. **GIS and Geologic Mapping.** Jason Tipton, Arkansas Geological Survey; Brian Kehner, Arkansas Geological Survey.
- T6. **Undergraduate Research Poster Session** (cosponsored by Council on Undergraduate Research).
- T7. **Groundwater Quality in Gas Production Areas.** Timothy M. Kresse, U.S. Geological Survey; Phillip D. Hays, Univ. of Arkansas.

REGISTRATION

Early registration deadline: 10 Feb. 2014

Cancellation deadline: 18 Feb. 2014

Online registration opens in December. If you have questions or special requirements, please contact the local committee chair, Steve Boss, at sboss@uark.edu; or the technical program chair, Phil Hays, at pdhays@uark.edu. Detailed information is online. Anyone interested in proposing additional theme sessions or field trips should contact Phil Hays.

FIELD TRIPS

1. **Karst Hydrogeology of the Southern Ozarks.** Leader: J. Van Brahana, Univ. of Arkansas.
2. **Lower to Middle Mississippian Shelf to Basin Transect, SW Missouri and NW Arkansas.** Leader: Darwin Boardman, Oklahoma State Univ.
3. **Uppermost Mississippian Strata in the Ozarks—Recent Mapping of the Imo Interval in North-Central Arkansas.** Leaders: Richard Hutto, Arkansas Geological Survey; Erin Smart, Weatherford Laboratories; Angela Chandler, Arkansas Geological Survey.
4. **Quaternary Geology and Geomorphology of the Buffalo National Scenic River.** Leader: Stephanie L. Shepherd, Bloomsburg, Univ. of Pennsylvania; Amanda Keen-Zebert, Desert Research Institute; Mark Hudson, U.S. Geological Survey.
5. **Middle and Late Morrowan Depositional History and Sequences of Northwest Arkansas.** Angela Chandler, Arkansas Geological Survey; Doy Zachry, Univ. of Arkansas; Walter Manger, Univ. of Arkansas.

ACCOMMODATIONS

The Hotel Chancellor will be the conference hotel this year with its ideal location adjoining the University of Arkansas Global Campus in downtown Fayetteville.

Rates: US\$129 (+tax) per room per night; a limited number of student rooms are available for US\$99 and can accommodate up to four people. To receive the discounted room rates you must **call** the hotel at +1-855-285-6162 to make your reservation (the conference rate cannot be given online), tell them you are reserving the room for the upcoming GSA South-Central Meeting, and let them know you would like the student rate. Students will be required to show a valid college ID onsite to get the student room rate.

Parking: The hotel offers free parking for guests. For those not staying in the Hotel Chancellor, the Fayetteville Chamber of Commerce will provide tokens for free parking in the Fayetteville Town Center parking deck one block from the conference location.

OPPORTUNITIES FOR STUDENTS

Mentor Programs

www.geosociety.org/mentors/

The **Roy J. Shlemon Mentor Program in Applied Geosciences** is designed to extend the mentoring reach of individual professionals from applied geology to undergraduate and graduate students. Students and mentors: Join us for a free lunch on Monday, 17 March. Space is limited—first come, first served.

The **Mann Mentors in Applied Hydrogeology Program** presents mentoring opportunities for undergraduate, graduate, and recent graduate students with a declared interest in applied hydrogeology as a career. Lunch will be provided for students and mentors on Tuesday, 18 March. Space is limited—first come, first served.

Travel Grants

Application deadline: 10 Feb. 2014

The GSA Foundation and the GSA South-Central Section will provide funds to help undergraduate and graduate student members of GSA come to the meeting, with awards of up to US\$200. Watch the meeting website for application criteria and the online application system opening in December 2013. For more information, contact the section secretary, Jay Sims, wmjaysims@gmail.com.

Volunteers

Student volunteers are requested to assist with meeting activities including assistance in the Speaker Ready Room and at technical sessions and symposia. GSA will cover the cost of meeting registration for student volunteers who commit to a minimum of half a day of service during the meeting.

Outstanding Student Poster Program

First place undergraduate and graduate awardees receive complimentary registration to the 2014 GSA Annual Meeting in Vancouver, British Columbia, Canada, a cash award, and their posters will be prominently displayed at the GSA Annual Meeting.

COMMITTEE CHAIRS

General Chair: Stephen Boss, sboss@uark.edu

Technical Program Chair: Phil Hays, pdhays@uark.edu

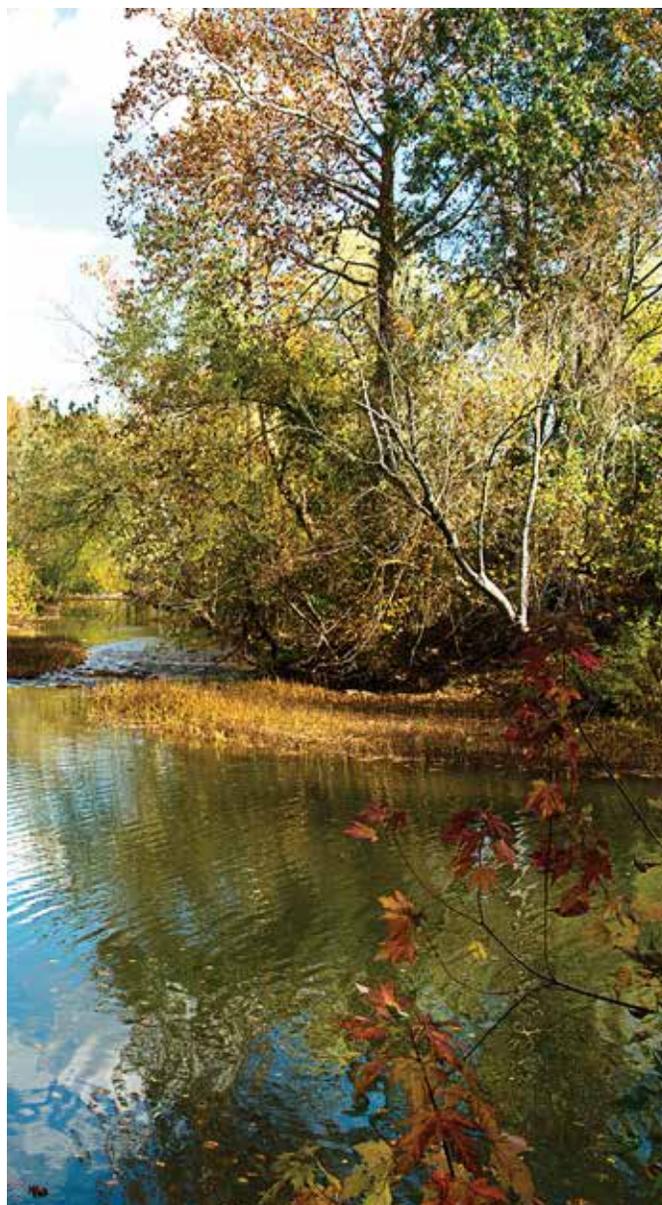
Field Trip Chair: Erik Pollock, epollock@uark.edu

Media Relations: Jo Ann Kvamme, jkvamme@uark.edu

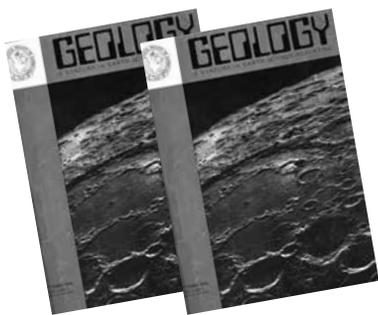
K–12 Teacher Program Chair & Community College Liaison:
Position Open

Event Coordinator: Jo Ann Kvamme, jkvamme@uark.edu

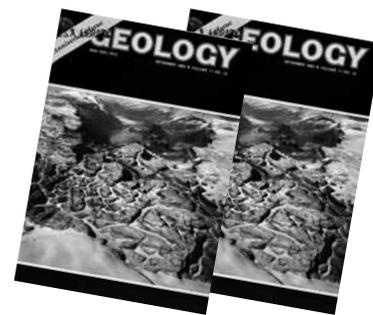
Student Volunteer Chair: Doy L. Zachry, dzachry@uark.edu



Strawberry River in northern Arkansas, USA, is an ~115-mile-long tributary of the Black River; photo courtesy Arkansas Dept. of Parks & Tourism.



Geology—Past & Future REVISITED



Editor's note: The following is the second installment of our encore presentation of articles highlighting the 10th anniversary of the first issue of *Geology*, as published in *Geology* in Dec. 1983 [v. 11, no. 12, p. 679–691, doi: 10.1130/0091-7613(1983)11<679:GAF>2.0.CO;2]. Each section was written by a different author (author affiliation notations are as originally published in 1983). See the August 2013 *GSA Today* (v. 23, no. 8, p. 18–19) for the first installment and table of contents. In this issue: article 4: “Solid earth geophysics,” by Don L. Anderson; and article 5: “Geology and public policy,” by Priscilla C. Grew.

Solid earth geophysics

Don L. Anderson, *Seismological Laboratory, California Institute of Technology, Pasadena, California 91125, USA*

Ten years ago seismologists were, or thought they were, putting the finishing touches on average Earth models, including the so-called radially symmetric reference Earth model, and were starting to devote their attention to lateral variations. It was clear, even then, that the mantle was heterogeneous everywhere, not just in the lithosphere and asthenosphere, but it was not clear how these anomalies related to surface tectonics.

We were much further away from an average Earth model than we thought but are now much closer to having a three-dimensional description of the mantle than we anticipated. The recognition that anelastic dispersion causes the elastic properties to be frequency dependent made it possible to reconcile free oscillation, surface-wave data, and body-wave data. The concept of a global, partially molten low-velocity zone [LVZ], almost universally accepted a decade ago, suffered several setbacks. First, the anelasticity-corrected velocities in the LVZ were much greater than previously thought, removing the necessity of partial melting except in local areas. Second, subsolidus mechanisms of attenuation such as dislocation relaxation were found to decrease velocities as much as partial melting. Third, it was discovered that the surface-wave data could not be explained without anisotropy in the upper mantle, and this effect caused the estimates of the velocities in the LVZ to be increased still further. Attempts to derive an average Earth model that was consistent with a variety of seismic data had to start anew and incorporate anelasticity and anisotropy. The present situation is that velocities above 200 km can be explained in most regions by oriented olivine crystals, and partial melting is required only in regions having anomalously low velocities, such as continental rifts, particularly the Red Sea–Gulf of Aden and parts of western North America, back-arc basins, and some ridge segments. We had only a very crude description of the geoid and a poor idea of its relation to surface tectonics and mantle structure.

Tomographic techniques are now being applied to a variety of deep Earth problems, and information is accumulating rapidly on lateral heterogeneity, anelasticity, and anisotropy. Hundreds of surface-wave paths and millions of body-wave paths are being inverted in global approaches to Earth structure. Deep crustal reflection data are rapidly being accumulated. Satellite techniques are being used to map the geoid on smaller and smaller scales.

Ten years from now, a global digital seismic network of perhaps 200 stations will be recording in real time via satellite telemetry. Floppy or laser discs will have replaced film clips. Transportable seismic arrays of up to 1,000 elements will have surveyed the crust and upper 400 km of the mantle of most of the tectonically interesting areas of North America. About 10 seismic crews will be mapping, on a global basis, the deep crust and upper mantle, using combined reflection, refraction, and three-dimensional imaging techniques. A complete description of the geoid and Earth's gravity and magnetic fields will be available with a horizontal resolution of 100 km. We will be able to model steady and nonsteady convection in three dimensions, including the effects of layering, partial melting and phase changes, and temperature- and stress-dependent rheology. Ten years from now we should have complete global maps of mantle seismic velocities, with a 500-km lateral resolution, and maps of anelasticity and anisotropy. The resultant direct view of mantle convection, as well as high-resolution geoid maps and three-dimensional convection calculations, will shed light on the driving mechanism for plate tectonics and the depths of continents, mountains, ridges, and plumes. The geoid should be understood in great detail. The relation of mantle anomalies to the geoid and the spin axis will stimulate research into the relationship between true polar wander and the episodicity of plate motions. Crude maps of lateral heterogeneity in the core should also be available.

High-pressure and high-temperature data possibly will be interpreted in terms of composition, temperature, and stress.

(Contribution No. 3962, Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena, California 91125, USA.)

† Send brief comments to gsatoday@geosociety.org. Should this article spark a longer comment, please consider writing a *GSA Today* Groundwork or science article; learn more at www.geosociety.org/gsatoday/.

Geology and public policy

Priscilla C. Grew, California Public Utilities Commission, San Francisco, California 94102, USA.

“Knowledge without conscience is the ruination of the soul.”
—François Rabelais (1532)

A decade ago, printouts from the MIT computers showed that if world population continued to grow exponentially, food production could not keep pace with human needs, and available resources of fuel and nonfuel minerals would dwindle within a century. Dismissed by some as “less than pseudoscience and more than polemical fiction,” these *Limits to Growth* (D.H. Meadows et al., 1972) projections nevertheless presaged the preoccupations of the decade in geology and public policy. Since 1973, geologists have been deeply involved in increasing resource production and in mitigating adverse environmental impacts of resource consumption. Familiar issues include enhanced recovery of petroleum and geothermal resources; siting of nuclear power plants and management of nuclear waste; reclamation of mined land; and management of toxic wastes to prevent groundwater contamination. Work has begun on determination of soil-loss tolerances for sustained crop production. Continued growth of urban areas has intensified the need for mitigation of the hazards associated with earthquakes, floodplains, volcanic eruptions, and landslides.

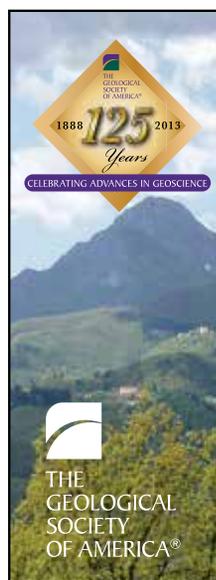
Today we complacently enjoy a “time-out” in the resources crisis, but as scientists we must remain alert to portents of additional trouble in the coming decade. Federal support for scientific education and non-defense-related research continues to decline, with persistent disregard for long-term needs of our society. There are significant new threats to international scientific cooperation. And, although a comprehensive nuclear test ban is one of the “arms control imperatives for the coming decade,” as Stanley Hoffman says, fewer earth scientists today work on arms control issues than a decade ago.

In 1973, Glenn Seaborg proclaimed that “we are entering the world’s greatest era of international science cooperation.” The U.S.

had launched the first Earth Resources Technology Satellite in 1972, and its data were to be “available to everyone.” Nixon and Brezhnev were promoting the exchange of 500 scientists, including specialists in earthquake prediction, genetic effects of toxic chemicals, and environmental impacts of offshore oil production. In 1983, the Office of Science and Technology Policy, the National Security Council, and the Departments of State, Defense, and Energy are all studying how to restrict international scientific exchanges and control the release of unclassified information at scientific meetings. Admiral Bobby Inman puts it bluntly—he says we should sacrifice our academic freedom in order to restrict the flow of scientific ideas to the Soviet Union. As geologists, we should prepare to respond to this challenge.

Nuclear-arms control has reappeared as a central policy issue since the Cold War resumed in 1980. Many today would join Andrei Sakharov in saying that “averting thermonuclear war has absolute priority over all other problems of our times.” But the arms talks resemble the thirteenth-century debate on how many angels fit on the head of a pin—how many MIRVs go on the head of an ICBM? Does geology still have a role in this era? Yes, because verification of underground weapons testing is still a key issue. In 1982, the U.S. discontinued talks on a comprehensive test-ban treaty, claiming that seismic techniques are inadequate to police a ban. President Reagan complains that the Soviet Union has violated the 150-kiloton limit set by the Threshold Test Ban Treaty of 1974. But Lynn Sykes and Jack Evernden argue that we could indeed verify a comprehensive ban, because we now have the scientific capability to monitor Soviet explosions one-fifteenth the size of the Hiroshima bomb. Sykes also questions whether the Soviets have actually violated the 150-kiloton limit. If earth scientists do not participate in resolving these issues, the U.S. may decide to retaliate by testing above the 150-kiloton limit or may insist on a verification program on-site that can never be agreed upon.

In the coming decade, we should use our scientific knowledge in good conscience to promote international cooperation and prevent a thermonuclear war. Of course, that’s just common sense. But in the society of 1984, “the heresy of heresies is common sense,” as George Orwell put it. To heed the warning of Rabelais may not be as easy as we think.



Celebrate GSA's 125th Anniversary!

Propose a Penrose Conference or Field Forum

Penrose Conferences bring together multidisciplinary groups for open and frank discussion of geoscience research and ideas in an informal atmosphere, on location in some of the most fascinating places in the world. Learn more at www.geosociety.org/penrose/.

Field Forums capture the essence of exciting discoveries or controversial topics via forays into the field for on the spot discussions. Learn more at www.geosociety.org/fieldforums/.

March 2012 Penrose Conference location: Castelvechio Pascoli, Lucca, Italy.





GSA FOUNDATION UPDATE

P. Geoffrey Feiss, GSA Foundation President

GIVE 125

Can you think of 125 ways to support or honor GSA? The Give 125 fundraising effort invites members to exercise their creative spirits and celebrate GSA's 125th anniversary through philanthropy. To date, 286 members have made gifts of their time, talent, and financial resources in order to advance GSA's mission of science, stewardship, and service. Members have shared some of the following examples on the Give 125 website comment section:

- Organizing a badge workshop for Junior Girl Scouts;
- Presenting to a group of “tweens” (ages 10–12) about geosciences at Adolphine Fletcher Terry Library in Little Rock, Arkansas, USA, including making “fossils” with Play-Doh, plastic dinosaurs, and glitter glue!
- Two members have each named the GSA Foundation in their wills in the amount of US\$125,000;
- Numerous gifts of US\$125, totaling more than US\$38,000, will support a range of priorities, including the *On To The Future* effort to bring 125 students from diverse backgrounds to this year's annual meeting.

The generosity of GSA members is a defining aspect of this community of geoscientists and has touched the lives and careers of many students and professionals. As GSA approaches a remarkable milestone in its history, I invite you to join thousands of other members who support GSA through their gifts to the Foundation. You can give what makes the most sense for you—dollars, time, possessions, and/or your skills and talents. Work with other members to pool your resources and talents to tackle a Give 125 project. Track your time and donations online at www.geosociety.org

www.geosociety.org/125. You can also choose GIVE 125 when renewing your membership. All participants will be recognized with a special memento at the 2013 GSA Annual Meeting & Exposition in Denver, Colorado, USA, on 27–30 October 2013.

Learn more at www.geosociety.org/125/give125.asp. Thank you, and remember that GIVE 125 supports and celebrates GSA's mission of science, stewardship, and service!

QUIZ RESULTS

GSA member **Linda Kyle** is the winner of the July GSA *Today* Foundation Anniversary Quiz. Linda correctly answered the following quiz questions:

- Q. **The first GSA memoir in 1934 was made possible by the Penrose bequest. What was the topic and who were the authors?**
- A. The first GSA memoir, *Stratigraphy of Western Newfoundland*, published in 1934, was written by Charles Schuchert and Carl Owen Dunbar.
- Q. **What was the first associated society and when did this association commence?**
- A. The first associated society was the Paleontological Society. The association commenced in 1909.

Linda will receive a copy of *GeoTales V*.
Congratulations Linda!



Test your GSA knowledge!

1

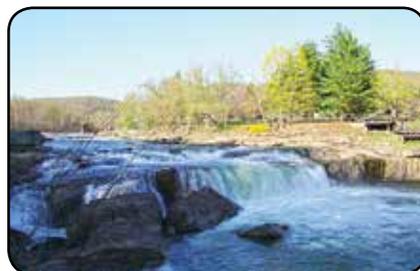
Among the giants of 19th century geology were the four leaders of the western surveys which preceded the creation of the USGS. Three lived to see the creation of GSA in 1888 (John Wesley Powell, Major George Wheeler, and Clarence King; Ferdinand Vandever Haydin died in 1887). Which one(s) served as a president of GSA?

Please submit answers by the end of the month to gsaf@geosociety.org

One winner will be selected each month to receive a copy of *GeoTales V: A Collection of Stories & Memories Written by GSA Members*.



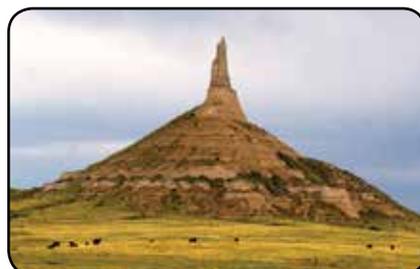
SOUTH-CENTRAL SECTION
Fayetteville, Arkansas, USA
17–18 March 2014
 University of Arkansas Global
 Local Committee chair: Steve Boss
 Abstracts deadline: 3 Dec. 2013
 Early registration deadline: 10 Feb. 2014



NORTHEASTERN SECTION
Lancaster, Pennsylvania, USA
23–25 March 2014
 Lancaster Marriott
 Local Committee co-chairs: Noel Potter
 and Roger Thomas
 Abstracts deadline: 10 Dec. 2013
 Early registration deadline: 18 Feb. 2014



SOUTHEASTERN SECTION
Blacksburg, Virginia, USA
10–11 April 2014
 Skelton Conference Center at Virginia Tech
 Local Committee chair: Robert Tracy
 Abstracts deadline: 7 Jan. 2014
 Early registration deadline: 10 Mar. 2014



NORTH-CENTRAL SECTION
Lincoln, Nebraska, USA
24–25 April 2014
 Cornhusker Marriott
 Local Committee chair: Matt Joeckel
 Abstracts deadline: 14 Jan. 2014
 Early registration deadline: 24 Mar. 2014



**ROCKY MOUNTAIN/
 CORDILLERAN SECTIONS**
Bozeman, Montana, USA
19–21 May 2014
 Montana State University,
 Strand Union Building
 Local Committee chair: Dave Lageson
 and Jeff Vervoort
 Abstracts deadline: 11 Feb. 2014
 Early registration deadline: 14 Apr. 2014



Wilson Park, Fayetteville, Arkansas; used with permission of Wikimedia Commons.

Ohioyle falls at Ohioyle State Park, Ohioyle, Pennsylvania; used with permission of Wikimedia Commons.

Blue Ridge Mountains, Shenandoah National Park, Virginia. Photo by Amrinder Arora; used with permission of Wikimedia Commons.

Chimney Rock National Historic Site, Morrill County, Nebraska. Photo by Allen Stutheit; used with permission of Wikimedia Commons.

Grinnell Glacier, Glacier National Park, Montana. Public Domain.



GSA's New Storefront

GSA has launched a new online store that is easy to use and easy on the eyes. It looks and acts like websites you visit every day.

- Details on what books are in press, plus a way to request notification when they become available
- Suggestions of books in your interest area as you shop

What's the same:

You can browse all of GSA's offerings:

- Publications (Special Papers, Memoirs, Field Guides, Reviews in Engineering Geology volumes, maps and charts, meeting abstracts, and more)
- Specialty books from other publishers
- Rite in the Rain products
- Educational materials
- EarthCache items (Geocoins, pins, caps, etc.)

What's new:

- Better searching capabilities and streamlined navigation
- More choices for books—print, PDF, Google e-books
- Links to e-versions of books not available in print

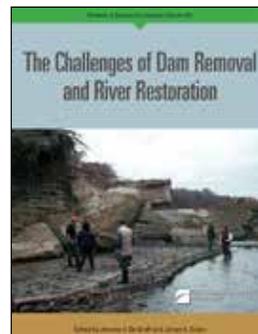
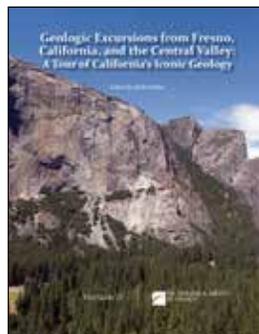
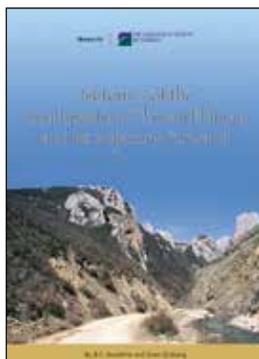
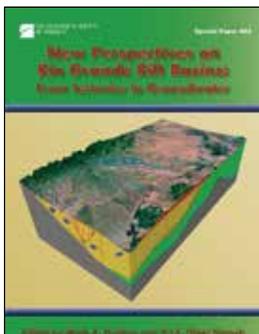
Take it for a test drive!

Visit the site at <http://rock.geosociety.org/store/> and browse all you like. When you decide to make a purchase, you'll be asked to log in using your GSA username and password. These credentials are the same ones you would use to log in to the GSA Connected Community pages at <http://community.geosociety.org/>.

GSA Members already have a profile in the system populated from GSA's membership data—all you have to do is activate it to get your username and login.

Not a GSA member? It's easy to log in. Learn how at <http://community.geosociety.org/Help/>.

<http://rock.geosociety.org/store/>



Classified Rates—2013

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. Contact advertising@geosociety.org, +1.800.472.1988 ext. 1053, or +1.303.357.1053. All correspondence must include complete contact information, including e-mail and mailing addresses. To estimate cost, count 54 characters per line, including punctuation and spaces. Actual cost may differ if you use capitals, boldface type, or special characters. Rates are in U.S. dollars.

Classification	Per Line for 1st month	Per line each addt'l month (same ad)
Positions Open	\$9.00	\$8.75
Fellowship Opportunities	\$9.00	\$8.75
Opportunities for Students		
First 25 lines	\$0.00	\$4.75
Additional lines	\$4.75	\$4.75

Positions Open

LECTURER OR SENIOR LECTURER DIVISION OF EARTH SCIENCES NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

The Division of Earth Sciences was founded in 2011 as the academic arm of the Earth Observatory of Singapore (EOS). The Division and the Observatory are working in partnership to develop academic capacity in areas such as the sustainable use of energy and water resources, the identification of and adaptation to natural hazards and changing climate, and the environmental consequences of human activities. DES will be launching a new undergraduate major and minor to support this mission.

For more information please visit us on the Web: www.earthobservatory.sg/ and www.spms.ntu.edu.sg/des/.

Position Description: We are seeking an Earth scientist for a lecturer position in the Division of Earth Sciences at Nanyang Technological University in Singapore. The lecturer will develop and teach introductory and advanced courses including laboratory and/or discussion sessions for the undergraduate major and minor. They also may participate in undergraduate advising, mentoring undergraduate research projects, promoting the undergraduate programme at the pre-University level, and developing and teaching undergraduate field courses.

The position will be appointed for a 1–3 year term, with the possibility to renew. The Lecturer is a member of the Division of Earth Sciences reporting to the Head of the Division. He/she will work closely with the Head of Division, the Undergraduate Programme Director, the Field and Laboratory Coordinator, members of the Office of Education and Outreach, and other members of the faculty.

Required Qualifications

- Ph.D. in Earth Science or a related field;
- Effective oral and written communication skills in English;
- Strong interest in and aptitude for teaching and mentoring at the undergraduate level;
- Ability to work well with a team in a dynamic working environment;
- Strong organizational and project management skills.

Preferred Qualifications

- Ability to teach GIS, field courses, and/or advanced courses in the field of their expertise;

- Experience teaching about the Earth from a systems perspective.

To apply, please submit the following materials to eos_humanresources@ntu.edu.sg:

- Statement of university teaching and/or laboratory experience;
- Curriculum vitae; and
- The names of 3 references who are familiar with your work.

For additional information, please contact the Undergraduate Programme Director, Dr. Malinda Kent-Corson, at mkentcorson@ntu.edu.sg. Review of applications will continue until the position is filled.

FACULTY POSITION EARTH SURFACE PROCESSES/ GEOMORPHOLOGY NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

The Division of Earth Sciences and the Earth Observatory of Singapore at Nanyang Technological University, Singapore invites applications for a tenure-track position in geomorphology/Earth surface processes with emphasis on the geomorphic response to climate and/or anthropogenic change. Specific areas of interest include (but are not limited to) **physical, chemical, and/or biological aspects of Earth-surface dynamics and evolution or changes in the Earth's surface** as a result of human and natural impacts. Research approaches should encompass some combination of field, laboratory, and modeling. We seek an individual with research interests

that augment our existing strengths in Earth systems science and surficial processes. This position is part of the continued expansion of the Division of Earth Sciences with the Earth Observatory of Singapore.

We invite candidates who have developed an internationally recognized, externally funded, multi-disciplinary research program to apply at the assistant, associate or full professor level. Successful candidates will also be required to actively participate in our core undergraduate and graduate teaching and in the administration of the Division of Earth Sciences.

To apply, please submit the following materials to: eos_humanresources@ntu.edu.sg

- Statement of research and teaching interests;
- Curriculum vitae;
- A copy of three relevant publications; and
- The names of three references who are familiar with your work.

Further information about the Division of Earth Sciences and the Earth Observatory of Singapore is available at www.earthobservatory.sg. Contact cmrubin@ntu.edu.sg for job specific information. Review of applications will begin on 1 Feb. 2014 and will continue until the position is filled.

RESEARCH POSITION COASTAL PALEOSEISMOLOGY/QUATERNARY ENVIRONMENTAL CHANGE NANYANG UNIVERSITY, SINGAPORE

The Earth Observatory of Singapore, Nanyang Technological University, invites applications for a



GEOLOGIST

The Department of Atmospheric, Oceanic, and Earth Sciences invites applications for a full-time, term faculty position in geology starting January 10, 2014. We seek a dynamic educator with extensive teaching expertise in geology and earth science. Preference will be given to candidates whose specialty is in earth science education, geology lab management, and in emerging educational technologies, especially the development of online introductory geology courses. The successful candidate will be expected to have excellent teaching and organizational skills, a dynamic and welcoming personality, to participate in undergraduate program management, and to engage students using innovative technology. Teaching duties will be at the undergraduate level including: physical geology, historical geology, and associated labs; as well as the development of innovative general education geology courses. A Ph.D. in geology with teaching experience is preferred but exceptional candidates with a M.S. in geology and at least five years of college-level teaching experience will be considered. Degrees and experience are required by the start date.

The Department offers undergraduate degrees in Geology and Earth Science and a Ph.D. in Climate Dynamics. Also, the geology faculty has recently moved into a new science building with four innovative geology laboratory classrooms.

For full consideration, applicants must apply online at <http://jobs.gmu.edu> for position number F9723z; upload a CV; a letter of intent; a statement of teaching experience, interests and innovations; teaching evaluations (if available); and contact information (with e-mail addresses) of five references. AA/EOE

Research Fellow (post-doctoral level) in Coastal Paleoseismology/Quaternary Environmental Change.

This project is part of an on-going program to recover stratigraphic records of past earthquakes and tsunamis, and sea-level change in Indonesia. Skills in quantitative micropaleontology/palaeoenvironmental reconstructions and/or sedimentology of coastal systems are highly desirable. The candidate is required to have a Ph.D. in coastal geomorphology/geology.

The coastal paleoseismic project is led by Charles Rubin and Ben Horton and supported by the Earth Observatory of Singapore. All applicants should demonstrate a clear desire for adventurous fieldwork and exceptional science. Further details may be obtained from the Earth Observatory of Singapore, Nanyang Technological University cmrubin@ntu.edu.sg

Initially the contract duration will be 2 years, although a longer period (up to 4 years) can be negotiated. Excellent knowledge of English, both in speaking and writing, is a requirement.

International candidates are highly encouraged to apply. Applications should include a CV, list of publications, a short (1-page) synopsis of previous research achievements and research plans, and the names of at least two references.

Applications and inquiries should be sent electronically to eos_humanresources@ntu.edu.sg

We will begin reviewing applications 1 Feb. 2014. However, applications will be reviewed until the position is filled.

**TENURE-TRACK FACULTY POSITION
PETROLOGY/MINERAL RESOURCES
CALIFORNIA STATE POLYTECHNIC
UNIVERSITY, POMONA**

The Geological Sciences Dept. invites applications for an Assistant Professor tenure-track appointment beginning September 2014. Applicants must hold a Ph.D. in Geology or a related field by August 2014. The ideal candidate will have teaching and research interests in areas of "hard-rock geology" that emphasize practical applications of petrologic field and laboratory studies to structural, tectonic and/or mineral resource problems. We seek an enthusiastic instructor for undergraduate courses in Igneous/Metamorphic Petrology, Field Methods/Field Modules, Mineralogy, Megascopic Petrography, willing to co-teach Optical Mineralogy. Preferred areas of specialization include but are not limited to Geochronology, Economic Geology, Igneous or Metamorphic Petrology, High Temperature/Isotope Geochemistry, Volcanology. The successful candidate is expected to ensure that our curriculum in their specialty area remains current, engage students in research and supervise MS and senior theses. He/she must have experience with field studies and data collection using modern instrumentation and ability to manage our Petrology/XRF/XRD analytical laboratory. Preferred qualifications include demonstrated success with external funding, established ties to research institutions, mining industry or government agencies and interest in developing intradepartmental and cross-campus collaborations. Applicants must submit a signed application form (<http://academic.csupomona.edu/faculty/docs/application.pdf>), letter of interest, CV, statement of teaching and research interests, and

contact information for five professional references. A campus interview, three formal reference letters and official confirmation of degree transcripts are required of all finalists. Initial screening begins 6 Jan. 2014. Mail application materials to Petrology Search Chair, Geological Sciences Dept., California State Polytechnic University, Pomona, CA 91768. Cal Poly Pomona is an affirmative action, equal opportunity employer. Full Position Description: <http://geology.csupomona.edu/employment.htm>.

**SEDIMENTARY BASIN ANALYSIS AND
MODELING POSITION, BERG-HUGHES
CENTER AND DEPT. OF GEOLOGY
AND GEOPHYSICS
TEXAS A&M UNIVERSITY**

The Berg-Hughes Center for Sedimentary and Petroleum Systems and the Dept. of Geology and Geophysics at Texas A&M University invite applications from individuals for a non-tenure-track, three-year renewable contract position as a research professor (assistant to full professor ranks will be considered) in Sedimentary Basin Analysis and Modeling beginning 1 Jan. 2014. This position will be a joint appointment with teaching, research and service responsibilities in the Berg-Hughes Center and Dept. of Geology and Geophysics.

The principal responsibility of this position is to spearhead the collaborative research and teaching programs in the newly established Chevron-TAMU/BHC Basin Modeling Center of Research Excellence in the Berg-Hughes Center and Dept. of Geology and Geophysics. This responsibility includes leading in the development of a robust externally funded research program in basin analysis and modeling that includes research collaboration with researchers in the petroleum industry; teaching integrative courses that introduce advanced concepts and technologies needed for unraveling the geohistory of sedimentary basins and the origin and distribution of unconventional and conventional petroleum resources inherent to sedimentary basins; and supervising graduate students and mentoring faculty in the use of sophisticated computational and applied research approaches and techniques to solve complex geologic problems.

We seek candidates who have had experience in sedimentary basin analysis and modeling and can serve as a team leader on multi-disciplinary research projects, and who have demonstrated the ability to develop and maintain an externally funded research program. Applicants must have a record of success in working collaboratively with researchers in academia and the petroleum industry and be enthusiastic about teaching integrative courses and supervising graduate students in basin analysis, basin architecture, basin modeling, basin geodynamics, and related areas.

Applicants must have an earned Ph.D. at the time of appointment. Successful applicants will be expected to teach effectively at the graduate level in basin analysis and modeling and related fields and in team taught courses, including classes in the Petroleum Certificate curriculum and to supervise undergraduate, M.S. and Ph.D. research, including students who are interested in pursuing careers in the petroleum industry. Applicants are expected to build and maintain a collaborative research program with colleagues in the College of Geosciences, the Berg-Hughes

Center, the Dept. of Geology and Geophysics, the Dept. of Petroleum Engineering, and other energy related groups at Texas A&M University and the Texas A&M University System and with geoscientists and petroleum engineers in the oil and gas industry and other national and international research institutions.

Interested candidates should submit electronic versions of a letter of application, curriculum vita, statement of research vision, strategies to implement that vision, accomplishments, teaching philosophy, and the names and email addresses of at least three references to the Chair of the Basin Analysis and Modeling Search Committee (mcpope@geos.tamu.edu). Screening of applications for the position will begin 1 Oct. 2013 and will continue until the position is filled.

The Berg-Hughes Center (berg-hughes.tamu.edu) and the Dept. of Geology and Geophysics (geoweb.tamu.edu) are part of the Texas A&M University College of Geosciences, which also includes the Departments of Atmospheric Sciences, Geography, and Oceanography; the Geochemical and Environmental Research Group (GERG); and the Integrated Ocean Drilling Program (IODP). Texas A&M University, a land-, sea-, and space-grant university, is located in a metropolitan area with a dynamic and international community of 172,000 people. Texas A&M University is an affirmative action/equal opportunity employer committed to excellence through the recruitment and retention of a diverse faculty and student body and compliance with the Americans with Disabilities Act. We encourage applications from minorities, women, veterans, and persons with disabilities. Texas A&M University also has a policy of being responsive to the needs of dual-career partners.

**LECTURER
DEPT. OF GEOLOGY AND GEOGRAPHY
COLLEGE OF SCIENCES AND MATHEMATICS
AUBURN UNIVERSITY**

The Dept. of Geology and Geography at Auburn University invites applications for a 9-month non-tenure track faculty position in geology beginning 1 Jan. 2014. The position is a one-year appointment subject to annual review based on performance and funding. The candidate should be pedagogically trained to teach courses in physical geology and historical geology.

Applicants must have either a Ph.D. or M.S. in Geology/Geoscience with demonstrable teaching experience, and those with pedagogical/education coursework and/or degrees are preferred. The successful candidate will: teach three or more lecture sections and possibly one or more lab sections per term; serve as laboratory coordinator in charge of weekly meetings with GTAs, and interface regularly with instructors; supervise, mentor, and evaluate GTAs; be in charge of lab evaluations and assessments and make sure that the labs are maintained; and participate in STEM activities and grant-writing opportunities in conjunction with the Director of Outreach, College of Sciences and Mathematics. Required qualifications include exemplary communication, teaching, and interpersonal skills. The candidate selected for the position must meet eligibility requirements to work in the United States at the time the appointment begins.

Review of applications will begin 15 Aug. 2013, and will continue until a suitable applicant is found. Applicants should submit curriculum vitae, a letter of application (1–2 pages) describing teaching philosophy and experience, and the names and contact information of at least three references.

In order to apply for this position and view full details, please visit our online website at <https://aufacultypositions.peopleadmin.com/postings/179>

Applicants are encouraged to visit the AU website to learn more about Auburn University and the Dept. of Geology and Geography (www.auburn.edu/academic/cosam/departments/geology/).

In support of our strategic plan, Auburn University will maintain its strong commitment to diversity with standards to help ensure faculty, staff, and student diversity through recruitment and retention efforts. Auburn University is an Affirmative Action/Equal Opportunity Employer. **Women and minorities are encouraged to apply.**

**TENURE TRACK FACULTY POSITION
GEOMORPHOLOGY/SURFICIAL PROCESSES
DEPT. OF GEOLOGY AND GEOGRAPHY
AUBURN UNIVERSITY**

The Dept. of Geology and Geography at Auburn University invites applications for a tenure-track Assistant Professor position in the field of Geomorphology/Surficial Processes to begin Fall Semester 2014. Opportunities exist for collaboration with related on-campus programs including units in the College of Sciences and Mathematics, College of Agriculture, College of Engineering, and School of Forestry and Wildlife Sciences.

The successful candidate will be expected to teach at the undergraduate and graduate levels including a geomorphology/surficial processes course as well as general education classes such as Physical Geography, Physical Geology, and/or World Regional Geography and to establish a productive record of independent research, extramural funding, and publication. A Ph.D. in Geography or related field is required at the time of appointment. Desired qualifications include training in both geology and geography. The candidate selected for this position, which begins August 2014, must meet eligibility requirements to work in the United States on the date the appointment is scheduled to begin and to continue working legally for the term of employment; excellent communication skills are required.

Applicants should submit a letter of application (1–2 pages) describing professional experience, research and teaching interests; a curriculum vitae; copies of all transcripts; and the names and contact information of at least three references.

In order to apply for this position and view full details, please visit our online website at <https://aufacultypositions.peopleadmin.com/postings/173>.

Applicants are encouraged to visit the AU website to learn more about Auburn University and the Dept. of Geology and Geography (www.auburn.edu/academic/cosam/departments/geology/). Review of applications will begin 4 Nov. 2013, and will continue until the position is filled.

In support of our strategic plan, Auburn University will maintain its strong commitment to diversity with standards to help ensure faculty, staff, and

student diversity through recruitment and retention efforts. Auburn University is an Affirmative Action/Equal Opportunity Employer. Women and minorities are encouraged to apply.

**SEDIMENTARY GEOLOGY
CALIFORNIA STATE UNIVERSITY
AT BAKERSFIELD (CSUB)**

The Dept. of Geological Sciences at California State University at Bakersfield (CSUB) announces a tenure track position in Sedimentology at the Assistant Professor level beginning in fall 2014. The successful candidate will demonstrate a strong commitment to sharing in department responsibilities toward the education of our undergraduate and graduate majors as well as toward our service courses and outreach to K–12 schools. Preference will be given to candidates that demonstrate experience or at least strong interest in expertise relevant to petroleum geology and/or basin analysis.

The small, high-quality geology department at CSUB is very active in peer-reviewed research involving both undergraduates and M.S.-level graduate students. The department is well equipped including an SEM equipped with EDS, WDS, CL and a micro XRF source, a rock crushing and preparation facility, a Frantz magnetic separator, aqueous chemistry and hydrology labs including field hydrology equipment, an automated XRD, an ICP-MS with laser ablation system, a clean fume hood, a research petrography lab, a laser particle-size analyzer, carbon coulometer, elemental analyzer, and a Giddings coring rig. The California Well Sample Repository, located on campus, houses the largest public collection of oil- and water-well cores and cuttings in California. The department is a National Science Foundation Center for Research Excellence in Science and Technology (CREST) which enhances its already strong research capabilities and provides substantial support for student research assistantships and faculty released time. The successful candidate will have the opportunity to join in the application for a 5-yr renewal of funding for our CREST grant due in the Spring of 2016. The school will provide two courses re-assigned time during each of the first two years to help the successful candidate establish a research program at CSUB and submit proposals for funding research.

The San Joaquin Valley is located in an active tectonic environment and is one of the world's great centers of both the agricultural and petroleum industries. Thus, local research opportunities are readily available and connections are easily made with local industry and government agencies.

California State University at Bakersfield is a regional comprehensive university that prides itself in a liberal arts approach to undergraduate education and small, high-quality graduate programs. It has an enrollment of approximately 8,000 students and resides in a rapidly growing metropolitan area of over 800,000 people in the southern San Joaquin Valley of central California. The campus is conveniently located near popular beach, mountain, and desert attractions and is a two-hour drive from Los Angeles.

Applications received by **20 Dec. 2013** will receive full consideration. Position remains open until it is filled. CSUB faculty will be conducting initial interviews at the Geological Society of America and

MINDS THAT MATTER
Los Alamos
NATIONAL LABORATORY
EST. 1944

Geosciences Postdoc
1-Year Contract (with potential for extension)

Located in northern New Mexico, Los Alamos National Laboratory (LANL) is a multidisciplinary research institution engaged in strategic science on behalf of national security. We're currently seeking an outstanding candidate to conduct integrated geosciences research for national security applications.

The position requires a PhD in Geology or a related field completed within the last 5 years. A strong background in field-based geology and an ability to integrate geology with geophysical and optical datasets is also required. Position involves regular fieldwork in Nevada.

Please apply for this position at:
<http://bit.ly/IRC25955> or visit <http://careers.lanl.gov> and reference vacancy **IRC25955**. Please also send a copy of your CV and letter of interest to spring@lanl.gov.

AA/EOE

American Geophysical Union National meetings. Candidates should submit a letter of application, a current curriculum vitae, and names and contact information of at least three references to: Chair of the Geological Sciences Search Committee, Dept. of Geological Sciences, California State University, 62SCI, 9001 Stockdale Highway, Bakersfield, CA 93311-1099 USA, Web site: www.csu.edu/Geology/ Email: geologysearch@csu.edu

CSUB fosters and appreciates ethnic and cultural diversity among its faculty and students, and is committed to increasing the diversity of its faculty to reflect the diversity of the campus community. Applications from women, ethnic minorities, veterans, and individuals with disabilities are welcome.

**ASSISTANT PROFESSOR
OF ORGANIC GEOCHEMISTRY
GEOSCIENCES DEPARTMENT
THE UNIVERSITY OF TULSA**

The Dept. of Geosciences at The University of Tulsa invites applications for a tenure-track faculty position in Organic Geochemistry at the Assistant Professor level. A Ph.D. in geochemistry or a related field is required, with demonstrated expertise in Organic or Petroleum-related Geochemistry. We seek an individual who shows the potential for outstanding achievement in research and teaching. The successful candidate will be expected to teach courses at the undergraduate and graduate levels, and establish

an externally funded research program. Interdisciplinary and international collaborative research is encouraged. The University of Tulsa is a premier private doctoral-granting research institution committed to excellence in teaching, creative scholarship, and service. The University offers competitive salary and benefits packages. Minorities and women are encouraged to apply.

The city of Tulsa has a vibrant geological and geophysical community. Tulsa is home to the international headquarters of the American Association of Petroleum Geology, Society of Exploration Geophysics, and the Society for Sedimentary Geology. The Dept. of Geosciences boasts an array of analytical equipment in geochemistry, including new state-of-the-art precision GC units, Soxhlet extraction capability, as well as state-of-the-art X-ray diffraction, SEM, micro-FTIR, UV-Vis and Electron Microprobe. Accessible research equipment in the College includes E-SEM, SEM-FIB, LC-MS/MS, ICP-MS, and a confocal Raman microscope.

Send a letter of application stating research and teaching interests, curriculum vita, and name and contact information for three references to Dr. Bryan Tapp, Chair, Dept. of Geosciences, The University of Tulsa, 800 South Tucker Drive, Tulsa, OK 74104-9700 or e-mail to beverly-phelps@utulsa.edu. Application review will begin immediately and continue until the position is filled. The University of Tulsa does not discriminate on the basis of personal status or group characteristics including but not limited to the classes protected under federal and state law. The University of Tulsa is an EEO/AA employer.

**GEODYNAMICS
DEPT. OF EARTH SCIENCE
UNIVERSITY OF CALIFORNIA
SANTA BARBARA**

The Dept. of Earth Science at the University of California, Santa Barbara, invites applications for a tenure-track Assistant Professor position in the broad area of geodynamics, starting 1 July 2014. We seek an innovative geophysicist who investigates solid earth processes with modern geophysical data and simulation methods. Areas of technical expertise might be in geodesy, seismology, and numerical modeling, but are not limited to them. We particularly seek candidates who both complement our current research program and integrate across tectonics and geophysics.

The successful candidate is expected to develop a vigorous, externally funded research program, and supervise research by graduate and undergraduate students. A Ph.D. or an equivalent degree is required at the time of appointment.

Applicants should submit a PDF containing a letter of application; their curriculum vitae; a description of teaching and research objectives and accomplishments; and the contact information of three referees who will provide letters. Applicants should request three referees to send letters of evaluation by 1 Nov. 2013. The application file and letters of reference should be submitted to <https://recruit.ap.ucsb.edu>.

Review of applications will begin 1 Nov. 2013. The position will remain open until filled, but to ensure full consideration, application materials should be submitted by this date.

The department is especially interested in candi-

dates who contribute to the diversity and excellence of the academic community through research, teaching, and service.

UCSB is an Equal Opportunity/Affirmative Action employer.

**FACULTY POSITION IN PETROLOGY
DEPT. OF EARTH AND
ENVIRONMENTAL SCIENCES
BOSTON COLLEGE**

The Dept. of Earth and Environmental Sciences at Boston College invites applications for a tenure-track position in the field of Petrology to start in Fall 2014. The successful candidate will be expected to develop an externally funded research program integrated with excellence in teaching within the geological sciences and environmental geoscience curriculum at both the undergraduate and graduate levels. Teaching responsibilities will include Mineralogy, Igneous and Metamorphic Petrology, and other courses in the candidate's area of research expertise. The successful candidate should have a commitment to integrate with existing department research expertise in structural geology, sedimentary geology, igneous and metamorphic terrane analysis, and geochronology/geochemistry. Candidates with a strong field emphasis in research and teaching are particularly desired. This is an open-rank position, and applications at all levels are invited. The department is equipped with a range of modern research instrumentation listed on our website (www.bc.edu/content/bc/schools/cas/geo/instrumentation-and-facilities.html). Information on the department, its faculty and research strengths can be viewed on the department's web page at www.bc.edu/eesciences. Applicants should send a *curriculum vitae*, statements of teaching and research interests, and the names and contact information of at least three references as a **single PDF-file e-mail attachment to petrposition@bc.edu**. Review of applications will begin on 11 Nov. 2013. Department faculty will be available at the GSA and AGU fall meetings to meet with applicants. Boston College is an academic community whose doors are open to all students and employees without regard to race, religion, age, sex, marital or parental status, national origin, veteran status, or handicap.

**TENURE-TRACK POSITION
STRATIGRAPHY/SURFACE PROCESSES
DEPT. OF GEOLOGICAL SCIENCES
SUNY GENESEO**

The Dept. of Geological Sciences at SUNY Geneseo, a public liberal arts college in western New York, invites applicants for a tenure-track position in Stratigraphy and/or Earth Surface, beginning in August of 2014. The successful applicant will be qualified to teach upper level undergraduate courses in Sedimentology/Stratigraphy, upper level electives that complement existing strengths in the department, and introductory courses for geology majors and for non-science majors. The successful candidate will be committed to excellence in undergraduate education, have strong interpersonal skills, and will demonstrate the potential to maintain an active, undergraduate-focused research program. Additional responsibilities include organizing, leading, and participating in international departmental

field courses. Preference will be given to candidates with the ability to integrate geographic information systems and/or digital learning into their courses. Candidates with a Ph.D. at the time of appointment are preferred.

The College strives to provide a diverse learning environment in which to prepare students for an increasingly multicultural society and interconnected world. For further information about SUNY Geneseo, please see our homepage at www.geneseo.edu.

To apply, submit an online Faculty application at <https://jobs.geneseo.edu> and attach a cover letter, vita, references, unofficial transcripts, a statement of teaching philosophy, and a research statement. Applicants should arrange for three recent letters of recommendation to be faxed to Benjamin Laabs, Chair, Dept. of Geological Sciences, +1-585-245-5116.

To ensure full consideration, complete applications should be received by 1 Oct. 2013. All applicants are subject to drug and criminal background checks.

SUNY Geneseo is an Affirmative Action/Equal Opportunity, Equal Access Employer committed to recruiting, supporting, and fostering a diverse community of outstanding faculty, staff, and students. The College actively seeks applications from women and members of underrepresented groups.

**PEVEHOUSE CHAIR IN GEOSCIENCES
TEXAS TECH UNIVERSITY**

The Dept. of Geosciences at Texas Tech University invites applications for the Pevehouse Chair in Geosciences. The purpose of this endowed position is to support innovative research and education that are broadly aligned with petroleum geosciences and may include geophysics, structural geology, geomechanics, sedimentology, petrophysics, and organic geochemistry. A Ph.D. in geosciences or closely allied field is required, as is a record of research as demonstrated by professional publications. The chair holder will conduct a vigorous, externally-funded research program, direct graduate student research, and teach undergraduate and graduate courses in his/her specialty. The position is expected to be filled at the tenured Full Professor level.

Texas Tech is a state-supported, graduate research-oriented university with over 32,000 students. The Dept. of Geosciences consists of twenty-four tenured/tenure-track faculty, with teaching and research emphases in solid earth geosciences, atmospheric science, and geography. It offers degree programs in solid earth geosciences at the BS, MS, and Ph.D. levels. The chairholder will join a dynamic, growing department with more than 200 undergraduate majors and more than 60 graduate students. Texas Tech is committed to growth in disciplines aligned with hydrocarbon geology through addition of at least one junior faculty position.

The department computer labs are equipped with GIS, geologic mapping/modeling, and seismic processing/interpretation software packages. Available experimental/analytical facilities include a stable isotope laboratory, XRD, XRF, analytical SEM, TEM, laser ablation ICP-MS, a heat flow lab, and remote sensing spectroradiometers. In addition, the Dept. of Petroleum Engineering maintains experimental and

analytical facilities in petrophysics, drill fluids, cement, enhanced recovery, and reservoir simulation, as well as X-ray CT/nuclear magnetic resonance imaging lab.

Lubbock is located on the Southern High Plains in close proximity to the Permian Basin. The city has a population of over 225,000 and the semi-arid climate is conducive to outdoor activities. Cultural amenities include musical, theatrical, and sports events, and the city offers numerous options for shopping and dining. The city also offers the best healthcare facilities in the region, including the university's Health Sciences Center. The cost of living is low compared to national norms.

Applicants must first go to the employment website of the university at <http://jobs.texasstate.edu>. There, go to "Search Postings," search for requisition number 87107, and fill out necessary forms in applying for the position online. Then, applicants should submit a letter of application, curriculum vitae, a statement of teaching and research interest, names and contact information (including e-mail address) of at least 3 professional references. These documents should be uploaded to the employment website and we request that copies be emailed or sent directly to: Dr. Calvin Barnes, Pevehouse Chair Search Committee, Dept. of Geosciences, Texas Tech University, MS 1053, Lubbock, TX 79409-1053.

Additional information on the department can be found at website www.depts.ttu.edu/geosc/. E-mail questions regarding the position are received at cal.barnes@ttu.edu. Review of applicants will begin immediately and continue until the position is filled.

Texas Tech University is an affirmative action/equal opportunity employer, committed to excellence through diversity. Texas Tech welcomes applications from minorities, women, veterans and persons with disabilities.

ASSISTANT PROFESSOR OF GEOSCIENCES SOFT ROCK GEOLOGY PACIFIC LUTHERAN UNIVERSITY

The Dept. of Geosciences at Pacific Lutheran University invites applications for a tenure-track position in soft rock geology at the level of Assistant Professor to begin 1 Sept. 2014. A commitment to excellence in teaching at a predominately undergraduate institution and a dedication to establishing a field-based research program that engages students are expected. Teaching responsibilities will include stratigraphy and sedimentation, an upper division course in one's expertise, the gateway course for the major (GEOS 201), and topical lower division geoscience courses. Participation in extended field trip experiences, the general education program, and mentoring senior capstone research projects is also expected. Ph.D. in Geology or closely related field is required. ABD will be considered, but Ph.D. must be in hand by 1 Sept. 2014.

PLU is a comprehensive university of 3,500 students offering a curriculum integrating the liberal arts and professional programs. Located in a uniquely scenic region of the Pacific Northwest, the university's campus is 40 miles south of Seattle and 40 miles west of Mount Rainier near Tacoma, Washington, USA. AA/EOE.

Submit application at <https://employment.plu.edu/postings/2573>. Required materials: cover let-

ter, CV, statement of teaching philosophy, unofficial undergraduate and graduate transcripts, and potential research plans with undergraduates. Three confidential letters of recommendation will also be requested by PLU upon application. Review of applications will begin 1 Oct. 2013, but the position will remain open until filled. For questions or more information, please contact Dr. Jill Whitman, Chair of Geosciences at +1-253-535-8720 or whitmaj@plu.edu.

Opportunities for Students

Graduate Fellowships in Sedimentary Basin Modeling. The Berg-Hughes Center (BHC) for Sedimentary and Petroleum Systems and the Dept. of Geology and Geophysics at Texas A&M University invite applications from outstanding students for graduate fellowships in sedimentary basin modeling. Two fellowships will be awarded beginning in the spring semester of 2014. These fellowships are for three years for Ph.D. students and for two years for M.S. students. The fellowships are US\$30,000 per year.

The fellowships are an integral part of a robust research and education program initiated by the newly established Chevron-TAMU/BHC Basin Modeling Center of Research Excellence in the Berg-Hughes Center and Dept. of Geology and Geophysics at Texas A&M University. The Center was established to contribute to the advancement of science, technology and higher education through the teaching and mentoring of students and the supporting of independent academic research. The research focus of the Center is to further the understanding of the geohistory of sedimentary basins and the origin and location of unconventional and conventional petroleum resources inherent to sedimentary basins. Research will be conducted in collaboration with researchers at the University and geoscientists and petroleum engineers in the petroleum industry and is designed to solve complex geoscientific problems through integrated solutions.

Interested students should send a letter of application to Dr. Michael C. Pope (mcpope@geos.tamu.edu) by 1 Oct. 2013.

The Berg-Hughes Center (berg-hughes.tamu.edu) and the Dept. of Geology and Geophysics (geoweb.tamu.edu) are part of the College of Geosciences, which also includes the Departments of Atmospheric Sciences, Geography, and Oceanography; the Geochemical and Environmental Research Group (GERG); and the Integrated Ocean Drilling Program (IODP). Texas A&M University, a land-, sea-, and space-grant university, is located in a metropolitan area with a dynamic and international community of 172,000 people. Texas A&M University is an affirmative action/equal opportunity employer committed to excellence through the recruitment and retention of a diverse faculty and student body and compliance with the Americans with Disabilities Act. We encourage applications from minorities, women, veterans, and persons with disabilities. Texas A&M University also has a policy of being responsive to the needs of dual-career partners.

Call for Applications



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Apply today!



International EarthCache Day Helps Kick-Off Earth Science Week



The sixth annual International EarthCache Day returns on Sunday, 13 Oct., to help kick-off Earth Science Week 2013. The public is invited to join the Geological Society of America (GSA), Geocaching.com, and the American Geosciences Institute (AGI) in exploring this exciting and educational Earth science experience.

On International EarthCache Day, EarthCache enthusiasts around the globe organize small gatherings where people learn about Earth and visit EarthCache sites. This is a day to introduce the EarthCache program to those who are not yet familiar with it. Special events will be held around the world, including in Germany, the United Kingdom, the United States, and elsewhere.

GSA is participating in International EarthCache day by highlighting some of the newest and most exciting developments in the EarthCache community. On 10 Jan. 2014, the EarthCache program will celebrate its 10th birthday, commemorating the date of

publication of the first EarthCache ever, which is on a headland three hours south of Sydney, Australia. Later in the year, from 8 to 15 Nov. 2014, GSA will conduct its first-ever EarthCache GeoVenture: “Caching on an Active Volcano,” on the Big Island of Hawaii. This new trip will involve a wonderful mix of caching experiences and learning about active volcanoes.

An EarthCache is a place people can discover with a GPS device while participating in a “treasure hunt” called geocaching, a global game popularized by Geocaching.com. “The treasure you find at an EarthCache is a lesson about the Earth itself,” says EarthCache program director Gary Lewis of GSA.

For information about International EarthCache Day events, and for more details about EarthCache, visit www.earthcache.org and www.facebook.com/earthcache, or contact earthcache@geosociety.org.

www.geosociety.org/bookstore

Tectonic Styles in Canada: The LITHOPROBE Perspective

Edited by John A. Percival, Frederick A. Cook, and Ron M. Clowes

This volume (Special Paper 49 from the Geological Association of Canada) provides an in-depth overview of most of the major scientific results deriving from the LITHOPROBE project, Canada's 20+ year national research project in the earth sciences. The project combined multidisciplinary earth science studies of the Canadian landmass and surrounding offshore margins to determine how the northern North American continent formed over geological time from 4000 million years ago to the present. Although LITHOPROBE results have been published in hundreds of scientific articles during the life of the project, and in a series of special issues of the *Canadian Journal of Earth Sciences*, Special Paper 49 is the only book to be published on LITHOPROBE scientific results. Seven chapters cover the wide range of geotectonic regions studied through the ten LITHOPROBE transects (study areas) and an eighth provides a summary. Each chapter incorporates a geological overview and discusses a range of physical parameters as appropriate to the area (e.g., crustal thickness and its variation; crustal structure, composition, seismic velocity and reflectivity; nature of orogen margins; age and style of rifting; nature and age of accreted terranes; nature and age of continental magmatic arcs; location and nature of paleo-suture zones; age and style of accretion; variation of P-T conditions through time; and the age and style of post-collisional processes). The chapters also include discussions of important aspects of orogenic and post-orogenic evolution, have extensive reference lists, and include many color illustrations. This volume will be the main source of information about the Canadian landmass for many years to come. The authors include many individuals who were key players in the LITHOPROBE project, in particular the editors John Percival, Fred Cook and Ron Clowes, the latter of whom was director of the project from its inception to the end.

LPROBE, 512 p., ISBN 9781897095607 | list price \$95.00 (sorry, no additional discounts)

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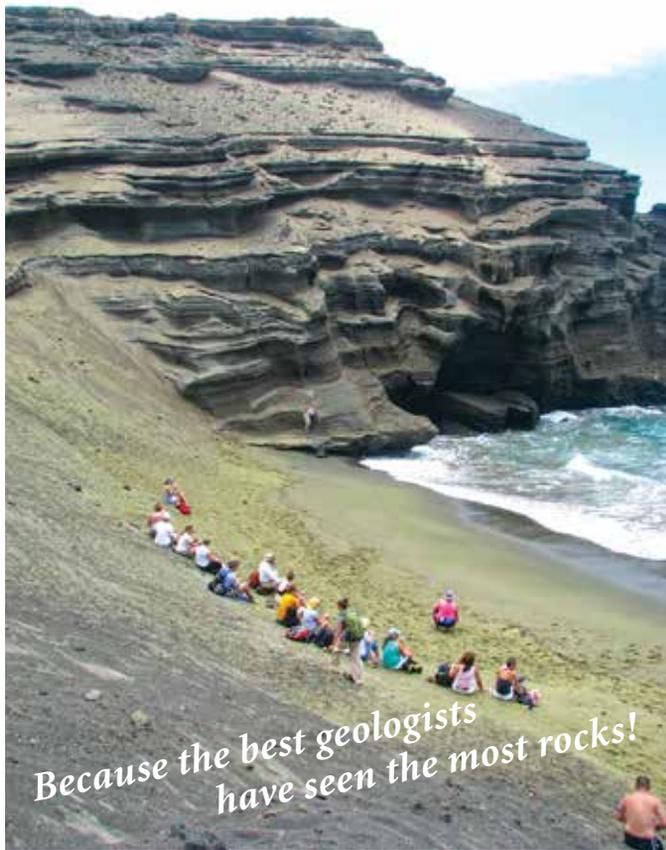
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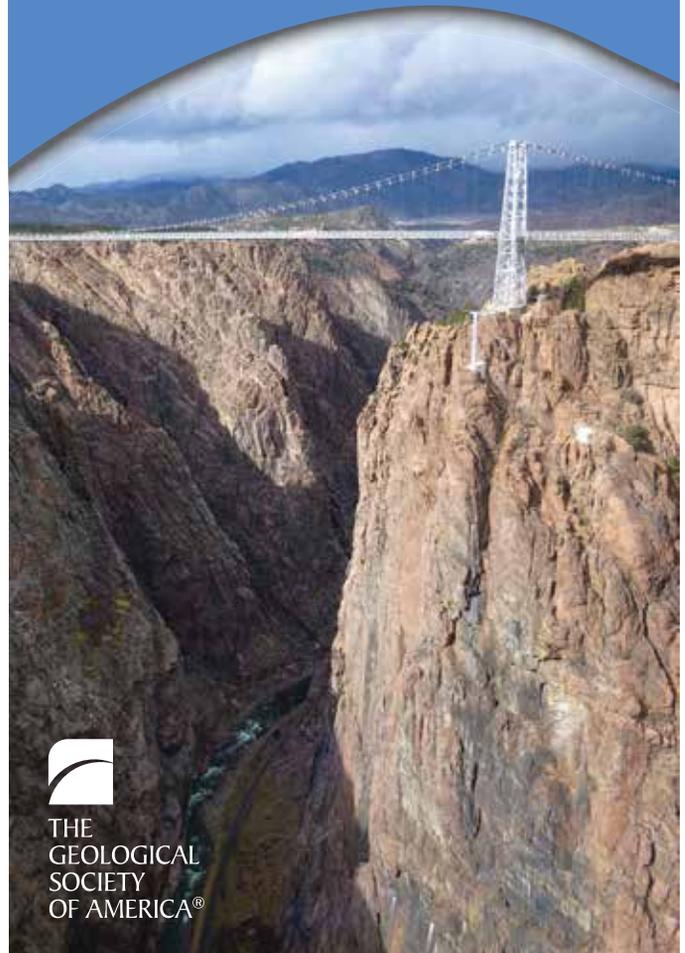
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Proposals deadline: 14 Jan. 2014

Abstracts deadline: 29 July 2014

Help ensure that your area of research and expertise is represented in next year's technical program. Any individual or geoscience organization is welcome to suggest topics and submit proposals for both Topical Sessions and Pardee Keynote Symposia. Pardee Symposia are high-profile sessions on significant scientific developments, with invited speakers only. Topical Sessions are a combination of invited and volunteered papers. Unique formats are allowed, but they must be outlined in the proposal along with the technical support needs. Sessions that promote discussion are encouraged. <https://gsa.confex.com/gsa/2014AM/sessionproposals.epl>

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Deadline: 2 Dec. 2013

Know of a great geoscience excursion in the Vancouver, British Columbia, Canada, area? Teach your colleagues and peers about the wondrous scenery and ground-breaking research in this region. Trips can be a half-day to 5 days long. *Questions?* Please contact Beth Engle, bengle@geosociety.org.

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Deadline: 1 Feb. 2014

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No more lousy PowerPoint slides

Eric S. Cheney, Department of Earth and Space Sciences, Box 351310, Univ. of Washington, Seattle, Washington 98195-1310, USA, cheney@ess.washington.edu

ABSTRACT

Too many PowerPoint and other visual presentations are positively lousy: The graphics or the text on the slides are illegible. Illustrations directly imported into PowerPoint from a printed page or the Internet are routinely lousy, especially if two or more such illustrations are placed on a single slide. The most effective slides are those expressly crafted for a visual presentation. However, remedial techniques can make published illustrations effective. The key to creating effective slides is to make both images and text sufficiently large and simple.

INTRODUCTION

The major purpose of any visual presentation is effective communication, which enhances the speaker's message. However, at GSA's and other professional meetings too many PowerPoint slides are positively lousy: The graphics and text are not legible from the back of the hall. Of course, a slide can be legible and still communicate little of substance (Tufte, 2006). Beauty, artistic frills, and fine details are of miniscule importance. Too commonly, slides seem only to serve as lecture notes for, and visible only to, the speaker (and to the audience in the two front rows). Many speakers even have lousy slides for their signature presentations.

For those unfamiliar with the vast literature on graphic design, two important empirical guidelines exist. The first is Gallagher's 12:1 ratio (1965): Measure the maximum dimension of the original figure (most commonly now a computer image) in inches; then step back that far in feet; if everything is legible, the slide will project well. Since Gallagher's time, technological advances in projection equipment probably have reduced the ratio to 10:1.

The second guideline (Cheney, 1996) is known in the U.S. military as KISSing: Keep It Simple, Stupid. Stupid refers to the speaker, not to the message. KISSing means that slides should be simple, not complex, and that slides with only peripheral relevance (no matter how beautiful) should be deleted. Of course, KISSing is an acquired skill.

Two types of illustrations in graphic design are analysis graphics and presentation graphics (Tufte, 1997; Dutrow, 2007). Analysis graphics range from computer plots of raw data to illustrations in engineering and scientific papers; these are used for research (discovery, insight, and the testing of hypotheses). In contrast, presentation graphics, such as PowerPoint, are designed to communicate concepts effectively and quickly. To the extent that PowerPoint presentations summarize or simplify evidence,

instead of showing it, they corrupt data and debase the scientific method in favor of marketing or spin (e.g., Tufte, 2006). However, because PowerPoint is ubiquitous, we should use it effectively by employing Gallagher and KISSing, while at the same time preserving the sanctity of data and the scientific method.

The best strategy is to redraft all analysis graphics into presentation slides. However, too many speakers use images taken directly from a printed page (analysis graphics) or from the Internet, both of which routinely violate Gallagher's ratio and KISSing. Some imported photographs are suitable, but almost all graphs, maps, and other illustrations will be illegible. Two or more such images on a single slide (a favorite technique) are always illegible from the back of the hall. For speakers addicted to the Internet and with limited computer drafting skills, time, or funding, the remedial techniques mentioned below can produce acceptable presentation slides.

PRESENTATION SLIDES

The first step in planning a presentation slide is to heed Gallagher. To utilize the maximum dimensions of virtually all modern projection screens, slides should be composed in landscape configuration, not portrait.

The second step is to eliminate trivia. Trivia, or "chartjunk" (Tufte, 1990; Dutrow, 2007), includes grid lines, logos, fancy fonts, numerous small labels (where a few large ones would do), separate keys instead of labels, etc. Text or labels that are not telegraphic in style also are chartjunk.

Simple x-y plots are the easiest graphics for the audience to comprehend. A general audience probably will not quickly understand diagrams or projections that are specific to the speaker's subdiscipline. Complex diagrams (such as many three-dimensional representations) can sow apprehension, confusion, or even distrust in an audience (e.g., Dutrow, 2007). An effective method of showing change is several small but very simple two-dimensional images, or information slices, on a single slide; this is the "small multiples" method of Tufte (1990).

Complicated slides can be avoided by presenting a series of simple slides that lead to the complex result. Some busy slides can be transformed by eliminating chartjunk. An admission that a slide is "busy" is an admission of failure.

Space is a commodity to be spent wisely. The margins of a slide should be as narrow as possible. Artwork and logos of sponsoring institutions in the margins (except for obligatory introductory slides) are chartjunk. Overly large titles waste space. The deeply indented lines of hierarchal lists of bullets also waste space (Tufte, 2006); moreover, multiple indentations risk rendering the most important point to look like the most subordinate. The size and configuration of text boxes should be carefully composed to

permit the sufficient size of any accompanying image or text. Tables commonly are the most efficient method of comparing data (Tufte, 2006).

All slides (even those as seemingly routine as a thin section of a rock or a scanning electron microscope image of a mineral) should have a title or a caption, labels, scale bars, directional indicators, sources of data and no chartjunk. These features keep scientific data quantitative. Titles reinforce communication and also serve to distinguish one slide from similar ones in the presentation.

The audience needs help in quickly reading text. Black (or dark blue) font on a white or pastel background usually is the most legible. Lower case lettering makes words more rapidly recognizable. Simple (not frilly) fonts help. Fonts that border on being too small can be made more legible by making them bold. Font sizes over 40, even for titles, are rarely needed. More than 12 lines of text on a slide become illegible. Of course, multiple slides crammed with text are boring. Among the most egregious text slides are those that cite published papers in their originally printed font.

Because about 15% of the population is color blind, critical data and text should not be in red or green (e.g., Dutrow, 2007). Colored texts or symbols on colored backgrounds (other than pastels) might be legible only to the speaker.

The use of color should do no harm (e.g., Tufte, 1990). More than a few colors on a slide promote confusion. Pastels, instead of fully saturated colors, are best because they imitate nature (Tufte, 1990). Audience eye fatigue can be lessened by reducing the size of white areas on the slides; this is done by choosing pastels for the margins (background), text boxes in or near the margins, and fills for large unused peripheral areas of any accompanying graphic.

REMEDIAL TECHNIQUES

Because it promotes Gallagher's ratio, cropping is the first and one of the most important remedial techniques. An imported figure in portrait dimensions should be cropped to landscape. After cropping, the remnant is enlarged to nearly fill the entire slide. If the image still is not legible, more cropping and enlarging are necessary. Judicious cropping also can eliminate chartjunk. Subsequently, the title can be placed in a margin or over some peripheral part of the image that is not relevant.

More than two imported images on one slide are rarely legible. Two slides with two images definitely are more legible than one slide with three or more images, and, ultimately, such multiple slides require less time to present clearly. As opposed to small multiples of related images, multiple unrelated images on a slide that is shown only briefly are chartjunk or information-overload.

In some cases, cropping and enlarging the remnant may be sufficient to generate an effective slide. Usually, however, the work has just begun. The width of lines should be proportional to their importance; the important lines may have to be traced over to significantly increase their width. For example, on a graph, the regression line (if necessary) should be the boldest; this is the "notable difference" of Tufte (1997). Likewise, bold arrows or leaders promote the rapid recognition of important details, but the arrows should not overpower the image (e.g., Tufte, 1997). Original labels and symbols can be overprinted with larger fonts, or new labels can be added. Chartjunk can be masked (covered) with the same colors used on

the slide. Illustrations (especially photographs) commonly can be enhanced by varying contrast or brightness.

FINAL ACTIONS

After all of the slides have been composed, they should be reviewed to see which texts and images can be enlarged still more. Before giving the presentation, the speaker should preview the slides from the back of a large lecture hall, or trust Gallagher. Then practice the presentation! Effective presentation slides do not, by themselves, guarantee an effective presentation; the skills of public speaking, about which much has been written elsewhere, also must be mastered.

CONCLUSIONS

To create effective PowerPoint slides, put yourself in the place of a viewer in the last row of the lecture hall. Like good writing, the crafting of good PowerPoint slides requires experience, imagination, and time. In any case, there is no profit to be had in lousy slides making good work look bad.

ACKNOWLEDGMENTS

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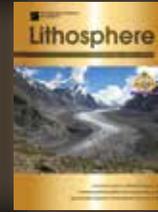
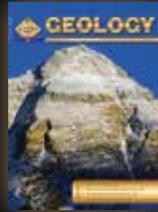
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2012 Impact Factors Announced



Thomson Reuters has released the 2012 impact factors, and GSA is pleased to announce that *Geology* continues its reign as the #1 ranked geology journal for the seventh year in a row. The journal has an impact factor (IF) of 4.087 and a 5-year IF of 4.660.

Geological Society of America Bulletin's IF rose to 4.286, the fifth consecutive increase. With a five-year IF of 4.494, it is the #8 ranked multidisciplinary geosciences journal.

Lithosphere's IF increased to 2.169, making it the #10 ranked journal in the geology category.

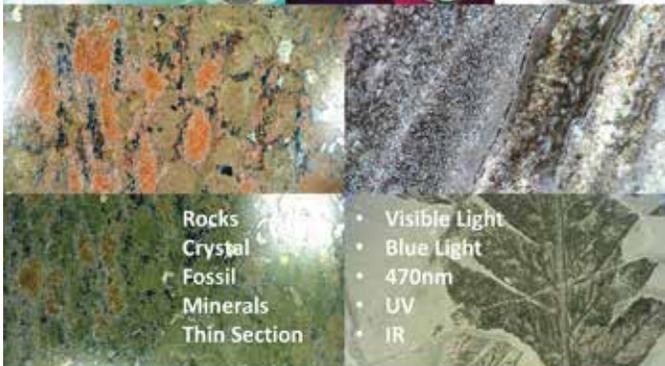
Geosphere held roughly steady with an IF of 2.023 and a 5-year IF of 2.373.

While Thomson Reuters does not produce impact factors for book series, it continues to index GSA's Special Papers, Memoirs, and Reviews in Engineering Geology in its Book Citation Index.

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