2010 GSA Annual Meeting & Exposition, p. 13

GSA TODAY

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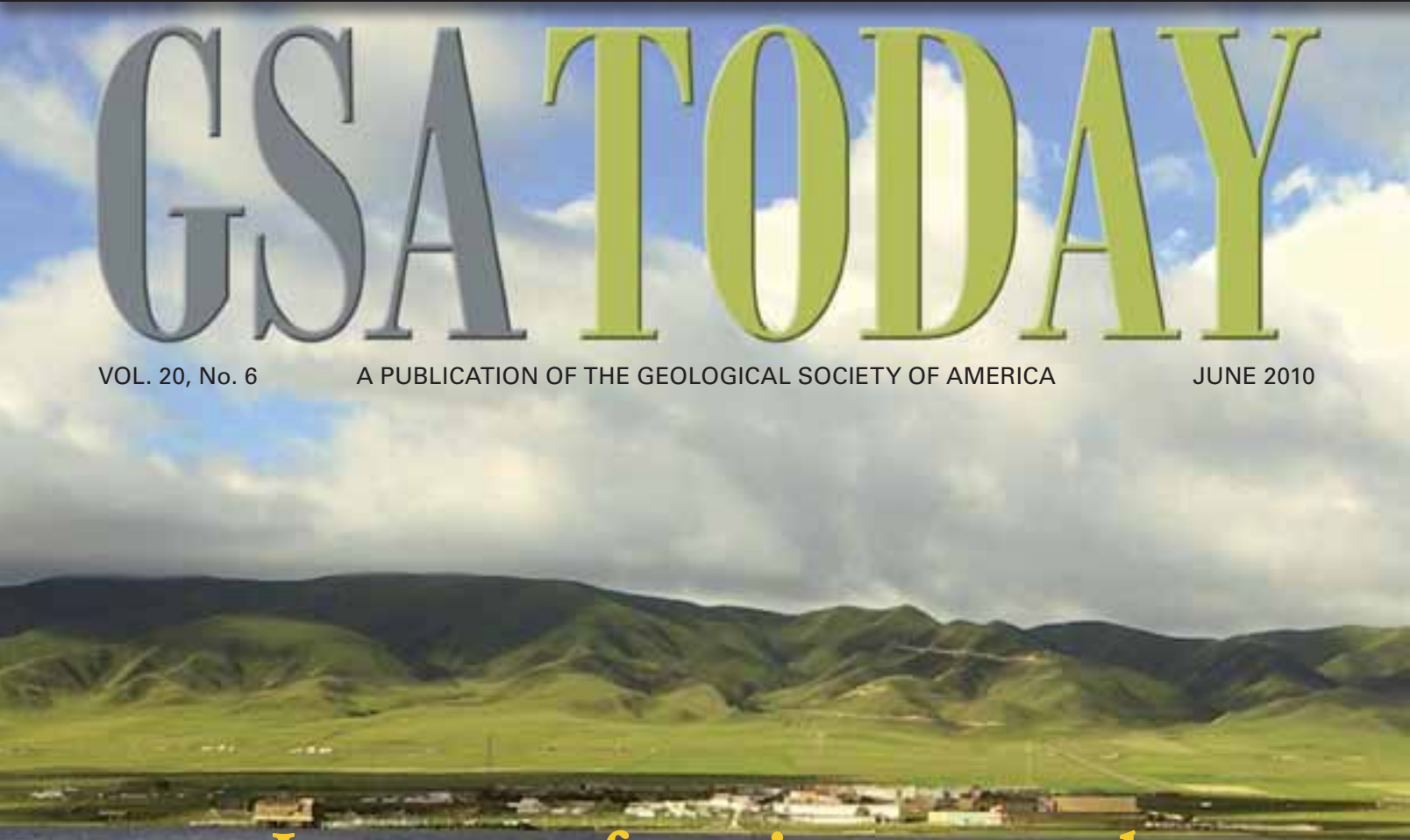

Impacts of environmental change and human activity on microbial ecosystems on the Tibetan Plateau, NW China

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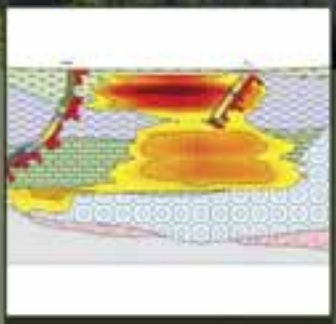

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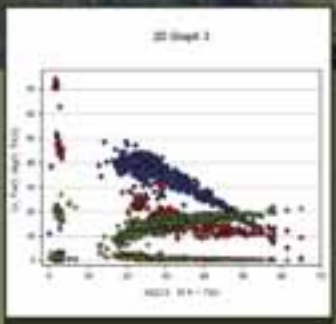

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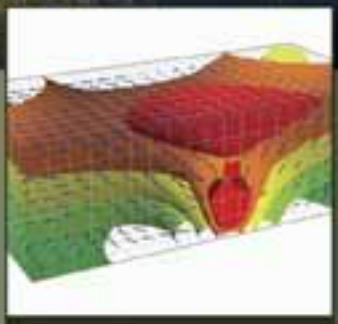

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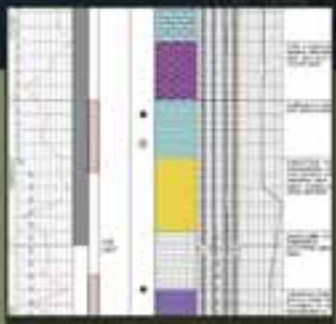

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SCIENCE ARTICLE

Cover: Qinghai Lake and surrounding mountains. Qinghai Lake is the largest inland saline lake in China, with an altitude of ~3196 m above sea level. The average water depth is 19.2 m, and salinity is 12.5 g/L. Photo by Nicole Berzins. See "Impacts of environmental change and human activity on microbial ecosystems on the Tibetan Plateau, NW China," by Dong et al., p. 4–10.

2010 Annual Meeting & Exposition, Denver, Colorado, USA

Corrections & Clarifications
The Penrose Conference Report in the March *GSA Today* (v. 20, no. 3, p. 12–13) did not include the name and affiliation of one of the co-conveners, **Sergey Drachev** of ExxonMobil Russia, Inc., 31 Novinsky Boulevard, 5th floor, 123242 Moscow, Russia. *GSA Today* regrets this oversight.

Impacts of environmental change and human activity on microbial ecosystems on the Tibetan Plateau, NW China

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ABSTRACT

Microorganisms play important roles in maintaining ecosystem functions. It is poorly known, however, how microbial ecosystems respond to environmental changes and human activities. The purpose of this paper is to demonstrate that the microbial record in lake sediments and ice cores contains a wealth of paleoenvironmental and paleoclimatic information. Saline lakes on the Tibetan Plateau exhibit multiple environmental gradients and have accumulated thick sequences of sediments through time. Microbial abundance and species diversity vary considerably along environmental gradients across the plateau. Studies of lake sediments reveal that wet and warm climates are correlated with high bacterial abundance and diversity, whereas cold and dry climates result in low abundance and diversity. Recent human activities have enhanced sulfate reduction in lake sediments. Ice cores from the plateau reveal that bacterial abundance and diversity are positively correlated with dust particle concentration and temperature.

INTRODUCTION

Recent research on biological responses to global climate change has focused on animals and plants and their interactions (Pounds et al., 2006; Whitfield et al., 2007). A limited number of studies have shown that, in soils and aquatic systems, microbial community structure, abundance, and activity respond to environmental changes, such as atmospheric CO_2 level, precipitation, temperature, and nitrogen deposition (Bowatte et al., 2008; Horz et al., 2004; W.X. Liu et al., 2009; Van der Gucht et al., 2007; Zak et al., 2000).

Lakes play important roles in the study of the response of microbial ecosystems to climate change and human activity. It has been suggested that the microbial record in lake sediments is thought to be inappropriate for reconstruction of paleoenvironmental conditions because microorganisms continue to be active after deposition, and their measured abundance and diversity today may not reflect community structure and functions in the past. However, several studies have shown that certain groups of microorganisms preserved in lake sediments, such as phototrophs and aerobes, may be useful in reconstructing recent environmental changes (Coolen et al., 2004a, 2004b, 2006, 2008). These studies are limited to a few geographic locations, and the impacts of climate changes on microbial ecosystems are still poorly understood.

The goal of this paper is to demonstrate that the microbial record preserved in lake sediments and ice cores on the Tibetan Plateau can be a reliable indicator of past environmental change and human activity. We review and compile current literature on microbial response to environmental changes (elevation, water chemistry, mountain topography, UV radiation, salinity, and temperature/precipitation) and human activities (agriculture and eutrophication) recorded in lake sediments of the Tibetan Plateau. Data from ice core records are included to understand the response of microbes to dust storms and changes in temperature. We focus on the Tibetan Plateau because this region underwent dramatic environmental changes in recent geological history. The microbial response to these dramatic changes may be of global significance because understanding the microbial response to past environmental change is a key to predicting the impacts of future climate change on the biosphere.

CLIMATE EVOLUTION OF THE TIBETAN PLATEAU

The Tibetan Plateau is the largest (2×10^6 km^2) and highest plateau (average ~4500 meters above sea level [masl]) on Earth. This high elevation results from the Tertiary collision between the Eurasian continent and the India subcontinent. The plateau is bounded by deserts of the Tarim and Qaidam Basins to the north, the Himalayan, Karakoram, and Pamir mountain chains to its south and west, and the Tanggula Mountains on the east.

The Tibetan Plateau lies at a critical and sensitive junction of four climatic systems: the Westerlies, the East Asian Monsoon, the Siberian cold polar airflow, and the India monsoon (Fig. 1). Paleoclimate studies indicate that the last glacial period (late Pleistocene) was terminated by an abrupt warming event at 15 ka (Severinghaus and Brook, 1999). The subsequent transition to the Holocene was characterized by frequent fluctuations between warm and cold phases (Liu et al., 2008; Zhu et al., 2008; X.Q. Liu et al., 2009). The wet and warm climate in the early to mid-Holocene is recorded in lakes and loess deposits worldwide (Liu et al., 2008). The warm temperatures during this period accelerated evaporation and caused many

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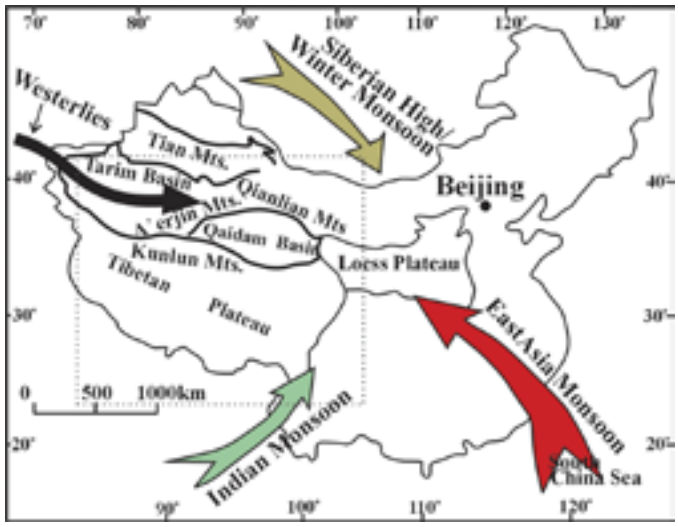

Figure 1. Major climatic systems on the Tibetan Plateau: the Westerlies, the East Asia Monsoon, the cold polar airflow from the Siberian high pressure, and the Indian monsoon. Dashed box shows the location of photo in Fig. 2.

lakes to evolve from open freshwater systems to saline lakes. During the late mid-Holocene to late Holocene, decreased solar insolation led to a cooler and drier climate. More recently, human activities and related regional climate changes have significantly changed the regional hydrology and ecosystem functions of the plateau (H. Wang et al., 2008).

Progressive desiccation since the Holocene has resulted in the formation of thousands of lakes of limited surface inflows and outflows (Fig. 2). The total lake area is 4.5×10^4 km^2, and the lakes range in age from 2 to 8 Ma (Zheng and Yao, 2004; Zheng, 1995). Tibetan lakes exhibit multiple environmental gradients, including salinity (0.1 to 426.3 g/L), pH (5.4 to 9.8), and nutrient levels (Zheng, 1995). Because of the high elevation, UV radiation is intense, and changes in light conditions can be extreme between ice-covered and ice-free seasons. Many of these lakes have accumulated thick sequences of sediments that provide an archive of climatic change and vegetation succession. Ice core records provide another important means to investigate climatic and environmental changes in the Tibetan Plateau region (Yao et al., 2008, and references therein).

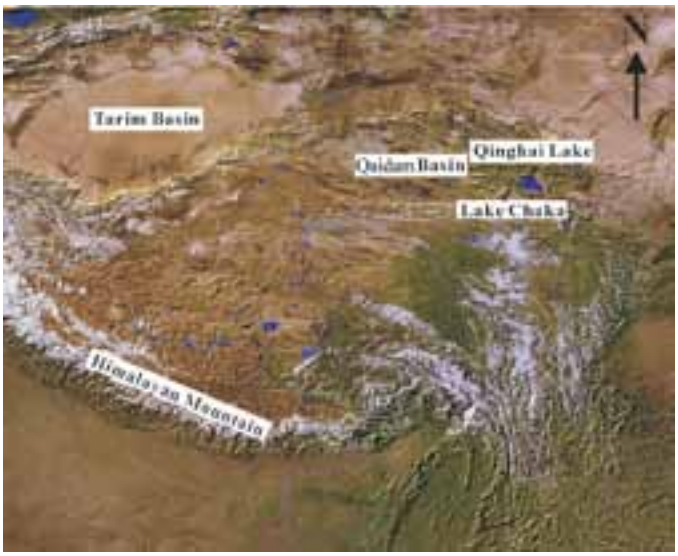

Figure 2. Topography of the Tibetan Plateau and distribution of lakes (in blue). The largest one is Qinghai Lake, with the longest dimension of 106 km.

MICROBIAL RESPONSE TO ENVIRONMENTAL GRADIENTS ON THE TIBETAN PLATEAU

High elevation does not limit the presence and distribution of microbes in lakes (Wu et al., 2006), and many "typical freshwater bacteria" present in low-elevation lakes (Hahn, 2006; Zwart et al., 2002) also occur in Tibetan lakes. Many members of marine benthic groups (MBG-B, -C, and -D archaea) and Miscellaneous Crenarchaeotic Group are present in Qinghai Lake (Jiang et al., 2008). These groups were previously believed to be exclusively present in deep-sea environments, and many are associated with methane gas hydrate deposits (Jiang et al., 2008, and references therein). Jiang et al. (2008) concluded that similar water chemistry between Qinghai Lake and seawater may be responsible for the occurrence of marine archaeal communities in Qinghai Lake. A subsequent study (Jiang et al., 2009) confirms this conclusion, showing that salinity, ionic ratios, and Na^+ and HCO_3^- concentrations are important factors in shaping archaeal community composition. Hydrothermal activity, as suggested by water chemistry (Zheng, 1995), may be partially responsible for the presence of methanogenic and methanotrophic archaea in Tibetan lakes.

Tibetan lakes also harbor unique microbial communities. A total of 343 DNA sequences were compiled from published sources for Tibetan freshwater lakes, 74% of which could not be affiliated with any typical freshwater clusters (Hahn, 2006; Zwart et al., 2002). These sequences are unique to Tibetan lakes and are hereafter defined as "typical Tibetan freshwater bacteria." They share certain characteristics with those from glacier ice or tundra soils in the Arctic or Antarctic (Y. Liu et al., 2009). The presence of these bacteria may be explained by a combination of geographic isolation and unique environmental conditions on the Tibetan Plateau.

Although elevation does not limit the presence of microbes in lakes, surface topography does control microbial diversity, likely by influencing precipitation patterns. For example, bacterial diversity in multiple lakes on the windward side of the Himalayan Region (Sommaruga and Casamayor, 2009) is higher than that in many lakes on the leeward side (Wu et al., 2006). We hypothesize that the moisture source may be responsible for the observed difference. On the windward side, the moisture source is the Indian monsoon, and favorable climatic and environmental factors (higher temperature, wetter climatic conditions, higher vegetation density and productivity) may lead to a higher diversity of bacteria in lake waters. As moist air rises over the mountains, it condenses and forms precipitation. We suggest that by the time the air moves over the mountains, most microorganisms have been removed by condensation-related particle fall-out, thus accounting for a lower diversity on the leeward side. This hypothesis is consistent with the observations of Yao et al. (2008), who reported that bacterial diversity during the monsoon season was greater than during the non-monsoon season.

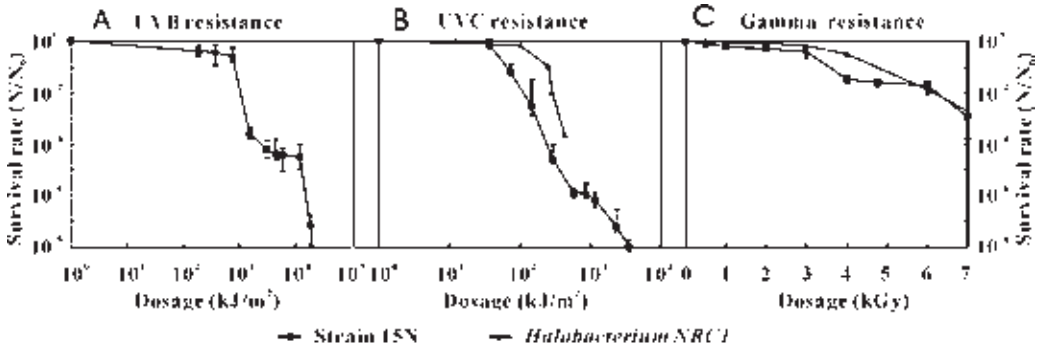

Figure 3. Survival rate of a halophilic bacterium 15N upon exposure to ultraviolet light (A) and comparison of the survival rate between 15N (solid squares) and *Halobacterium* NRC-1 (solid triangles) (B and C). (A) Ultraviolet-B (UVB) (312 nm) radiation. (B) Ultraviolet-C (UVC) (254 nm) radiation. (C) ^{60}Co gamma radiation. N—number of viable cells after radiation; N_0—the initial number of viable cells in unradiated sample. Error bars represent standard errors from duplicate experiments (from Dong, 2008).

Bacterial isolates obtained from Tibetan lakes are either phylogenetically or physiologically unique. Phylogenetically, many of them belong to the "typical Tibetan freshwater bacteria." Physiologically, isolates exhibit various pigments and higher tolerance to salinity and UV radiation than those from other freshwater lakes, indicating local adaptation of the microbes. Y. Liu et al. (2009) reported that bacterial isolates from Lake Puma Yumco (5030 masl) and glacial melt water (6350 m on the East Rongbuk Glacier, Mount Everest) exhibit a variety of colors. Despite the phylogenetic similarity of some isolates to common bacteria, they nonetheless possess unique pigments. The ability of these isolates to resist the intense UV radiation present at high elevations suggests that the pigments may provide some protection (Dong, 2008; Dong and Yu, 2007; Jiang et al., 2006). Indeed, a *Bacillus* isolate exhibits a similar level of UV and gamma radiation resistance as *Halobacterium* NRC-1 (Fig. 3), an archaeon known to be extremely resistant to UV and gamma radiation (Baliga et al., 2004; Kottemann et al., 2005).

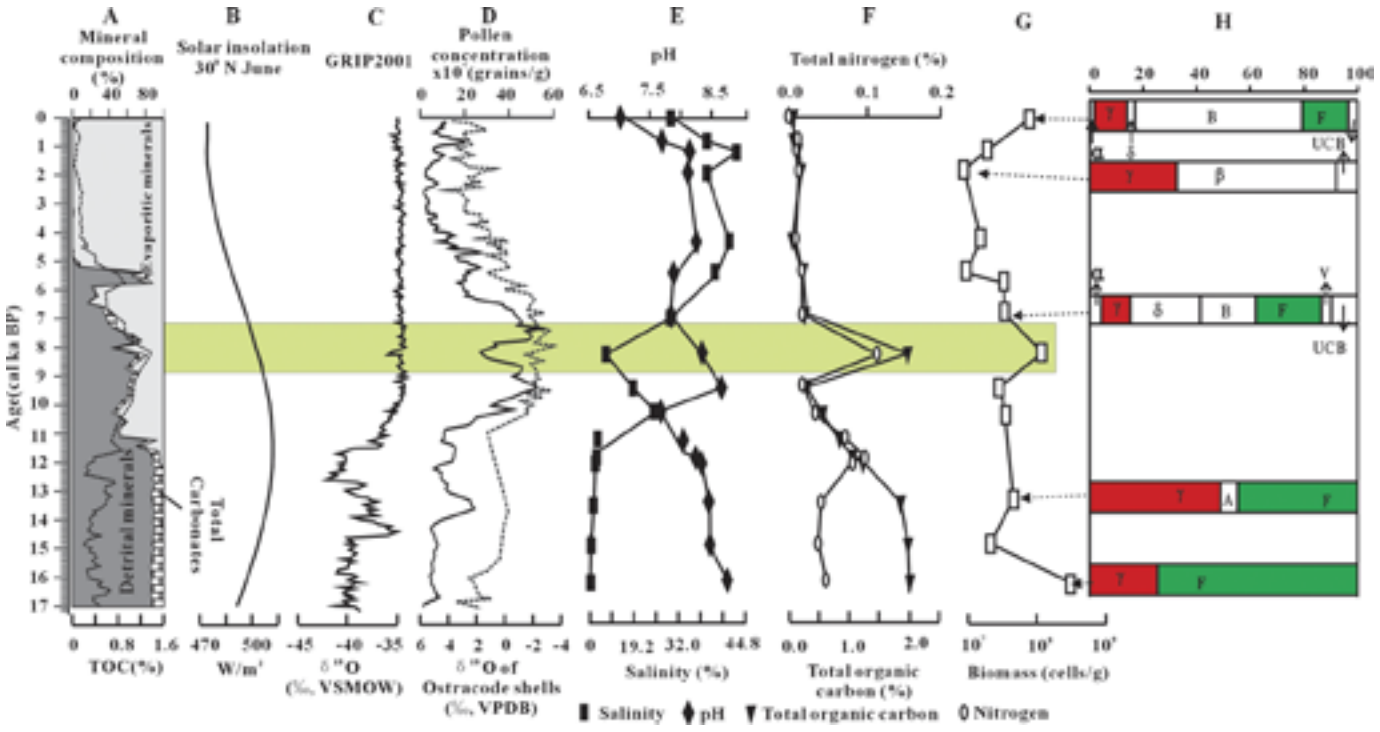

Figure 4. Correlation between paleoclimate indicators and bacteria abundance and diversity recorded in the sediments of Lake Chaka on the Tibetan Plateau. (A) A 9-m (17,000 yr) sediment core with superimposed mineral composition and total organic carbon (TOC) content (Liu et al., 2008). The dark-shaded area near the bottom third of the core represents detrital minerals (quartz, clays, and feldspars), and the light-shaded area near the top represents evaporative minerals (halite and sulfates). (B) Solar insolation at 30°N. (C) The Greenland Ice Core Project (GRIP) $\delta^{18}O$ record from Greenland (Johnsen et al., 2001). VSMOW—Vienna standard mean ocean water. (D) Solid and broken lines are pollen concentration (Shen et al., 2005) and $\delta^{18}O$ of ostracod shells (Liu et al., 2007), respectively. VPDB—Vienna Peedee belemnite. (E) Salinity and pH as measured in pore water from the core. (F) TOC and total nitrogen (TN) contents as measured in bulk sediments. (G) Bacterial abundance as measured by phosphorlipid fatty acid. (H) Phylogenetic groups of bacteria at five depths: α—*Alphaproteobacteria*; β—*Betaproteobacteria*; δ—*Deltaproteobacteria*; γ—*Gammaproteobacteria*; A—*Actinobacteria*; B—*Bacteroidetes*; F—*Firmicutes*; V—*Verrucomicrobia*; UCB—unclassified bacteria. Figures E, F, G, and H are from Jiang et al. (2007). A wet/warm period at 9 to 7 ka (the gold bar on the diagram) is identified by high TOC/TN/pollen contents, a peak in detrital mineral content, low salinity, and high pH. Bacterial abundance and diversity are highest during this time period.

MICROBIAL RESPONSE TO PAST ENVIRONMENTAL CHANGES AND HUMAN ACTIVITY

Climate Change

Using a 9-m sediment core from Lake Chaka, an inland hypersaline lake on the Tibetan Plateau, Jiang et al. (2007) observed that archaeal communities systematically respond to salinity change: The *Crenarchaeota* are predominant in the bottom freshwater sediments of the core, but absent in the salt layers near the top; instead, the halophilic *Halobacteriales* of the *Euryarchaeota* are the most important group in the hypersaline sediments near the top of the core.

Two strategies may be operative for the microbial response to increased salinity—replacement of one taxa by another or gradual adaptation of the same taxa (Jiang et al., 2007). The bacterial community exhibits a similar response pattern as the archaeal community. In addition to the salinity response, the microbes show a response to precipitation and temperature. For example, high bacterial abundance and diversity are correlated with the wet and warm climate in the early to mid-Holocene (9–7 k.y. B.P.; shaded area in Fig. 4), suggesting that enhanced nutrient levels during this period may have stimulated microbial growth and diversification. The presence of DNA sequences of phototrophic organisms (belonging to the *Alphaproteobacteria* in Fig. 4) indicates enhanced productivity, consistent with high total organic carbon (TOC) and total nitrogen (TN) contents in the lake at this time (Fig. 4). The enhancement of sulfate-reducing activity (i.e., the *Deltaproteobacteria* in Fig. 4) indicates water column anoxia, further supporting enhanced weathering and increased nutrient supply to the lake.

Human Activity

The impacts of combined human activity and climate change are observed in the sediments of Qinghai Lake. We focused on microbial diversity, functional genes, and lipid biomarkers for the top 50 cm of sediments corresponding to 1500 yr of deposition (Dong et al., 2006) (Fig. 5); TOC, TN, pollen concentration, and $\delta^{13}C$ of organic matter (Shen et al., 2005) all indicate a high productivity in the lake ~1000 yr ago. High biomass and bacterial diversity characterizes this time period. Unlike the over- and underlying sediment layers, the 1000-year-old sediment contains the *Deltaproteobacteria* (largely sulfate-reducing bacteria) as a major group (Fig. 5) (Dong et al., 2006). Enhancement of sulfate-reducing activity is consistent with high productivity in the lake that led to entrophication and anoxic conditions.

The 1000-year-old sediments display a greater number of species with an affiliation to phototrophic green, nonsulfur bacteria. Because the light flux in sediment is insignificant, the presence of phototrophic bacteria may correspond to a period when phototrophs were abundant at a certain depth in the water column (Ji et al., 2009), reflecting enhanced productivity. High microbial diversity and activity during this time period is also supported by microarray data, a technique that detects diversity and relative abundance of functional genes in environmental samples. The detected functional genes are mostly related to C, N, and S biogeochemical cycling.

The high productivity in Qinghai Lake at this time may be due to human settlement and climate changes in the region. According to the historical records, the Qinghai Lake region was the governing center of minority groups and was under the influence of the Han ethnic group. In the Han Dynasty, the

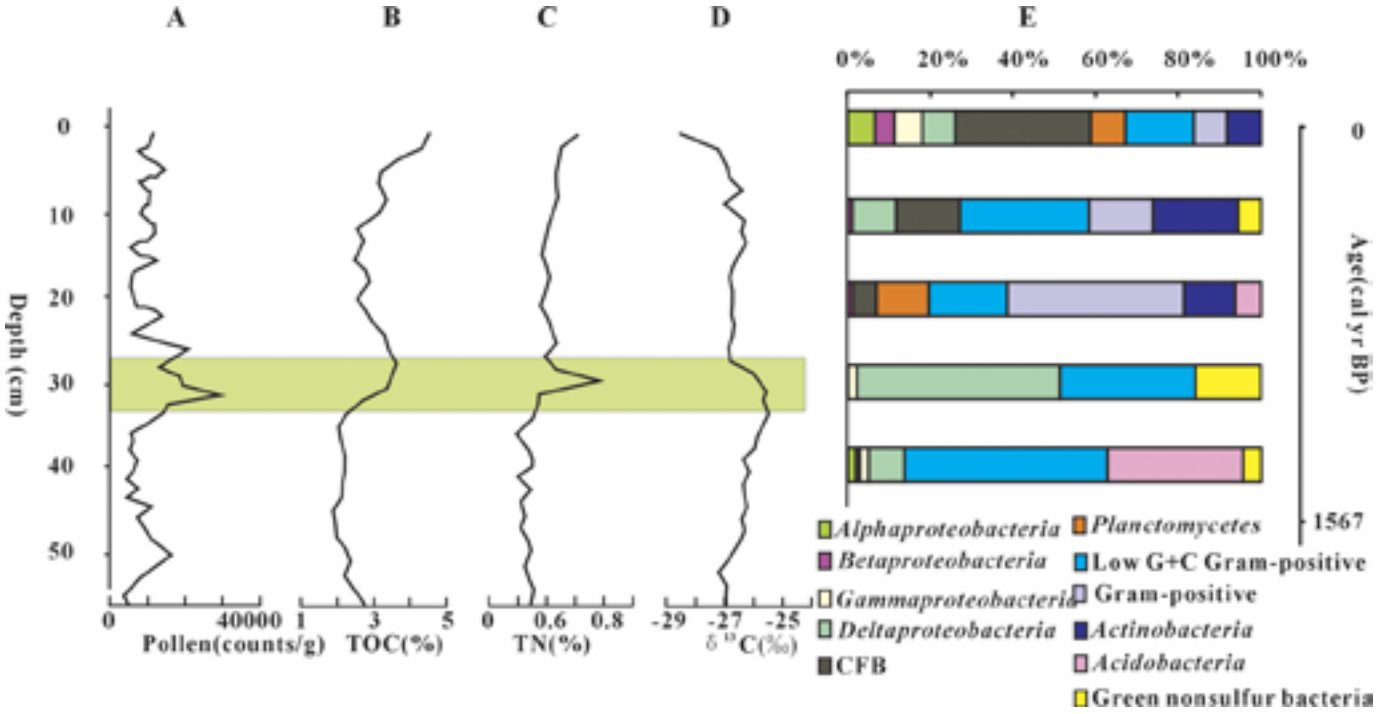

Figure 5. Correlation for a 50-cm sediment core from Qinghai Lake. High total organic carbon (TOC), total nitrogen (TN), pollen contents, and $\delta^{13}C$ of organic matter suggest a period of enhanced primary productivity ~1000 years ago. This period corresponds to settlement of the Han ethnic group in the Xihai County near the Qinghai Lake region and a warm period that preceded the Little Ice Age. This enhanced productivity drove the lake to an anoxic condition, resulting in increased sulfate reduction activity (i.e., a large increase in *Deltaproteobacteria* on E). Figures A, B, C, and D are from Shen et al. (2005); the bacterial data are from Dong et al. (2006). CFB—*Cytophaga/Flavobacterium/Bacteriorides*; G+C—Low C + C gram positive bacteria, a subgroup of *Firmicutes*.

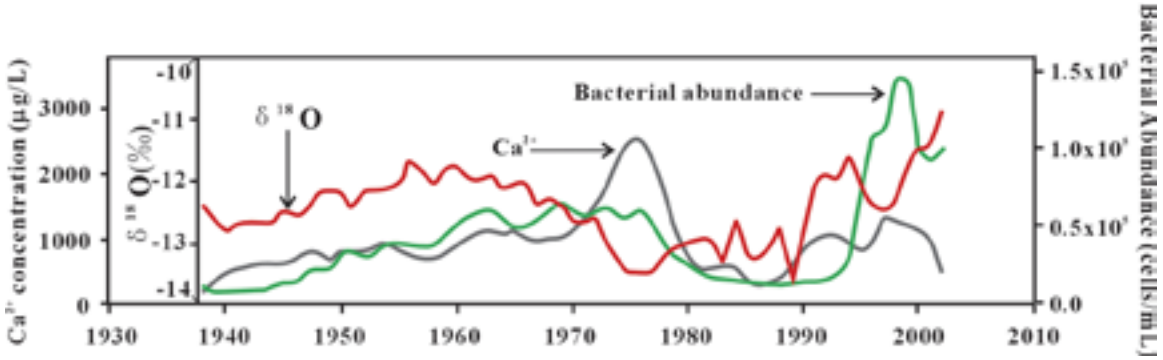

Figure 6. Annual variations of bacterial abundance, Ca^{2+} concentration (a proxy for dust particle concentration), and $\delta^{18}O$ value of ice (a proxy for temperature) in an ice core from Mount Geladaindong (the summit of the Tanggula Mountains) from 1935 to 2004. The two prominent peaks of bacterial abundance in the middle 1970s and 1990s can be explained by a combination of dust and temperature effects. The highest Ca^{2+} concentration (in the middle 1970s) indicates the greatest dust transport of bacteria, but the lowest temperature does not support bacterial growth in ice; thus, the bacterial abundance is only the second highest. In the late 1990s, a combination of high dust content and warm temperature would have transported the greatest amount of bacteria and allowed the greatest amount of growth, thus accounting for the highest bacterial abundance. Data and interpretation are from Yao et al. (2008).

"Xihai County," now called Sanjiaochen, was 20 km from the northeastern corner of Qinghai Lake (Shen et al., 2005). The development of this population center and related human activities may have resulted in increased nutrient loading into the lake, resulting in eutrophication and enhanced sulfate-reducing activity. This time also corresponds to a warm period that preceded the Little Ice Age. Thus, the combined effects of human activity and climate change may have been responsible for the enhanced primary productivity and sulfate reduction. The subsequent drop in productivity may be explained by a climatic shift to drier and colder conditions (Shen et al., 2005) and a related reduction in the local population.

Dust Storms

Ice cores provide another record of the microbial response to past environmental change, especially dust storm activity. Past studies demonstrate that bacterial abundance is positively correlated with dust or clastic content (Chu et al., 2009; Xiang et al., 2004, 2005; Zhang et al., 2007). A recent study (Yao et al., 2008) found a positive correlation between bacteria abundance and Ca^{2+} concentration in ice cores, a proxy for dust particle concentration, but with certain exceptions (Fig. 6). The exceptions are ascribed to a temperature effect. Bacterial growth can occur before snow densification and transformation into ice (Yao et al., 2008). Strong dust storms and high temperatures therefore appear to provide favorable conditions for bacterial growth on ice sheets and glaciers.

FUTURE PERSPECTIVES

The results summarized here demonstrate the potential of using the microbial record in lake sediments and ice cores for paleoenvironmental reconstruction. We hypothesize that vertical permeability of lake sediments and the rate of microbial evolution play important roles in determining the time frame over which the microbial record may be preserved in lake sediments and the degree to which this record can reflect past environmental changes. Favorable conditions for paleoenvironmental reconstruction are to be found where vertical mixing of sediments is limited, such as in clay-rich anoxic sediments, and microbial evolution is slow. Future studies should focus on establishing the quantitative relationships between microbial records and environmental factors over longer time scales.

Anthropogenic lead, methane, ammonium, and organic compounds have been detected in ice cores of the Tibetan Plateau, and their concentrations have been increasing over the last several decades (X.P. Wang et al., 2008). It is unknown how these anthropogenic compounds impact the biosphere, especially with regard to microorganisms. Future endeavors should target specialized functional groups, such as phototrophs, aerobic methanotrophs, Pb-resistant organisms, and ammonia-oxidizing microorganisms. These functional traits may be more responsive to environmental changes (Green et al., 2008).

CONCLUSIONS

Microbial abundance and diversity respond to environmental gradients in Tibetan lakes. Microbial records in lake sediments and ice cores contain a wealth of information about past climate changes and human activities. In lake sediments, wet and warm climates favor high bacterial abundance and diversity, whereas low bacterial abundance and diversity are correlated with dry and cold environments. Enhanced primary productivity and eutrophication as induced by human activity and warm/wet climates are recognized by elevated levels of sulfate reduction and CO_2 fixation in lake sediments. Microbial records in ice cores provide a related record of dust storm activity and temperature variation.

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LETTER

Dear Editor:

After reading Richard P. Palmer's "Letter" in the March issue of *GSA Today**, I had to check the cover to make sure I was reading *GSA Today* and not *USA Today*. Mr. Palmer is certainly entitled to his opinion, but his polemic tone, word choice ("Saint Gore," "data rigging," "prostitution") and obvious political bias renders his letter inappropriate for any scientific society's publication. There are more than enough outlets for the shrill opinion, such as blogs, newspapers, talk radio, or street demonstrations.

Perhaps worst of all, *GSA Today's* publication of a "lifetime" geoscientist's diatribe lends a bit more credibility to the ideology-based criticisms of climate science. Those of us who work in the noisy classroom of science and public policy have enough trouble getting the students to pay attention. There is plenty of room for thoughtful opinion and discourse, but disruptive shouting serves neither the science nor the students.

So please, *GSA Today*: Give scientific debate and opinion its rightful place, but do not follow the commercial media in giving "equal voice" to fake scientific challenges that are, in reality, angry and emotional yells.

Rob McDowell, Ph.D., P.G., Director, Environmental Policy Program, University of Georgia
Member, GSA Geology and Society Division

*v. 20, no. 3, p. 11

Send letters to GSAToday@geosociety.org or Managing Editor, *GSA Today*, P.O. Box 9140, Boulder, CO 80301-9140, USA. Please keep your letter to 300 words or fewer; letters longer than 300 words will not be published. The *GSA Today* managing editor will edit letters for length and clarity. All letters will be forwarded to the *GSA Today* science editors for review before publication, and *GSA Today* reserves the right to reject any letter at the discretion of the science editor. Opinions presented do not reflect official positions of the Society.

DIALOGUE

Jean Bahr, *GSA President*

Jack Hess, *GSA Executive Director*

The three highest awards the Geological Society of America presents each year are the Penrose, Day, and Donath (Young Scientist Award) Medals. All three medals are 2.25 inches in diameter and have traditionally been made of 14-karat solid gold. We are now challenged by the fact that the price of gold has far-outstripped the ability of the Penrose and Day medal funds to provide the financial resources to fully cover the costs of producing those medals. At the time of this writing, each gold medal costs about US$6,000.

Fred Donath continues to fully support the cost of the gold Donath Medal, but to maintain the tradition of presenting the Penrose and Day 14-karat-gold medals every year, an endowment of more than US$150,000 for each medal is needed. Currently, there is only about US$30,000 between the two funds.

The Day bequest specifies the gold content and size of the medal. Legal opinion states that we cannot change the bequest.

The Penrose bequest allows the freedom to change the composition and size of the medal. For Denver 2010, GSA Council has approved changing the Penrose Medal to a gold-plated silver medal. The Day and Donath medals will remain solid gold.

What choices does the Society have in order to continue presenting these prestigious medals?

- **Raise at least US$270,000** to endow both the Penrose and Day medal funds.
- **Use Society operating funds** to make up the difference. For fiscal year 2011, that would be about US$11,000.
- **Change the Penrose Medal** to 24-karat-gold–plated silver. Approximate cost: US$1,000.
- **Only present the medals when there are enough funds** to pay for them, knowing that this will create large gaps in the presentation of both medals.

What can you do to help?

Please make a donation to either the Penrose or Day Medal funds through the GSA Foundation at **www.gsafweb.org/makeadonation.html.**

The Penrose Medal

was established in 1927 by R.A.F. Penrose Jr. to be awarded in recognition of distinguished research in pure geology—outstanding original contributions or achievements that mark a major advance in the science of geology. The award is made only at the discretion of GSA Council, which interprets pure geology to apply to all scientific disciplines represented by the Society. Nominees may or may not be members of the Society and may be from any nation. Penrose's sole objective in making the gift was to encourage original work in purely scientific geology; scientific achievements are to be considered rather than contributions in teaching, administration, or service. Mid-career scientists who have already made exceptional contributions will be given full consideration for the award.

The Arthur L. Day Medal

was established in 1948 by Arthur L. Day to be awarded annually, or less frequently at the discretion of GSA Council, for outstanding distinction in the application of physics and chemistry to the solution of geologic problems. Day's intent was to recognize outstanding achievements and inspire further effort, rather than reward a distinguished career, and scientific achievements are to be considered rather than contributions in teaching, administration, and service.

The Young Scientist Award (Donath Medal)

was established in 1988 to be awarded to a scientist who will be 35 years of age or younger *throughout* the year in which the award is to be presented for outstanding achievement in contributing to geologic knowledge through original research that marks a major advance in the earth sciences. The award, consisting of the gold Donath Medal and an honorarium, was endowed by Dr. and Mrs. Fred A. Donath.

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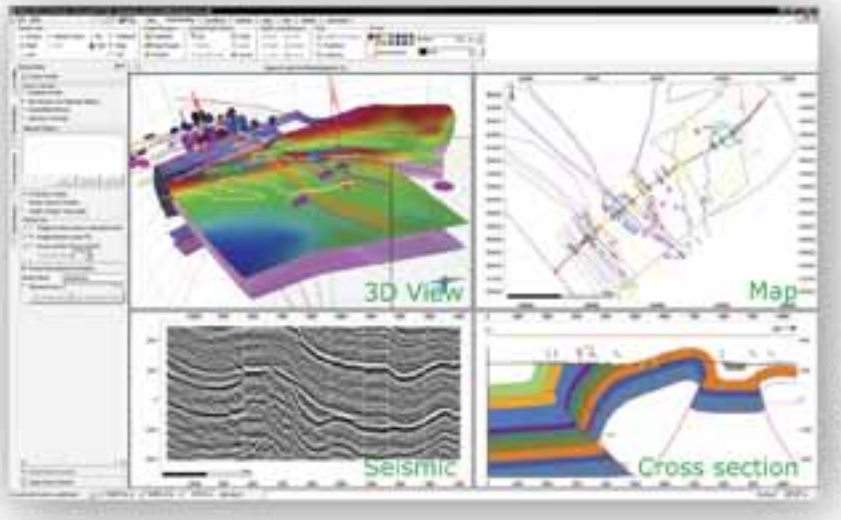

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- well and borehole data
- legacy data (eg scanned cross-sections, maps and diagrams)
- geophysical data (seismic, gravity, magentic)
- digital elevation models
- remote sensing data
- GIS shape files

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The structural geology experts

2010 GSA Annual Meeting & Exposition

Reaching New Peaks in Geoscience

A Message from Incoming GSA President Joaquin Ruiz

Joaquin Ruiz.
Photo © FOTOSMITH.

On behalf of your Society, it is my pleasure to invite you to the Mile-High City this October for our 122nd Annual Meeting & Exposition. On behalf of your hard-working geoscience colleagues, I invite you to actively participate in the voluminous technical program being assembled for the Denver meeting.

We have **156 Topical Sessions** proposed, some of which surely include your scientific specialty and beg your contribution. The deadline for submitting your abstracts is **10 August.**

GSA's new Mineralogy, Geochemistry, Petrology, and Volcanology (MGPV) Division has proposed numerous sessions—check them out. The Structural Geology and Tectonics Division is celebrating its 30th Anniversary. Petroleum geologists—for you we've arranged the "Best of AAPG" Lectures.

This year's **eight invited Pardee Symposia** will stimulate your thinking; **21 short courses** will develop and enhance your skills; **25 field trips** will get both your mind and your body moving; and more than **200 exhibits** will bring you up-to-date on the best and latest in everything.

Plan to arrive early to attend the **Presidential Address** on Saturday (30 Oct., 7–9 p.m.), during which this year's award winners will be honored. Then, on Sunday (31 Oct.), take a closer look into the lives and careers of the Penrose, Day, and Donath Medalists at the **GSA Gold Medal Lectures.**

You won't want to miss the popular **Lunchtime Lecture** series either, featuring Marcia McNutt (USGS), Tim Killeen (NSF), Thomas Ahlbrandt (2010 Halbouty Lecturer), and Timothy Dixon (University of Miami earthquake specialist).

Reaching New Peaks in Geoscience is an apt description—not only of our mountainous gathering place but also of our purpose in coming together. Our collective passion for discovery will be well-indulged by the program of scientific exchange in Denver. **Students:** There is no better opportunity to advance your geoscience career! I am confident that every attendee will find the personal and professional enrichment profoundly rewarding.

I encourage each of you to register right away and then pass along this invitation to international colleagues and non-members who will also find the meeting valuable. It's a great way to make new friends and demonstrate how smart you are!

Thanks

to the 2010 Organizing Committee

Technical Program Chair:
Richard C. Berg, Illinois State Geological Survey, berg@isgs.uiuc.edu

Field Trip Co-Chairs:
Lisa Morgan, U.S. Geological Survey, lmorgan@usgs.gov;
Steve Quane, Quest University Canada, steve.quane@gmail.com

Events & Deadlines

10 August
- Abstract Submission Deadline

27 September
- Early Registration Deadline
- Housing Deadline

4 October
- Registration Cancellation Deadline

27–30 October
- Premeeting Field Trips

29–31 October
- Short Courses & Workshops

30 October
- GSA Presidential Address & Awards Ceremony: 7–9 p.m.

31 October
- GSA Gold Medal Lectures
- Welcoming Party & Exhibits Opening: 6–8 p.m.

31 October–3 November Technical Program
- Oral Sessions
- Posters: Hung all day with half-day sessions, authors present a.m. or p.m.

31 October–3 November
- Lunchtime Keynote Lectures: 12:15–1:15 p.m.

1 November
- Group Alumni Reception: 7–9:30 p.m.
- Private Alumni Receptions

1–2 November
- Exhibit Hall Open: 9 a.m.–6 p.m.

3 November
- Exhibit Hall Open: 9 a.m.–2 p.m.

4–6 November
- Postmeeting Field Trips

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Rock glacier, northern Colorado. Photo by Marli Bryant Miller, University of Oregon, www.marlimillerphoto.com.

Pardee Keynote Symposia

Invited Papers

The Pardee Keynote Symposia are made possible by a grant from the Joseph T. Pardee Memorial Fund.

Pardee Keynote Symposia are special, interdisciplinary events representing issues on the leading edge of a scientific discipline or area of public policy and addressing broad, fundamental issues in the geosciences. Selection is on a competitive basis. This year's eight Pardee Symposia were reviewed and accepted by the Annual Program Committee; all speakers are invited.

P1. **Symbiosis and Global Change in Ancient and Modern Earth Systems**

Tues., 2 Nov., 8 a.m.–noon

Cosponsors: *Geochemical Society; Paleontological Society; GSA Geomicrobiology & Geobiology Division*

Disciplines: Paleontology, Diversity, Extinction, Origination; Geomicrobiology; Geochemistry, Organic

Advocates: Laurie Anderson, Louisiana State University, Baton Rouge, La., USA; Annette Summers Engel, Louisiana State University, Baton Rouge, La., USA

Description: Symbiosis has profoundly impacted Earth's biosphere and geosphere through time. This session highlights modern to ancient symbiosis, including chemosymbiosis, in the context of past and future biological, geological, and geochemical evolution.

P2. **Evolving Moon: Recent Advances in Understanding Our Planetary Neighbor from NASA's Lunar Reconnaissance Orbiter and Other Missions**

Mon., 1 Nov., 1:30–5:30 p.m.

Cosponsor: *GSA Planetary Geology Division*

Disciplines: Planetary Geology; Remote Sensing/Geographic Info System; Volcanology

Advocate: David A. Williams, Arizona State University, Tempe, Ariz., USA

Description: An armada of international spacecraft, including NASA's Lunar Reconnaissance Orbiter, is enabling exploration of Earth's Moon in new ways. This session will highlight recent discoveries using new sensors on these spacecraft. The latest results will be placed in the context of both ongoing global mapping and planning for future human exploration.

Artist concept (Chris Meaney, NASA) of the Lunar Reconnaissance Orbiter with Apollo mission imagery in the background, http://www.nasa.gov/mission_pages/LRO/multimedia/lroconcept2.html.

P3. **Why Aren't Our Ideas Getting Attention? Finding a More Convincing Voice on Controversial Issues**

Sun., 31 Oct., 1:30–3:30 p.m.

Cosponsors: *GSA Geology and Society Division; American Geological Institute; American Geophysical Union; Association of American State Geologists; GSA Geology and Public Policy Committee; GSA Hydrogeology Division; GSA Engineering Geology Division*

Disciplines: Public Policy; Environmental Geoscience; Geoscience Information/Communication

Advocates: James Davis, cosmos, Carmichael, Calif., USA; Jon Goodwin, University of Illinois, Champaign, Ill., USA; Craig Cooper, Idaho National Laboratory, Idaho Falls, Idaho, USA

Description: Panel/Audience Discussion of Geoscientists Making Useful Input to Policymakers—Panel presentations: policy-relevant USGS investigations update; climate change evidence as an example of science use in public decisions; elements of successful science communications to lay users; insights on achieving consensus about complex and controversial issues.

P4. **Mineral Evolution: The Coevolution of the Geo- and Biospheres**

Mon., 1 Nov., 8 a.m.–noon

Cosponsors: *Mineralogical Society of America; Geochemical Society*

Disciplines: Mineralogy/Crystallography; Geochemistry; Precambrian Geology

Advocates: John B. Brady, Smith College, Northampton, Mass., USA; Martin B. Goldhaber, U.S. Geological Survey, Denver, Colo., USA

Description: "Mineral evolution," the study of Earth's changing near-surface mineralogy, frames Earth materials research with a historical narrative, from approximately 12 minerals in prestellar molecular clouds to over 4,400 known minerals today.

"Cave of Crystals," Naica mine, Chihuahua, Mexico. April 2007 *Geology* cover photo by Javier Trueba (Madrid Scientific Films).

P5. **Rapid Environmental/Climate Change in the Cretaceous Greenhouse World**

Wed., 3 Nov., 8 a.m.–noon

Cosponsors: *Society for Sedimentary Geology (SEPM); International Geoscience Program 555*

Discipline: Paleoclimatology/Paleoceanography

Advocates: Chengshan Wang, China University of Geosciences, Beijing, China; Robert W. Scott, Precision Stratigraphy Associates & The University of Tulsa, Cleveland, Okla., USA; Michael Wagreich, University of Vienna, Vienna, Austria; Bradley B. Sageman, Northwestern University, Evanston, Ill., USA; William W. Hay, University of Colorado at Boulder, Estes Park, Colo., USA

Description: The goal of this symposium is to discuss the causes, processes, and consequences of rapid environmental changes in the Cretaceous greenhouse world, from both marine and terrestrial records.

P6. **Seeing the True Shape of Earth's Surface: Applications of Airborne and Terrestrial LiDAR in the Geosciences**

Sun., 31 Oct., 8 a.m.–noon

Cosponsors: *GSA Engineering Geology Division; GSA Structural Geology and Tectonics Division; GSA Quaternary Geology and Geomorphology Division; GSA Sedimentary Geology Division; GSA Geoinformatics Division; GSA Geophysics Division*

Disciplines: Engineering Geology; Neotectonics/Paleoseismology; Quaternary Geology

Advocates: Ian P. Madin, Dept. of Geology and Mineral Industries, Portland, Ore., USA; Kurt L. Frankel, Georgia Institute of Technology, Atlanta, Ga., USA

Description: High-resolution LiDAR data are now becoming available over large areas. This session will examine how these highly detailed images of the land surface provide unprecedented opportunities for qualitative and quantitative analysis of earth processes.

P7. **Impacts of Ocean Acidification: The Other CO_2 Crisis**

Wed., 3 Nov., 1:30–5:30 p.m.

Cosponsors: *GSA Quaternary Geology and Geomorphology Division; American Quaternary Association (AMQUA); GSA Geobiology & Geomicrobiology Division; GSA Geology and Society Division; International Union for Quaternary Research (INQUA); National Association of Geoscience Teachers (NAGT)*

Disciplines: Environmental Geoscience; Geochemistry; Quaternary Geology

Advocates: Andrew M. Buddington, Spokane Community College, Spokane, Wash., USA; George T. Stone, Milwaukee Area Technical College, Milwaukee, Wis., USA; Richard A. Feely, National Oceanic and Atmospheric Administration, Seattle, Wash., USA

Description: Surface waters of Earth's oceans are becoming increasingly acidic due to human activities. This rapid acidification threatens marine calcifiers, coral reef ecosystems, and oceanic food webs, including fisheries, exacerbating global ecologic and economic crises.

P8. **Exploring for Life in the Cosmos: Celebrating Five Decades of Astrobiology**

Tues., 2 Nov., 1:30–5:30 p.m.

Cosponsors: *GSA Geobiology & Geomicrobiology Division; GSA Planetary Geology Division*

Disciplines: Geomicrobiology; Planetary Geology; Paleontology, Diversity, Extinction, Origination

Advocate: Jack D. Farmer, Arizona State University, Tempe, Ariz., USA

Description: This session celebrates more than five decades of astrobiology as a scientific discipline, highlighting key discoveries that bear on life's origin and existence beyond Earth.

Large primnoid coral loaded with brittle stars on Dickins Seamount, Gulf of Alaska. Credit: National Oceanic and Atmospheric Administration (NOAA) Gulf of Alaska Seamount Expedition (library image ID expl0125), http://www.photolib.noaa.gov/htmls/expl0125.htm.

Call for Entries

SECOND ANNUAL PHOTO EXHIBITION

Geologic processes have sculpted this planet for more than 4.5 billion years. Geologists are witnesses to planetary change and history, and many of us record our observations with compelling images.

We invite geoscientists who are members of GSA and its Associated Societies (see p. 26) to share their best images of the planet with others through the 2010 Geological Society of America Photo Exhibition.

Images will be juried into the show by a panel consisting of a nationally known nature photographer, a geologist, and an artist. We have room to display the top 10 images in each of the four categories described below. All submitted images will be shown on a large HD screen at the GSA booth and will be considered for inclusion in a possible GSA Special Paper/photo book for the general public. We will also ask your permission for GSA to use the submitted images in its promotions and/or on the Web site.

Clarno Palisades, John Day Fossil Beds National Monument, Oregon. Photo by Ellen Bishop.

2010 Exhibition Categories

Rocky Mountain Regional Geology: Depict some aspect of Rocky Mountain landscapes, features, and/or geologic activity.

Abstract Images: Depict patterns or form by way of photomicrographs, satellite images, maps, or landscapes that capture a dynamic process or simply show the aesthetic patterns of geology at any scale.

Geologic Processes and Features: Depict images specific to processes or a feature resulting from a specific process; e.g., images of imbricated cobbles as bellwether of ancient rivers; images of lava flows that represent ancient eruptions, etc.

Iconic Landscapes: Depict iconic, commonly visited landscapes in national parks, monuments, or other public places that represent, or are part of, an important process; e.g., Yellowstone geysers, Grand Canyon, or Death Valley.

Submission

Deadline: 10 September 2010

Submissions will be accepted only from GSA members or members of GSA's Associated Societies (see www.geosociety.org/divisions/ to learn more). Both color and black and white images are eligible; images submitted in 2009 will not be considered again.

1. Submit .jpg files *no larger than* 1 MB but at a preferred resolution of 300 dpi.
2. The category into which the image is to be entered must be clearly indicated. Individuals may submit no more than two entries per category.
3. Images and descriptions should be e-mailed to Ellen Bishop and Marli Miller, contest managers, at geosocphotos@gmail.com.

Process

1. A jury of three—a photographer, an artist, and a geologist—will judge the 1 MB .jpg images and select those to be on display at the meeting.
2. Winners will be notified by 20 September.
3. The deadline for submission of files *for printing* is 4 October.
4. Winners will work directly with the printer (Cirrus Digital Printing) and mounter (Katayama) to print and mount their photographs. Recommended sizes for images to be printed and hung are 24 × 30 or 18 × 24 or 11 × 17, with exceptions for panoramic or other unique aspect ratios. GSA is seeking support to offset the cost of printing and mounting, but winners should be prepared to contribute US$60–US$80 per image.
5. This year, GSA meeting participants will vote for favorite images, with a prize (TBD) awarded to the top image in each category.

Questions about the contest and exhibition may be directed to Ellen Bishop, +1-541-398-1810, paleobishop@gmail.com

Special Events

2010 GSA Gold Medal Lectures

Colorado Convention Center
Sunday, 31 Oct.

About the 2009 GSA Gold Medal Lectures

"I'm glad that the series was viewed as a success and I will make attendance a regular feature at my future GSA's."

—T. Mark Harrison, 2009 Day Medalist

Continue the celebration!

The GSA Presidential Address and Awards Ceremony on Saturday is just the beginning…

Please join us on *Sunday* for the **GSA Gold Medal Lectures,** a special event hosted by GSA to honor the 2010 Penrose, Day, and Donath medalists. The honorees are scheduled to give half-hour lectures reflecting on their scientific careers. GSA President Joaquin Ruiz will chair this event.

ANNUAL

Geoscience Educators' Social Reception

Saturday, 30 Oct., 5–7 p.m.

The GSA Education Committee, the National Association of Geoscience Teachers (NAGT), the GSA Geoscience Education Division, Cutting Edge, the IRIS Consortium, the American Geological Institute (AGI), the Digital Library for Earth System Education (DLESE), the National Earth Science Teachers Association (NESTA), and UNAVCO invite all educators to a relaxing forum for socializing, sharing ideas, and meeting other geoscience community members interested in education.

Appetizers and cash bar provided.

GSA Lunchtime Lectures

Colorado Convention Center
Sun.–Wed., 12:15–1:15 p.m.

The second year of GSA's new Lunchtime Lecture series promises to be as good as the first! Please pencil these lunchtime events into your schedule and check coming issues of *GSA Today* for topic highlights.

- ☑ Sunday, 31 Oct.: **Marcia Kemper McNutt,** Director of the United States Geological Survey
- ☑ Monday, 1 Nov.: **Timothy Killeen,** Assistant Director for the Geosciences, National Science Foundation
- ☑ Tuesday, 2 Nov.: *2010 Halbouty Lecturer* **Thomas Ahlbrandt,** Vice President of Exploration, Falcon Oil and Gas Ltd.
- ☑ Wednesday, 3 Nov.: **Timothy Dixon,** University of Miami, Rosenstiel School of Marine and Atmospheric Sciences, Professor and Director of the Space Geodesy Laboratory

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Other Special Events and Ticketed Functions

301. **Paleontological Society Reception Buffet:** Sat., 30 Oct., 5–8 p.m. Professionals: $35; students: $10.
302. **National Association of Geoscience Teachers (NAGT) and GSA Geoscience Education Division Awards Luncheon:** Sun., 31 Oct., 11:30 a.m.–1 p.m. $42.
303. **AWG Breakfast:** Mon., 1 Nov., 6:30–8:30 a.m. Professionals: $30; students: $15.
304. **Engineering Geology Division Luncheon & Awards Ceremony:** Mon., 1 Nov., 11:45 a.m.–2:30 p.m. $42.
305. **History of Geology Division Luncheon & Business Meeting:** Mon., 1 Nov., noon–2 p.m. $42.
306. **Geoscience Information Society (GSIS) Luncheon:** Tues., 2 Nov., noon–1:30 p.m. $42.
307. **Hydrogeology Division Luncheon, Awards, and Business Meeting:** Tues., 2 Nov., noon–3 p.m., $42.
308. **MSA Awards Luncheon:** Tues., 2 Nov., 12:30–2:15 p.m. $42.
309. **Joint Reception of MGPV with MSA/GS:** Tues., 2 Nov., 5:45–7:30 p.m. Professionals: $10; students: $5.

Guest Program

Guest Hospitality Suite

Sun.–Wed., 31 Oct.–3 Nov., 8 a.m.–5:30 p.m.

GSA's Guest Hospitality Suite includes complimentary seminars, light food and beverages throughout the day, a welcome gift, and the President's guest breakfast. A hostess will be on-hand to assist you with questions regarding restaurants, activities, and attractions, as well as offer general information about Denver.

As a registered guest, you are welcome to attend your companion's technical session(s), and you will also have admittance to the exhibit hall. In addition, you have the opportunity to sign up for professional field trips (additional fees apply) or attend open lectures. See p. 21 for a field trip designed especially for families (no. 415).

Complimentary Guest Seminars

Guest Hospitality Suite, 10–11 a.m. daily

Sunday, 31 Oct.: Jewelry by Beth Finesilver

Beth Finesilver, a well-known jewelry artisan from Denver, will join us for an interesting, comprehensive, and spirited presentation on the many facets of her jewelry business—from the first glimmer of an idea all the way through to the marketing of her product. She will share her thoughts on design and the gemstones she uses in her beautiful creations. Finesilver's jewelry is sold in museum shops, boutiques, and galleries across the country. She has a BFA in graphic design and marketing and owned Finesilver Designs, a full-service advertising agency, prior to creating her jewelry design business 18 years ago.

Monday, 1 Nov.: Flute & Storytelling

Eric "Many Winds" Herrera's heritage includes Blackfeet Indian, European Hispanic, and German. As a musician, his talents span brass, string, percussion, and flute instruments. Herrera will delight you with traditional Native American storytelling accompanied by the beautiful sounds of the flute. Each musical piece conveys a story, whether for courtship, celebration, spiritual intent, or to honor someone's memory.

Tuesday, 2 Nov.: Birds of Prey

The Birds of Prey Foundation, based in Boulder, Colorado, cares for about 400 orphaned and/or injured birds each year and is ranked among the five best facilities in the United States. This presentation will include a live raptor, and guests will learn about various species of raptors and their recovery, behavior, and natural history. The seminar will also cover ecology, habitat, environmental issues, wildlife medicine, rehabilitation, endangered species, and ethics.

Wednesday, 3 Nov.: Halfway to Heaven

Mark Obmascik received the National Press Club Award for Environmental Journalism in 2003, was a lead *Denver Post* writer for its 2000 Pulitzer Prize content, and is author of *Halfway to Heaven: My White-Knuckled—and Knuckleheaded—Quest for the Rocky Mountain High*. Each year, more than half a million people try to climb a "fourteener" (a mountain reaching at least 14,000 feet above sea level), but only 1,300 have reported standing atop all 54 of Colorado's highest peaks. Obmascik will share his efforts to conquer a looming mid-life crisis by successfully climbing all Colorado's fourteeners in one year and the insight he gained into the quirky, colorful subculture of mountaineering obsessives who summit these mountains year after year.

Special Tours

All annual meeting attendees and guests are welcome to register for the following tours. Prices for these tours cover professional tour guide fees, transportation, admission, and gratuities. **Tours may be canceled if minimum attendance is not met, so please register early!**

Tour participants should check in at the Guest Hospitality Suite to be directed to the departure location at the Hyatt Regency Denver. Plan to arrive at the departure location 15–30 minutes before the scheduled departure time to ensure that you don't miss the bus; GSA is unable to refund tour costs.

We recommend that you periodically check the meeting Web site, **www.geosociety.org/meetings/2010/,** for updates and news about tours and seminars.

Sunday, 31 Oct.

101. **Haunted Denver,** 1–4 p.m. Cost: US$44; min.: 20.

Get into the "spirit" of Halloween with a tour through Denver's most beautiful older neighborhoods. Enjoy some of Denver's architectural wonders while exploring the characters and events that inspired some of the city's best-known ghost stories. Highlights of the tour include John and Mary Elitch and their haunted amusement park; the imposing Lumber Baron Inn Bed and Breakfast; Horace and Baby Doe Tabor; the ghosts of Capitol Hill and its mansions; and a tour of old Mount Prospect Cemetery, known as Cheeseman Park today.

Monday, 1 Nov.

102. **Georgetown Loop Railroad,** 8:30 a.m.–2:30 p.m. Cost: US$84; min.: 20.

Enjoy an excursion into the high Rockies to Georgetown, an authentic 1860–1870s silver mine "Boom Town." You will experience the Colorado Historical Society's Georgetown Loop Railroad, which travels between the towns of Georgetown and Silver Plume, taking you over the reconstructed Devil's Gate High Bridge and through spectacular Colorado mountain scenery. The tour concludes with free time in Georgetown to enjoy lunch and do some shopping.

Tuesday, 2 Nov.

103. **Rocky Mountain Rendezvous and Historic Estes Park,** 9 a.m.–6 p.m. Cost: US$94; min.: 20.

Your tour will begin with a drive up the spectacular U.S. 36 canyon to Estes Park, the eastern gateway to Rocky Mountain National Park. Early November is the tail-end of elk mating season, when the elk spend most of their time at lower elevations, making for great photo opportunities. You will tour Rocky Mountain National Park by motor coach, visiting the most scenic spots and landmarks. The tour will return to the charming town of Estes Park, where you will have free time to enjoy lunch and do some shopping. To keep you in the Halloween spirit, the excursion continues with a 90-minute behind-the-scenes ghost tour of the historic Stanley Hotel, which has long been considered one of America's most haunted hotels. The Stanley is also known for its architecture, famous visitors, and as the inspiration for Stephen King's novel, *The Shining*.

104. **A Colorado Castle,** 1–5 p.m. Cost: US$95; min.: 20.

Cherokee Ranch & Castle is perched on a hilltop in Sedalia, Colorado, and showcases stunning views of the Rockies. Constructed between 1924 and 1926, the castle features architectural details drawn from English and Scottish castles. Today, Cherokee Castle is a museum housing historic collections of fine art, furnishings, and memorabilia from around the world. Art lovers often visit to see original drawings by Sir Christopher Wren, the architect of St. Paul's Cathedral in London. This tour covers details of the castle's history and architecture, as well as its unique furnishings and art collections. The visit includes a traditional afternoon English-style tea, with four kinds of tea and a delicious assortment of scones, pastries, and tea sandwiches.

Wednesday, 3 November

105. **Hammond's Candy Factory,** 10 a.m.–noon. Cost: US$30; min.: 20.

Hammond's Candy Factory has been creating sweet treats in Denver since 1920. Over the years, the factory has outgrown itself and changed locations around the Denver area, but the candy is still made the way Carl Hammond made it, with the same tempting recipes and the same careful craftsmanship. Hundreds of different candies are manufactured in the factory, and guests will experience the sweet indulgence of an insider's tour. Guests will be guided through parts of the factory while hearing stories about the history of the famous candies and watching candy makers busy at work. The tour concludes with candy samples and a visit to the candy store.

Childcare at the GSA Annual Meeting & Exposition

Sat.–Wed., 30 October–3 November
Colorado Convention Center

KiddieCorp has provided high quality programs to children at conventions, trade shows, and corporate events in the United States and Canada since 1986. GSA has worked with KiddieCorp since 2005 to offer professional childcare services for children ages 6 months to 12 years. Children enrolled in the program will enjoy games, story time, arts and crafts, and other fun-filled activities for each age group. Fees are US$7 per hour, per child, with a 2-hour minimum.

For more information, contact the GSA's Meetings Department at meetings@geosociety.org. Childcare services are a contractual agreement between each individual and the childcare company. GSA assumes no responsibility for the services rendered.

Register at **www.kiddiecorp.com/gsakids.htm** by **27 September 2010** to secure your child's spot. This service may be cancelled if minimum is not met, so please register by the deadline!

Field Trips

Field Trip Chairs: Lisa Morgan, lmorgan@usgs.gov, and Steve Quane, steve.quane@gmail.com.

Keeping to the "Reaching New Peaks in Geoscience" meeting theme, the Denver 2010 field trips highlight glaciation, late Cenozoic evolution of the Colorado Rockies, and a spectrum of geologic terrains, ranging from mountain uplift to landscape collapse to structural influences on mineralization. Trips will also address societal challenges, including climate change and geologic hazards. Excellent geologic exposures in the Colorado Rockies region will emphasize how tectonism, volcanism, landslides, tectonic collapse, mineralization, and dinosaurs have shaped this region and now influence hazards, resources, and human habitation. Meet with colleagues, old and new, bring the family, or even ride your mountain bike on either a local afternoon trip or a four day regional adventure (or both!).

Trips begin and end at the Colorado Convention Center in Denver unless otherwise indicated. Trip fees include transportation during the trip; other services, such as meals and lodging, are noted with each trip by the following: B—breakfast, L—lunch, R—refreshments, D—dinner, ON—overnight lodging. If you have questions about a particular trip, please contact the trip leaders directly; you'll find trip descriptions and leader contact information at www.geosociety.org/meetings/2010/fieldTrips.htm.

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

Before the Meeting

401. **A Geologic and Anthropogenic Journey from the Precambrian to the New Energy Economy through the San Juan Volcanic Field.** Wed.–Sat., 27–30 Oct. US$460 (B, L, D, R, 3ON). Cosponsors: *U.S. Geological Survey; NTS Group; Fort Lewis College; CDPHE.* Leaders: Douglas B. Yager, USGS Mineral Resources Program; Alison Burchell; Raymond H. Johnson; Austin Buckingham.

402. **Lewis and Clark Line, Montana: Tectonic Evolution of a Crustal-Scale Structure of the Rocky Mountains.** Wed.–Fri., 27–29 Oct. US$347 (L, R, 4ON). Leaders: James Sears, University of Montana; Jeff Lonn; Katie M. McDonald. Trip begins and ends in Missoula, Montana, USA. Participants should arrive in Missoula on the evening of 26 October. Departs Missoula Sat., 30 Oct.

403. **Late Cenozoic Evolution of the Colorado Rockies: Interplay between Uplift, Climate, and Drainage Integration.** Thurs.–Sat., 28–30 Oct. US$306 (L, R, 2ON). Cosponsor: *GSA Quaternary Geology and Geomorphology Division*. Leaders: Andres Aslan, Mesa State College; Karl Karlstrom; Laura Crossey.

404. **Behind Colorado's Front Range—A New Look at Laramide Basin Subsidence, Sedimentation, and Deformation in Central Colorado.** Fri.–Sat., 29–30 Oct. US$179 (L, R, 1ON). Cosponsor: *GSA Sedimentary Geology Division*. Leaders: James C. Cole, USGS; James H. Trexler Jr.; Patricia Cashman.

405. **Quaternary Geology and Geochronology of the Uppermost Arkansas Valley—Glaciers, Ice Dams, Landslides, Flood.** Fri.–Sat., 29–30 Oct. US$228 (L, D, R, 1ON). Cosponsors: *GSA Quaternary Geology and Geomorphology Division; Crestone Science Center.* Leaders: James P. McCalpin, GEO-HAZ Consulting, Inc.; Jason Briner; Nicolás E. Young; Eric Leonard; C.A. Ruleman; Keenan Lee.

406. **Boulder Creek: A Stream Ecosystem in an Urban Landscape.** Sat., 30 Oct. US$87 (L, R). Cosponsors: *U.S. Geological Survey; GSA Quaternary Geology and Geomorphology Division*. Leaders: Sheila Murphy, USGS; Philip L. Verplanck; Larry Barber; Pete Birkeland; John Pitlick; Sarah Spaulding.

407. **Mechanisms of Post-Laramide Fracturing in the Rockies: Insights from Outcrops and Industry Data from the Northern Denver Basin, Colorado.** Sat., 30 Oct. US$88 (L, R). Cosponsors: *GSA Structural Geology and Tectonics Division; GSA Geophysics Division*. Leaders: Eric A. Erslev, University of Wyoming; Cody Lee Allen; Bryan W. Richter.

408. **A Hike through Geologic Time at Red Rocks and Dinosaur Ridge.** Sat., 30 Oct. US$93 (L, R). Cosponsors: *Friends of Dinosaur Ridge; GSA Sedimentary Geology Division*. Leaders: Chris Carroll, Friends of Dinosaur Ridge; Tim Connors.

409. **Garden of the Gods at Colorado Springs: Paleozoic and Mesozoic Sedimentation and Tectonics.** Sat., 30 Oct. US$69 (L, R). Cosponsor: *GSA Sedimentary Geology Division*. Leaders: Timothy L. Clarey, Delta College; John H. Whitmore; Marcus R. Ross; William A. Hoesch; Steven A. Austin.

410. **Geology and Natural Hazards of Golden.** Sat., 30 Oct. US$50 (L, R); **students only.** Cosponsor: *GSA Engineering Geology Division*. Leaders: Paul Santi, Colorado School of Mines; Jerry Higgins.

411. **Subaru Outback Mountain Biking & Discovery Adventure—with Gary Fisher & Globe Trekker.** Sat., 30 Oct. US$85 (L, R). Cosponsors: *Subaru; Gary Fisher Mountain Bikes; Globe Trekker*. Leaders: Laurie Brandt, Buckhorn Geotech; Abana Jacobs, Subaru.

412. **To Reactivate or Not to Reactivate: Nature and Varied Behavior of Structural Inheritance in the Proterozoic Basement of the Eastern Colorado Mineral Belt over ~1.7 Billion Years of Geologic Time.** Sat., 30 Oct. US$85 (L, R). Cosponsors: *GSA Structural Geology and Tectonics Division; U.S. Geological Survey; Society of Economic Geologists*. Leaders: Jonathan Saul Caine, USGS; John Ridley; Zachary R. Wessel.

413. **Historic Dinosaur Quarries within a Newly Interpreted Paleoenvironmental Context.** Sat., 30 Oct. US$118 (L, R). Cosponsor: *GSA Sedimentary Geology Division*. Leaders: Matt Mossbrucker, Morrison Natural History Museum; Thomas R. Fisher; Lisa Rae Fisher. This field trip also runs after the meeting (see trip 418) and is presented in conjunction with Topical Session T94.

414. **Old and New Geologic Studies along the Front Range between Golden and Morrison, Including Structural, Volcanic, and Economic Geology and Paleontology.** Sat., 30 Oct. US$114 (L, R). Cosponsors: *Friends of Dinosaur Ridge; GSA Sedimentary Geology Division*. Leader: Tim Connors, National Park Service Geologic Resources Division. This field trip also runs after the meeting (see trip 419) *and* as a family trip during the meeting (see trip 415).

During the Meeting

415. **Geology of the Dinosaur Ridge, Red Rocks, and Fossil Trace Areas (FAMILY Trip).** Mon., 1 Nov., US$94 (L, R). Cosponsors: *Friends of Dinosaur Ridge; GSA Sedimentary Geology Division*. Leaders: Tim Connors, National Park Service Geologic Resources Division. Versions of this trip also run before (trip 414) and after (trip 419) the meeting, but they are not specifically designated for families.

416. **U.S. Geological Survey.** Tues., 2 Nov., US$50. Leader: Ken Gerson, USGS. Tour of the Denver Federal Center facility.

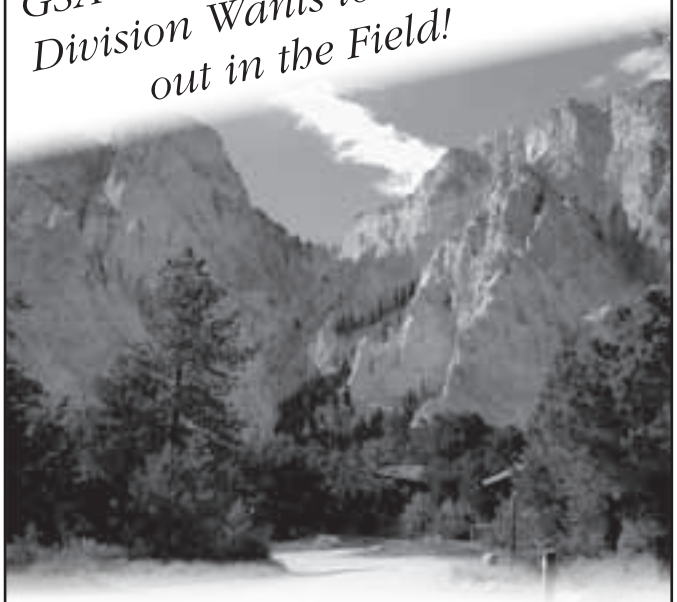
417. **Kirk Bryan Field Trip: Historical Range of Variability in the Colorado Rockies.** Wed., 3 Nov., US$95 (L, R). Cosponsor: *GSA Quaternary Geology and Geomorphology Division*. Leaders: Ellen Wohl, Colorado State University; Sara L. Rathburn.

After the Meeting

418. **Historic Dinosaur Quarries within a Newly Interpreted Paleoenvironmental Context.** Thurs., 4 Nov., US$118 (L, R). Cosponsor: *GSA Sedimentary Geology Division*. Leaders: Matt Mossbrucker, Morrison Natural History Museum; Thomas R. Fisher; Lisa Rae Fisher. This trip also runs before the meeting (see trip 413) and is presented in conjunction with Topical Session T94.

Red Rocks Amphitheatre. Photo by Bob Ashe for Denver Metro Convention & Visitors Bureau.

GSA's Engineering Geology Division Wants to Get YOU out in the Field!



Trip 410: Geology and Natural Hazards of Golden. The Engineering Geology Division will subsidize the first 33 student registrants for this trip. You must pay the full field trip fee when registering, but will be reimbursed $20 after the meeting.

Trip 423: Chalk Creek Valley: Colorado's Natural Debris-Flow Laboratory. The Engineering Geology Division will help cover the cost of this trip; both student and regular Division members (new members included) will be reimbursed US$100 and US$30 of the trip's cost, respectively, when the trip commences. Submit applications for reimbursement to Bill Schulz, U.S. Geological Survey, Box 25046, MS-966, Denver, CO 80225, USA, wschulz@usgs.gov.

View of monitoring basin from the debris-flow fan near Chaffee County Road 162. Photo used with permission from USGS.

2010 GSA Annual Meeting & Exposition

Reaching New Peaks in Geoscience

CONTINUING EDUCATION CREDITS

The annual meeting offers an excellent opportunity to earn CEUs toward your general continuing education requirements for your employer or K–12 school. Contact Beth Engle, bengle@geosociety.org, ***after the meeting,*** for a meeting evaluation form. We'll mail your CEU certificate once we receive the completed form.

419. **Old and New Geologic Studies along the Front Range between Golden and Morrison, Including Structural, Volcanic, and Economic Geology and Paleontology.** Thurs., 4 Nov., US$114 (L, R). Cosponsors: *Friends of Dinosaur Ridge; GSA Sedimentary Geology Division.* Leader: Tim Connors, Geologic Resources Division, National Park Service. This field trip also runs before the meeting (see trip 414) *and* as a family trip during the meeting (see trip 415).

420. **A Two-Hour Walking Tour of the U.S. Geological Survey's National Water Quality Laboratory.** Thurs., 4 Nov., US$58. Cosponsor: *U.S. Geological Survey, National Water Quality Laboratory.* Leader: Gary L. Cottrell, QAS, USGS.

421. **Rapid Environmental/Climate Change in the Cretaceous Greenhouse World.** Thurs.–Fri., 4–5 Nov. US$235 (B, L, D, R, 1ON). Cosponsor: *GSA Sedimentary Geology Division.* Leader: Bradley B. Sageman, Northwestern University.

422. **Geologic History of the Gold Belt Byway and Western Pikes Peak Country.** Thurs.–Fri., 4–5 Nov. US$264 (L, R, 1ON). Cosponsor: *Paleontological Society.* Leader: Herb Meyer, National Park Service–Florissant Fossil Beds National Monument; R.A. Wobus; T.W. (Woody) Henry.

423. **Chalk Creek Valley: Colorado's Natural Debris Flow Laboratory.** Thurs.–Fri., 4–5 Nov. US$255 (B, L, D, R, 1ON). Cosponsor: *GSA Engineering Geology Division.* Leaders: Jeffrey A. Coe, USGS; Jason W. Kean; Scott W. McCoy; Dennis Staley; Thad Wasklewicz.

424. **Estimating Natural Background Groundwater Chemistry, Questa Molybdenum Mine, New Mexico.** Thurs.–Sat., 4–6 Nov. US$307 (L, R, 2ON). Cosponsor: *U.S. Geological Survey.* Leaders: Philip L. Verplanck, USGS; Geoffrey S. Plumlee; D. Kirk Nordstrom; Bruce M. Walker.

425. **Alternative Sequence Stratigraphic Model for Channel-Shallow Marine Sandstones, Desert Member to Castlegate Sandstone Interval, Book Cliffs, Eastern Utah**
Thurs.–Sat., 4–6 Nov. US$307 (L, R, 2ON). Cosponsors: *GSA Sedimentary Geology Division; Society for Sedimentary Geology (SEPM).* Leader: Simon A.J. Pattison, Brandon University. Trip begins and ends in Grande Junction.

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Short Course Program

Early registration deadline: 27 September
Registration after 27 September: add US$30.
Cancellation deadline: 4 October

The following short courses are open to everyone. Early registration is highly recommended to ensure course viability.

If you would prefer not to register for the meeting but would still like to attend a short course, you can do so by paying the nonregistrant fee (US$45 by 27 Sept.; US$50 late/onsite registration) *in addition to* the course fee. This nonregistrant fee may then be applied toward meeting registration. **If you are a GSA K–12 teacher member,** you do not need to register for the meeting or pay the nonregistrant fee.

Continuing Education Units (CEUs): Most professional development courses and workshops offer CEUs. One CEU comprises 10 contact hours (one contact hour = 60-min. of classroom instruction or its equivalent) of participation in an organized continuing education experience under responsible sponsorship, capable direction, and qualified instruction.

See **www.geosociety.org/meetings/2010/courses.htm** or contact Jennifer Nocerino, jnocerino@geosociety.org, for additional information.

Professional Courses

501. **Training Session for Gale, A Free, Parallel Tectonics Code.** Sat., 30 Oct., 8 a.m.–5 p.m. FREE; includes continental breakfast and lunch. Limit: 50. CEU: 0.9. Cosponsor: *Computational Infrastructure for Geodynamics*. Walter Landry, Computational Infrastructure for Geodynamics; Todd Ehlers, University of Tuebingen; Mousumi Roy, University of New Mexico. **Attendees will need to bring laptop computers.**

502. **Field Hydrogeology.** Sat., 30 Oct., 8 a.m.–5 p.m. Fee: US$210. Limit: 50. CEU: 0.9. John Moore, USGS retired; Robert Raynolds, Denver Museum of Nature & Science.

503. **Introduction to Near-Surface Geophysics for Non-Geophysicists.** Sat., 30 Oct., 8 a.m.–5 p.m. Fee: US$150. Limit: 45. CEU: 0.9. Gregory S. Baker, University of Tennessee.

Faculty/Graduate Student Courses

504. **Field Safety Leadership.** Fri.–Sat., 29–30 Oct., 8 a.m.–5 p.m. Fee: US$25; includes continental breakfast and lunch. Limit: 24. CEU: 1.8. Cosponsors: *ExxonMobil Upstream Research Company; ExxonMobil Exploration Company*. Stephen R. Oliveri, ExxonMobil Upstream Research Co.; Kevin M. Bohacs, ExxonMobil Upstream Research Co.

505. **Fundamentals of Seismic Structural Interpretation and Trap Analysis: Petroleum Industry Applications.** Fri.–Sat., 29–30 Oct., 8 a.m.–5 p.m. Fee: US$25; includes continental breakfast and lunch. Limit: 30. CEU: 1.8. Cosponsors: *ConocoPhillips; ExxonMobil Exploration Company; GSA Structural Geology and Tectonics Division*. Peter Vrolijk, ExxonMobil Upstream Research Co.; Peter Hennings, ConocoPhillips; J. Steve Davis, ExxonMobil Exploration Co.

506. **Sequence Stratigraphy for Graduate Students.** Fri.–Sat., 29–30 Oct., 8 a.m.–5 p.m. Fee: US$25. Limit: 60. CEU: 1.8. Cosponsors: *ExxonMobil Exploration Company; Chevron Energy Technology Company; GSA Sedimentary Geology Division*. Art Donovan, BP; Morgan Sullivan, Chevron Energy Technology Co.; Kathryn Lamb-Wozniak, ExxonMobil Exploration Co.

507. **Structural and Stratigraphic Concepts Applied to Basin Exploration.** Fri.–Sat., 29–30 Oct., 9 a.m.–5 p.m. Fee: US$25; includes continental breakfast and lunch. Limit: 30. CEU: 1.6. Cosponsors: *ExxonMobil Exploration Company; ExxonMobil Upstream Research Company; GSA Sedimentary Geology Division*. Lori L. Summa, ExxonMobil Upstream Research Co.; Bob Stewart, ExxonMobil Exploration Co.

508. **Education Research I: Conducting Qualitative Geoscience Education Research.** Sat., 30 Oct., 8 a.m.–noon. Fee: US$118. Limit: 35. CEU: 0.4. Julie Sexton, University of Northern Colorado.

509. **Using Online Volcano Monitoring Data in College and University Courses: The Volcano Exploration Project, Pu`u `O`o.** Sat., 30 Oct., 8 a.m.–noon. Fee: US$84; includes continental breakfast. Limit: 30. CEU: 0.4. Cosponsors: *National Association of Geoscience Teachers (NAGT); GSA Geoscience Education Division*. Michael Poland, U.S. Geological Survey–Hawaiian Volcano Observatory; Katrien Kraft, Mesa Community College; Rachel Teasdale, California State University–Chico. **Attendees will need to bring laptop computers.**

510. **An Introduction to Using Active Learning to Reduce Student Misconceptions about Plate Tectonics.** Sat., 30 Oct., 8 a.m.–noon. Fee: US$25. Limit: 40. CEU: 0.4. Cosponsors: *GSA Geoscience Education Division; National Association of Geoscience Teachers (NAGT)*. Karen M. Kortz, Community College of Rhode Island; Jessica J. Smay, San José City College.

511. **Establishing and Sustaining an Undergraduate Research Program: A Professional Development Workshop for New and Future Faculty.** Sat., 30 Oct., 8 a.m.–5 p.m. Fee: US$50; includes continental breakfast and lunch. Limit: 30. CEU: 0.9. Cosponsor: *Council on Undergraduate Research (CUR)*. Lydia Fox, University of the Pacific; Laura Guertin, Penn State–Brandywine; Ed Hansen, Hope College.

KEY: —Faculty; —Graduate Student; —K–12—Teacher; —Professional

512. **Terrestrial Laser Scanning (Ground-Based LiDAR) Methods and Applications in Geologic Research and Education.** Sat., 30 Oct., 8 a.m.–5 p.m. Fee: US$80; includes lunch. Limit: 20. CEU: 0.9. Cosponsor: *UNAVCO.* John Oldow, University of Texas at Dallas; Carlos Aiken, University of Texas at Dallas; David Phillips, UNAVCO.

513. **Knowledge Surveys: An Organization and Assessment Tool with Countless Benefits.** Sat., 30 Oct., 8 a.m.–5 p.m. Fee: US$61; includes continental breakfast. Limit: 30. CEU: 0.9. Cosponsors: *ELIXR/ MERLOT Group; National Association of Earth Science Teachers (NAGT).* Edward Nuhfer, California State University–Channel Islands; Steven Fleisher, California State University–Channel Islands; Karl Wirth, Macalester College; Dexter Perkins, University of North Dakota.

514. **On the Cutting Edge Workshop: Teaching about Energy in Geoscience Courses.** Sat., 30 Oct., 8 a.m.–5 p.m. Fee: US$70. Limit: 40. CEU: 0.9. Cosponsors: *On the Cutting Edge; National Association of Geoscience Teachers (NAGT).* James Myers, University of Wyoming; Fred Loxsom, Eastern Connecticut State University; Karin Kirk, Science Education Resource Center at Carleton College; Devin Castendyk, State University of New York, College at Oneonta. **Attendees will need to bring laptop computers.**

515. **Using Geoinformatics Resources to Explore the Generation of Convergent Margin Magma.** Sat., 30 Oct., 9 a.m.–5 p.m. Fee: US$25; includes continental breakfast and lunch. Limit: 2. CEU: 0.8. Cosponsors: *EarthChem, MARGINS.* Kerstin Lehnert, Lahmont-Doherty Earth Observatory, Columbia University; Robert J. Stern, University of Texas at Dallas; Andrew Goodwillie, Lahmont-Doherty Earth Observatory, Columbia University. **Attendees will need to bring laptop computers.**

516. **U-Pb Geochronology and Hf Isotope Geochemistry Applied to Detrital Minerals.** Sat., 30 Oct., 9 a.m.–5 p.m. Fee: US$25; includes continental breakfast and lunch. Limit: 25. CEU: 0.8. George Gehrels, University of Arizona; Jeff Vervoort, Washington State University.

517. **A City State-of-Mind: Creating Effective Geoscience Assignments for Urban Students**. Sat., 30 Oct., 9 a.m.–5 p.m. Fee: US$70. Limit: 20. CEU: 0.8. Cosponsors: *On the Cutting Edge; National Association of Geoscience Teachers (NAGT).* Wayne Powell, Brooklyn College, CUNY.

518. **Education Research II: Conducting Quantitative Geoscience Education Research.** Sat., 30 Oct., 1–5 p.m. Fee: US$118. Limit: 35. CEU: 0.4. Julie Sexton, University of Northern Colorado.

519. **Introduction to Geographic Information Systems (GIS) Using ArcGIS for Geological and Environmental Science Applications.** Sat.–Sun., 30–31 Oct., 9 a.m.–5 p.m. Fee: US$31. Limit: 20. CEU: 1.6. Cosponsor: *ESRI.* Toni Fisher, ESRI; Joseph Kerski, ESRI.

K–12 Teacher Courses

520. **Analogue to Digital/Mapping to GIS**. Sat., 30 Oct., 9 a.m.–5 p.m. Fee: US$39; includes lunch. Limit: 18. CEU: 0.8. Cosponsor: *National Association of Geoscience Teachers (NAGT).* Nancy West, Quarter Dome Consulting, LLC; Kris Deardorff, Alexander Dawson School; Shelley Olds, UNAVCO.

521. **Engaging Tomorrow's Decision-Makers in Today's Geoscience.** Sat., 30 Oct., 1–5 p.m. Fee: US$32. Limit: 50. CEU: 0.4. Richard Hughes, British Geological Survey. **Attendees will need to bring laptop computers.**

GSA Associated Society Courses

522. **Environmental Geochemistry for Modern Mining.** Fri.–Sat., 29–30 Oct., 8 a.m.–5:30 p.m. Sponsor: *Society of Economic Geologists (SEG).* **Fee:** Early Registration (on or before 30 Sept.): Members, US$395; nonmembers, US$495; member students, $US195; nonmember students, US$245. Late Registration: Members, US$495; nonmembers, US$595; member students, US$245; nonmember students, US$295. Limit: 100. ***Course registration through SEG only*** via e-mail at seg@segweb.org or by phone +1-720-981-7882. Bob Seal, USGS; Kirk Nordstrom, USGS; Dirk Van Zyl, University of British Columbia; Carol Russell, USEPA; Rod Eggert, Colorado School of Mines; Kathy Smith, USGS; David Nimick, USGS; Geoff Plumlee, USGS; Graeme Spiers, Laurentian University; John Besser, USGS; Heather Jamieson, Queen's University; Kim Lapakko, Minnesota Dept. of Natural Resources; David Blowes, University of Waterloo; Devin Castendyk, SUNY-Oneonta; Chris Gammons, Montana Tech; Craig Johnson, USGS; Tanya Gallegos, USGS; Kate Campbell, USGS.

523. **Quantitative Methods in Paleobiology.** Sat., 30 Oct., 8:30 a.m.–5 p.m. Sponsor: *The Paleontological Society.* FREE. Limit: 400. John Alroy, Macquarie University; Gene Hunt, Smithsonian Institution.

KEY: —Faculty; —Graduate Student; —K–12—Teacher; —Professional

GSA Associated Societies

Attention members of the following societies: *We invite you to register for the meeting at GSA member rates.*

AASP - The Palynological Society
American Association of Petroleum Geologists (AAPG)
American Institute of Professional Geologists (AIPG)
American Quaternary Association (AMQUA)
American Rock Mechanics Association (ARMA)
American Society of Limnology and Oceanography (ASLO)
American Water Resources Association (AWRA)
Asociación Geológica Argentina (AGA)
Association for Women Geoscientists (AWG)
Association of American State Geologists (AASG)
Association of Earth Science Editors (AESE)
Association of Environmental & Engineering Geologists (AEG)
Association of Geoscientists for International Development (AGID)
The Clay Minerals Society (CMS)
Council on Undergraduate Research Geosciences Division (CUR)
Cushman Foundation (CF)
Environmental & Engineering Geophysical Society (EEGS)
Geochemical Society (GS)
Geological Association of Canada (GAC)
Geological Society of Africa
Geological Society of Australia (GSAus)
Geological Society of London (GSL)
Geological Society of New Zealand (GSNZ)
Geological Society of South Africa (GSSA)
Geologische Vereinigung (GV)
Geoscience Information Society (GSIS)
Groundwater Resources Association of California (GRA)
History of Earth Sciences Society (HESS)
International Association of Emergency Managers (IAEM)
International Association of Geochemistry (IAGC)
International Association of Hydrogeologists (IAH)
International Medical Geology Association (IMGA)
Karst Waters Institute (KWI)
Mineralogical Association of Canada (MAC)
The Mineralogical Society (MS)
Mineralogical Society of America (MSA)
National Association of Black Geologists and Geophysicists (NABGG)
National Association of Geoscience Teachers (NAGT)
National Association of State Boards of Geology (ASBOG®)
National Cave and Karst Research Institute (NCKRI)
National Earth Science Teachers Association (NESTA)
National Ground Water Association (NGWA)
Paleontological Research Institution (PRI)
Paleontological Society (PS)
Seismological Society of America (SSA)
Sigma Gamma Epsilon (SGE)
Sociedad Geológica Mexicana, A.C. (SGM)
Società Geologica Italiana (SGI)
Society for Environmental Geochemistry and Health (SEGH)
Society for Sedimentary Geology (SEPM)
Society of Economic Geologists (SEG)
Society of Vertebrate Paleontology (SVP)
Soil Science Society of America (SSSA)

Partners in pursuit of mutual goals to advance the geosciences, enhance the professional growth of members, and promote the geosciences in the service of humanity.

Sun., 31 Oct., 5–6:30 p.m.

This mentor program, sponsored by Subaru of America Inc. and the Association for Women Geoscientists, addresses issues faced by women in geology. This informal gathering begins with remarks from a few key speakers, followed by time for networking, sharing ideas, and getting to know other women geoscientists and geosciences educators.

Sponsored by

SUBARU AWG

Reception, with appetizers provided.

Graduate School Information Forum

Colorado Convention Center

HOURS

Sun., 31 Oct., 8 a.m.–6 p.m.
(optional 6–8 p.m. during the welcoming reception)

Mon.–Wed., 1–3 Nov., 8 a.m.–6 p.m.

GSA's Graduate School Information Forum is a relaxed and informal way for you to promote your school and have the opportunity to meet with more than 1,500 prospective students.

The forum begins on Sunday, 31 Oct., at 8 a.m. and runs through 6 p.m., with an option for you to keep your booth open from 6 to 8 p.m. so that students at the welcoming party have a chance to stop by. Monday through Wednesday, the forum hours are 8 a.m. to 6 p.m.

Booths may be booked for one day or up to all four days. We recommend that you reserve your booth early, because space is limited, and Sunday and Monday will be the first days to sell out. Schools reserving multiple days will be assigned first and to the most visible booths.

Participating schools will be promoted in the September *GSA Today* (pending submittal date of reservation form), the 2010 Annual Meeting Program book, and e-mail links on the GSA Web site so that interested students can schedule appointments prior to the meeting.

Reserve your booth at
https://rock.geosociety.org/registration?meetingid=10GSIF

Time is running out for…

Denver 2010 Space Requests

Are you planning a meeting, party, reception, banquet, or other event in association with the 2010 GSA Annual Meeting in Denver?

To be included in the annual meeting program book and to reserve space at the headquarters or co-headquarters hotels or at the convention center, we need to hear from you by **7 June.**

Learn more at **www.geosociety.org/meetings/2010/events.htm.**

GSA Employment Service Center

Looking for
EMPLOYMENT
in the geosciences?

CANDIDATE SERVICES

- Post your online profile
- View job postings
- Interview at the GSA Annual Meeting
- Review educational career search materials

Registering your résumé and viewing our job postings is FREE for all GSA Members.

THE GEOLOGICAL SOCIETY OF AMERICA®

Looking for
QUALIFIED CANDIDATES
in the geosciences?

Access an online database of hundreds of professionals in over 30 specialties who are actively seeking career positions at all levels.

EMPLOYER SERVICES

- Interview booth and scheduling
- Résumé search
- Posting of job announcement(s)

Interview services range from a one half-day booth rental to multiple days, starting at US$400.

www.geosociety.org/employment_service/

Exhibitors by Category

(as of press time)

Computer Software
Environmental Systems Research Institute Inc. (ESRI)
Golden Software Inc.

Gems/Minerals Dealers, Jewelry/Gifts
Cal Graeber
Crystals Unlimited
Delight's Earthly Delights
Evogeneao
Finesilver Designs
Gems & Crystals Unlimited
GEOGRAPHICS
IKON Mining & Exploration
Janice Evert Opals
Komodo Dragon
Nature's Own

General Educational Products
Armfield
Cengage Learning - Brooks/Cole
Gemological Institute of America
Little River Research & Design
Ward's Natural Science Est. LLC
Waveland Press

Geographic Supplies and Related Equipment
Estwing Mfg. Co.
Forestry Suppliers Inc.
Rite in the Rain

Geological Society of America
GSA Engineering Geology Division
GSA Geoinformatics Division
GSA Geology and Society Division
GSA Geology and Public Policy Committee
GSA Geoscience Education Division
GSA History of Geology Division & History of Earth Sciences Society
GSA Hydrogeology Division
GSA Limnogeology Division
GSA Planetary Geology Division

Geological and Geophysical Instrumentation
Advanced Geosciences Inc.
ASC Scientific
Australian Scientific Instruments Pty Ltd.
Beckman Coulter Inc.
Bruker AXS Inc.
Cameca Instruments Inc.
Campbell Scientific Inc.
elementar Americas Inc.
EmCal Scientific Inc.
Gatan Inc.
Geophysical Survey Systems Inc.
Horiba Instruments Inc.
In-Situ Inc.
Innov-X Systems
IsotopX Inc.
IXRF Systems Inc.
Leica Microsystems
Los Gatos Research
Mala GeoScience USA Inc.
Meiji Techno America
Optech Incorporated
Rigaku Americas Corp.
selFrag AG
Sensors & Software Inc.
Spectral Evolution
Thermo Scientific

Government Agencies (Federal, State, Local, International)
Minerals Management Service
NASA
National Park Service
National Science Foundation
Office of Surface Mining
Rocky Mountain Oilfield Testing Center
U.S. Bureau of Land Management
U.S. Forest Service (USDA)
U.S. Geological Survey

Other
Consortium for Ocean Leadership
Consortium of Universities for the Advancement of Hydrologic Science Inc. (CUAHSI)
GEON
Geoprobe Systems
HACH Hydromet
IRIS Consortium
Kendall Hunt Publishing Co.
Research Partnership to Secure Energy for America (RPSEA)
Retsch Inc.
Subaru of America Inc.

Professional Societies and Associations
AAPG Bookstore / Student Programs
AASP - The Palynological Society
American Geological Institute (AGI)
American Geophysical Union (AGU)
American Institute of Professional Geologists (AIPG)
American Meteorological Society
American Quaternary Association (AMQUA)
Association for Women Geoscientists (AWG)
Association of American State Geologists
Association of Earth Science Editors (AESE)
Association of Environmental & Engineering Geologists (AEG)
Clay Minerals Society
Council on Undergraduate Research (CUR), Geoscience Division
Cushman Foundation
EARTHTIME
European Geosciences Union (EGU)
Geochemical Society
Geological Association of Canada (GAC)
Geological Society of London
Geoscience Information Society (GSIS)
GeoScienceWorld (GSW)
International Association of GeoChemistry
Karst Waters Institute
Mineralogical Association of Canada
Mineralogical Society of America (MSA)
National Association of Black Geologists and Geophysicists (NABGG)
National Association of Geoscience Teachers (NAGT)
National Cave and Karst Research Institute (NCKRI)
National Earth Science Teachers Assoc. (NESTA)
Paleontological Society
Society for Sedimentary Geology (SEPM)
Sigma Gamma Epsilon
Society of Economic Geologists (SEG)

Publications, Maps, Films
Cambridge University Press
Columbia University Press
Elsevier
McGraw-Hill Publishers
Micropaleontology Project
Mountain Press Publishing Co.
NRC Research Press
Paleontological Research Institution
Pearson
Springer
Taylor & Francis
Treatise on Invertebrate Paleontology, Univ. of Kansas
University of California Press
W.H. Freeman
W.W. Norton & Company
Wiley-Blackwell

Services (Exploration, Laboratories, Consulting, and Others)
Activation Laboratories Ltd.
Beta Analytic Inc.
Environmental Isotope Lab
GNS Science – Rafter Radiocarbon
Ruen Drilling Inc.

State Surveys
Colorado Geological Survey

Universities/Schools
Baylor University Department of Geology
Colorado School of Mines Dept. of Geology & Geological Engineering
Dartmouth College Earth Sciences Dept.
Geocognition Research Laboratory
Geoinformatics for the Geosciences
Louisiana State University Dept of Geology & Geophysics
Mississippi State University
University of Nevada–Las Vegas
University of Nevada–Reno
University of Texas at Austin Jackson School of Geosciences
University of Texas at Dallas
University of Wyoming Geology & Geophysics Dept.

THE GEOLOGICAL SOCIETY OF AMERICA®

Explore 2011 GSA Annual Meeting

MINNEAPOLIS

Important Dates:

Field Trip Proposal Deadline.....7 December 2010
Short Course Proposal Deadline.....1 February 2011
Technical Session Proposals Deadline...11 January 2011
Abstracts Deadline.....Summer 2011

MINNESOTA

9–12 OCTOBER 2011 • MINNEAPOLIS, MINNESOTA, USA

Registration & Travel Funds

Registration

Early registration deadline: 27 September

Cancellation deadline: 4 October

Register online at **www.geosociety.org/meetings/2010/.**

REGISTRATION FEES (all fees are in U.S. dollars)

	Early Registration June–27 Sept.		Standard/On-site after 27 Sept.	
	Full Mtg.	One day	Full Mtg.	One day
Prof. Member	$325	$210	$405	$240
Prof. Member 70+	$255	$155	$340	$175
Prof. Nonmember	$425	$280	$505	$310
Student Member	$105	$70	$140	$80
Student Nonmember	$145	$90	$180	$100
High-School Student	$40	n/a	$40	n/a
K–12 Professional	$50	n/a	$60	n/a
Field Trip/Short Course only†	$40	n/a	$40	n/a
Guest or Spouse†	$85	n/a	$90	n/a
Low or Lower-Middle Income Country§	50%	n/a	50%	n/a

GSA will provide each meeting registrant† with an electronic copy of the *Abstracts with Programs*, which includes the 2010 Section Meeting abstracts. The *Abstracts with Programs* book will be available for **onsite pick-up only**.

†Field trip or short course only & guest or spouse registrants excluded.

§Residents of countries classified as "low or low-middle income" by the World Bank need only pay 50% of their registration category fee for full-meeting or one-day registration.

Online registration is not available for residents of "low and lower-middle income" countries (as classified by the World Bank) who wish to take advantage of the special rate. Please download a hardcopy of the registration form from the meeting Web site and send it via post to GSA, P.O. Box 9140, 3300 Penrose Place, Boulder, Colorado 80301, USA.

2009 GSA Annual Meeting advance registration desk.

GSA Student Travel Fund

GSA members and friends: You can make a difference in the life of a student by contributing to the Student Travel Fund when you register. Just indicate your intent and the amount you wish to give on your annual meeting registration form.

Your donation will help make it more affordable for students to attend the Annual Meeting in Denver. One-hundred percent of your contributions will go to help fund student travel.

The GSA Foundation has contributed US$1,000 to this fund.

International Section Travel Grant

2010 GSA Annual Meeting, Denver, Colorado, USA
Tectonic Crossroads Meeting, Ankara, Turkey

GSA's International Section has limited funds to assist the participation of international scientists and students in either the Annual Meeting of the Society or the Tectonic Crossroads Meeting in Turkey. Grants will not cover the full cost of attending the meeting, but are intended to help defray the combined cost of registration, housing, and travel.

To access the application, please go to the GSA International Section's Web page, www.geosociety.org/sectdiv/International/travelGrants.htm. All applications must be submitted by **1 August 2010.** If you have questions, please contact John Wakabayashi, jwakabayashi@csufresno.edu.

Especially For Students

GSA Wants to Help Get YOU There!

GSA Student Travel Grants

Deadline: 27 September

Application forms will be available during the registration period at www.geosociety.org/meetings/2010/travelgrants.htm.

Please remember that applying for a travel grant does not register you for the meeting. You must register for the meeting at www.geosociety.org/meetings/2010/reg.htm BEFORE you can apply for a travel grant.

Notification of grant status will be made by e-mail. Students receiving grants must pick up their checks in person (with photo ID) at the meeting. Checks that are not picked up will be voided.

GSA Sections administer these funds, so for eligibility requirements and other information, please visit the Section Web sites listed below or contact the Section secretary directly.

Cordilleran:
www.geosociety.org/sectdiv/cord/travelGrants.htm

Rocky Mountain:
www.geosociety.org/sectdiv/rockymtn/index.htm

North-Central:
www.geosociety.org/grants/ncgrant.htm

South-Central:
www.geosociety.org/sectdiv/southc/index.htm#travel

Northeastern:
www.geosociety.org/grants/negrant.htm

Southeastern:
core.ecu.edu/geology/neal/segsa/travel.html

International:
www.geosociety.org/sectdiv/International/travelGrants.htm
(International Section travel grants
are not limited to students; see p. 31.)

Note: The GSA Student Travel Grant for Minorities, Women, and Persons with Disabilities will not be available for the 2010 meeting.

Geoscience Education Division Student Travel Grants

Students in geoscience education: Are you presenting at GSA this fall? The Geoscience Education Division (GED) will offer several travel grants up to $250 to student members who are presenting their work at the 2010 GSA Annual Meeting in Denver. Grants will be awarded based on merit and financial need.

To be eligible for an award, you must be a student member in good standing of both GSA *and* the Geoscience Education Division. To join, contact GSA Sales and Services at gsaservice@geosociety.org. You must also be presenting a poster or talk at the 2010 GSA Annual Meeting in a *geoscience education* topical or discipline session.

To apply for the award, please send the following as a single e-mail attachment:

1. Confirmation of your standing as a student member of the GED (member number);
2. A copy of your accepted abstract;
3. A current CV, limited to two pages; and
4. A brief itemized budget and statement of your financial needs, including all other sources of funding.

Send applications to Steven Schimmrich, schimmrs@sunyulster.edu. **Deadline:** 1 August 2010. Notification of grant status will be made prior to the registration deadline, and awards will be made following confirmation of attendance at the annual meeting.

Be an invaluable asset to the meeting…

Serve as a Student Volunteer!

- Volunteer for 10 hours for FREE meeting registration;
- Volunteer an additional 5 hours and receive a FREE *Abstracts with Programs* book;
- And, for every 5 hours you volunteer, you'll earn a $25 stipend!

To register as a volunteer, go to
http://rock.geosociety.org/student_vol/.

For more information, contact
the GSA Meetings Department,
gsameetings@geosociety.org, +1-303-357-1000, opt. 6.

Student Mentor Programs

More information on these mentor programs is available at **www.geosociety.org/mentors/**.

Geology in Government

Mon., 1 Nov., 11:30 a.m.–1 p.m.

This popular program, sponsored by the GSA Foundation, features 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.

Geology in Industry

Tues., 2 Nov., 7– 8:30 a.m.

Chevron, Alpha Natural Resources, ExxonMobil, and the Society of Economic Geologists cosponsor this mentor program, which features a FREE breakfast for undergraduate and graduate students 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.

John Mann Mentors in Applied Hydrogeology Program

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 27 September. The first 25 students who respond to an e-mail invitation based on these criteria will receive FREE tickets for the luncheon (we anticipate sending the invitation on 28 Sept.).

Questions about Mentor Programs?
Contact Jennifer Nocerino,
jnocerino@geosociety.org.

President's Student Breakfast Reception

Sunday, 31 Oct., 7–8:30 a.m.

Sponsored by
ExxonMobil

Hosted by GSA
THE GEOLOGICAL SOCIETY OF AMERICA

GSA President Joaquin Ruiz invites all students registered for the meeting to attend a free breakfast buffet sponsored by ExxonMobil Corp. Joaquin and members of GSA leadership, along with ExxonMobil staff members, will be on-hand to answer questions and address student issues. The president's reception is one of the most popular student events at the annual meeting, and each registered student will receive a complimentary ticket for the breakfast buffet. This is a wonderful opportunity for networking and catching up with fellow students.

2010 GSA Annual Meeting & Exposition
Reaching New Peaks in Geoscience

31 Oct. – 3 Nov. 2010
www.geosociety.org/meetings/2010/
Denver, Colorado, USA

Travel & Transportation

Denver International Airport (DIA). Photo used with permission from the Denver Metro Convention & Visitors Bureau.

Air Travel

Denver International Airport (DIA; www.flydenver.com) is located 24 miles northeast of downtown Denver. Security wait times are updated hourly at +1-303-DIA-TIPS.

United Airlines

+1-800-521-4041, www.united.com

Receive at least a 5% discount on domestic and international roundtrip flights for the GSA Annual Meeting by using code **585RS** when you call the United MeetingsPlus reservation line at +1-800-521-4041, make a reservation online at www.united.com, or reserve through your travel agent. Discounts apply to travel between 20 Oct. and 13 Nov. 2010. **Car rental discount:** Hertz will offer discounts of up to 20% off car rentals when reservations are made in conjunction with your United Airline reservations; use Hertz discount number **CV02R30006.**

Ground Transportation

Ground transportation information is on Level 5 of DIA's main terminal; information counter hours are 6:30 a.m. to 11:30 p.m. daily, and their number is +1-303-342-4059. All commercial transportation arrives and departs outside the Level 5 doors on both the west and east sides of the terminal. Passengers must wait at the designated terminal "island" for transportation. Go to **www.flydenver.com/maps/tofrom/ground.asp** for a map of the transportation drop off/pick up area.

Shuttle Service

+1-800-258-3826, www.supershuttle.com

The SuperShuttle counter is also on Level 5 in the main terminal. Shuttles operate daily every 15 minutes from 7 a.m. to 5:15 p.m. and then as needed. SuperShuttle serves all downtown hotels to/from DIA for US$19 each way/US$38 roundtrip (save $6 on the roundtrip fare by using discount code **GWMPA** when reserving). Use GWMPA to also save $5 each way on private sedan/SUV trips to and from DIA.

Public Bus Service: RTD SkyRide

+1-303-299-6000, +1-800-366-7433

www.rtd-denver.com/skyRide_SubHome.shtml

Catch the bus from island 5 outside East Terminal exit door 511 or West Terminal exit door 506. Route information is available at the Regional Transportation District (RTD) information booth on Level 5. Downtown Denver is served by SkyRide Route AF: Buses leave DIA for downtown every 30 minutes from 6:45 a.m. to 12:45 a.m. The trip takes ~55 minutes and is US$10 (cash) each way (or US$18 roundtrip if you buy passes at the RTD booth).

Wheelchair-Accessible Buses, Shuttles, Taxis, or Vans

All of RTD's SkyRide buses are wheelchair accessible. SuperShuttle, Yellow Taxi, and Metro Taxi have accessible vehicles and can provide assistance for limited numbers of people with prior notice and reservation.

Taxis

Metro Taxi: +1-303-333-3333

Yellow Cab: +-303-777-7777

Taxi stands are located outside East Terminal exit doors 505 and 507 and West Terminal exit doors 510 and 512.

Flat rates are the same for both companies:

- DIA to downtown: US$51 + US$3.50 gate fee
- DIA to the Denver Tech Center: US$57 + US$3.50 gate fee
- DIA to Boulder: Flat rate of $US84 + $3.50 gate fee

Taxis *arriving* at DIA are not subject to gate fees.

Car Rental

Hertz will offer discounts of up to 20% off car rentals when reservations are made in conjunction with United Airline reservations; use Hertz discount number **CV02R30006.**

Enterprise Rent-a-Car, +1-800-593-0505, www.enterprise.com

Save 5% when you make your reservation online via the Enterprise Business Rental Program using number **1299A11** and pin **GEO.**

Downtown Denver and the Convention Center are connected by light rail. Photo by Steve Crecelius for the Denver Metro Convention & Visitors Bureau.

Travel to the United States

Most travelers to the United States must hold a valid visa and a passport that is valid for six months longer than the intended visit. Please go to **www.geosociety.org/meetings/2010/** to determine if you require a travel visa to attend the meeting.

If you do need a visa, we urge you to begin the process immediately. An interview appointment is required for a visa application at all embassies and consulates, and while the wait time for this appointment varies, it may take as long as three months, with processing taking an additional month or more. Check the U.S. State Department's Web site, **http://travel.state.gov/visa/temp/wait/tempvisitors_wait.php,** for specific wait time information.

There have been some important changes to the US-VISIT program. **The program now requires** most foreign visitors to have fingerprints made of all their fingers and a digital photograph taken to verify their identity at the consulates as well as the port-of-entry (Canadians should double-check their US-VISIT exempt status). A departure confirmation program is also now currently in place as part of US-VISIT. This program applies to all visitors, including those from visa-waiver countries.

Also new: Beginning in January 2010, visitors from countries participating in the Visa Waiver Program must register with the Electronic System for Travel Authorization (ESTA; **www.cbp.gov/xp/cgov/travel/id_visa/esta/**) before entering the country. Learn more on the U.S. State Department's Web site, **http://travel.state.gov/visa/temp/without/without_1990.html#countries.**

PURCHASE CARBON OFFSETS FOR YOUR TRIP

PROJECT C
We Have The Power
ColoradoCarbonFund.org

The Geological Society of America encourages attendees to offset travel emissions via the Colorado Carbon Fund. All contributions to the fund support new clean energy projects in Colorado that reduce greenhouse gas emissions. To participate, please check the box on your registration form, and we'll collect US$25 for the fund. If 10% of this year's 6,500 attendees donate, we could offset more than 800 tons of CO_2—that's equal to the emissions from burning nearly 90,000 gallons of gasoline.

Call for Papers

Abstract submission deadline: 10 August 2010

Submitting An Abstract

- Find tips for preparing an abstract at http://gsa.confex.com/gsa/preparations.htm or see p. 37.
- Submit your abstract at http://gsa.confex.com/gsa/2010AM/index.epl.
- Abstracts must be no more than 2,000 characters long (not counting spaces). Do not include your title and authors in the abstract.
- A non-refundable fee of US$35 per abstract submission will be charged to professionals; graduate and undergraduate students will be charged a non-refundable fee of US$20 per submission.
- Payment by credit card must be made when you submit your abstract, or your paper will not be considered for the meeting.
- You may present two volunteered abstracts during the Annual Meeting, *as long as one of these abstracts is a poster presentation.*
- Please don't miss the deadline for abstract submission—Tuesday, 10 August 2010.
- All speakers and poster presenters must pay the meeting registration fee.

Oral Presentations

- The normal length of an oral presentation is 12 minutes, plus three minutes for Q&A.
- You *must* visit the Speaker Ready Room at least 24 hours before your scheduled presentation.
- All technical session rooms are equipped with a PC.
- If your presentation was created on a Macintosh, you must save it to run on a PC. Please test it before coming to the meeting and again in the Speaker Ready Room. If you have any questions on this, please contact Nancy Wright, nwright@geosociety.org.
- If your presentation includes embedded video, please convert any .mov files to .avi format, or create a link in your slide show to an external .mov file. If you choose the latter, your animation will play in a separate QuickTime window, outside of your PowerPoint presentation.
- The decision by the Joint Technical Program organizers to place your paper in an oral session is final.

Poster Presentations

- You will be provided one horizontal, freestanding 8-ft-wide by 4-ft-high display board along with Velcro for hanging the poster, and each poster booth will share a 6-ft by 30-in table.
- Electricity will be available in the poster area at no charge.
- Posters will be on display 9 a.m.–6 p.m. Authors should be present either 9–11 a.m. *or* 2–4 p.m. and are encouraged to be at their posters during the 4:30–6 p.m. beer reception as well.
- The decision by the Joint Technical Program organizers to place your paper in a poster session is final.

Topical Sessions

The Denver GSA Annual Meeting will have 156 topical sessions for which you may submit an abstract. Each of these sessions is designed to promote the exchange of interdisciplinary, state-of-the-art information. You'll find a complete list of topical sessions at www.geosociety.org/meetings/2010/sessions/topical.asp. In addition to these proposed sessions, GSA will have a multitude of disciplines sessions. Discipline sessions are equally vital in order to complete our technical program (see p. 39).

Tips for Preparing an Abstract

1. Determine the discipline category for your paper (see p. 39). This is an essential step, even if you are submitting to a topical session. You may select up to three additional relevant categories.
2. Select your preferred mode of presentation: Oral, poster, or either (no preference). *Please note*: The program organizers will do their best to fit your abstract into your preferred mode; however, they will override your original mode selection if they feel your paper would fit well in a particular session with other compatible abstracts. The decision of the program organizers is final.
3. Include a title for your paper as well as up to five keywords.
4. Include the name and contact information for each author; e-mail addresses must be provided for communication purposes. No more than 10 authors may be listed on a paper, and group names will not be accepted.
5. The body of your abstract must be no more than 2000 characters long (not counting spaces). Do not repeat title and authors in the abstract.
6. Please proofread your abstract and check your spelling. We won't check or edit it for you.
7. If your abstract includes more than one complicated equation, or a table, or a lot of subscripts, superscripts, or Greek letters, we suggest that you type the characters using HTML coding. For information on how to include HTML codes, see http://gsa.confex.com/gsa/fonts.htm. If you simply try to copy-and-paste that abstract into the submission form, you will lose all of those special elements.
8. For typing and pasting, add an extra line between paragraphs or they will run together when displayed.
9. Have a credit card available to cover the submission fee.

Poster Printing Services

For a second year, GSA has made arrangements with DP_i Printing to offer presenters the option of having their posters printed in advance and available for pick up in the exhibit/poster hall at the Colorado Convention Center. The approximate cost for a 4-ft by 8-ft poster is US$100. Please note that all orders must be pre-paid and received on or before 28 October. Files to be submitted must be either .PDF or .jpeg. Valid ID is required for pick up. If you have questions regarding poster printing orders, contact DP_i Printing at www.dpi-sf.com, +1-415-216-0031, or via fax at +1-415-358-4685, or check www.geosociety.org/meetings/2010/.

2010 Joint Technical Program Committee

2010 Technical Program Chair
Richard C. Berg, berg@isgs.uiuc.edu

GSA Technical Program Manager
Nancy Wright, nwright@geosociety.org

Discipline Categories

Can't find a topical session that fits your abstract? No problem! In addition to the topical sessions, we offer the following discipline categories. Discipline sessions are equally vital to a robust annual meeting. Please feel free to contact the JTPC member associated with your discipline if you have any questions about your abstract.

Review Group	Discipline	Contact(s)
GSA Archaeological Geology Division	archaeological geology	Andrea Freeman, freeman@ucalgary.ca
GSA Coal Geology Division	coal geology	Sharon Swanson, smswanson@usgs.gov; Sue Rimmer, srimmer@geo.siu.edu
GSA Engineering Geology Division	engineering geology	John C. Jens, jensjcjens@earthlink.net; William H. Schulz, wschulz@usgs.gov
Environmental Geoscience	environmental geoscience	John F. Bratton, jbratton@usgs.gov
GSA Geobiology & Geomicrobiology Division	geomicrobiology	Jack D. Farmer, jack.farmer@asu.edu; Stuart Birnbaum, stuart.birnbaum@utsa.edu
Geochemical Society	geochemistry; geochemistry, organic	Troy Rasbury, troy.rasbury@sunysb.edu
GSA Geoinformatics Division	geoinformatics	Sally Brady, srbrady@usgs.gov; Hassan A. Babaie, hbabaie@gsu.edu
GSA Geology and Health Division	geology and health	Syed Hasan, hasans@umkc.edu
GSA Geology and Society Division	public policy	Karen McCurdy, kmccurdy@georgiasouthern.edu; James F. Davis, jamesdavis93@comcast.net
GSA Geophysics Division	geophysics/tectonophysics/seismology	Kevin Mickus, kevinmickus@missouristate.edu; Audrey D. Huerta, huerta@geology.cwu.edu
GSA Geoscience Education Division; National Association of Geoscience Teachers (NAGT)	geoscience education	Paul E. Baldauf, pb501@nova.edu; Mike Taber, mike.taber@coloradocollege.edu; Steven H. Schimmrich, schimmrs@sunyulster.edu; Elizabeth Wright, ewrigh@saic.edu
Geoscience Information Society (GSIS); Association of Earth Science Editors (AESE)	geoscience information/communication	Janet Dombrowski, jdombrow@uwyo.edu; Monica Easton, monica.easton@ontario.ca
GSA History of Geology Division	history of geology	Vic Baker, baker@hwr.arizona.edu; John A. Diemer, jadiemer@uncc.edu; Kenneth R. Aalto, kra1@humboldt.edu
GSA Hydrogeology Division	hydrogeology	Bill Cunningham, wcunning@usgs.gov; Madeline E. Schreiber, mschreib@vt.edu
GSA Limnogeology Division	limnogeology	Michael Rosen, mrosen@usgs.gov; Dan Deocampo, deocampo@gsu.edu
Marine/Coastal Geology	marine/coastal science	Mark Kulp, mkulp@uno.edu
Mineralogical Society of America (MSA)	mineralogy/crystallography; petrology, experimental; petrology, igneous; petrology, metamorphic; volcanology	James Beard, jim.beard@vmnh.virginia.gov; Philip Brown, pbrown@geology.wisc.edu
GSA Mineralogy, Geochemistry, Petrology, and Volcanology Division	mineralogy; geochemistry; petrology; volcanology	Cathy J. Busby, cathy@crustal.ucsb.edu; Russell S. Harmon, russell.harmon@us.army.mil
Paleoceanography/Paleoclimatology	paleoclimatology/paleoceanography	Sharon Kanfoush, skanfoush@utica.edu
Paleontological Society (PS)	paleontology, biogeography/biostratigraphy; paleontology, diversity, extinction, origination; paleontology, paleoecology/taphonomy; paleontology, phylogenetic/morphological patterns	Ellen Currano, ecurrano@smu.edu; Thomas D. Olszewski, tomo@geo.tamu.edu; Matthew E. Clapham, mclapham@es.ucsc.edu
GSA Planetary Geology Division	planetary geology; remote sensing/geographic info system	Jayne Aubele, jayne.aubele@state.nm.us; David Williams, david.williams@asu.edu
Precambrian Geology	Precambrian geology	Joe Meert, jmeert@geology.ufl.edu
GSA Quaternary Geology and Geomorphology Division	geomorphology; Quaternary geology	Paul Bierman, pbierman@zoo.uvm.edu; Kyle House, khouse@unr.edu
GSA Sedimentary Geology Division	sediments, carbonates; sediments, clastic; stratigraphy	Troy Rasbury, troy.rasbury@sunysb.edu; Brenda Beitler Bowen, bbowen@purdue.edu
Society of Economic Geologists (SEG)	economic geology	Karen D. Kelley, kdkelley@usgs.gov
GSA Structural Geology and Tectonics Division	neotectonics/paleoseismology; structural geology; tectonics	Scott Johnson, johnsons@maine.edu; David P. West, Jr., dwest@middlebury.edu

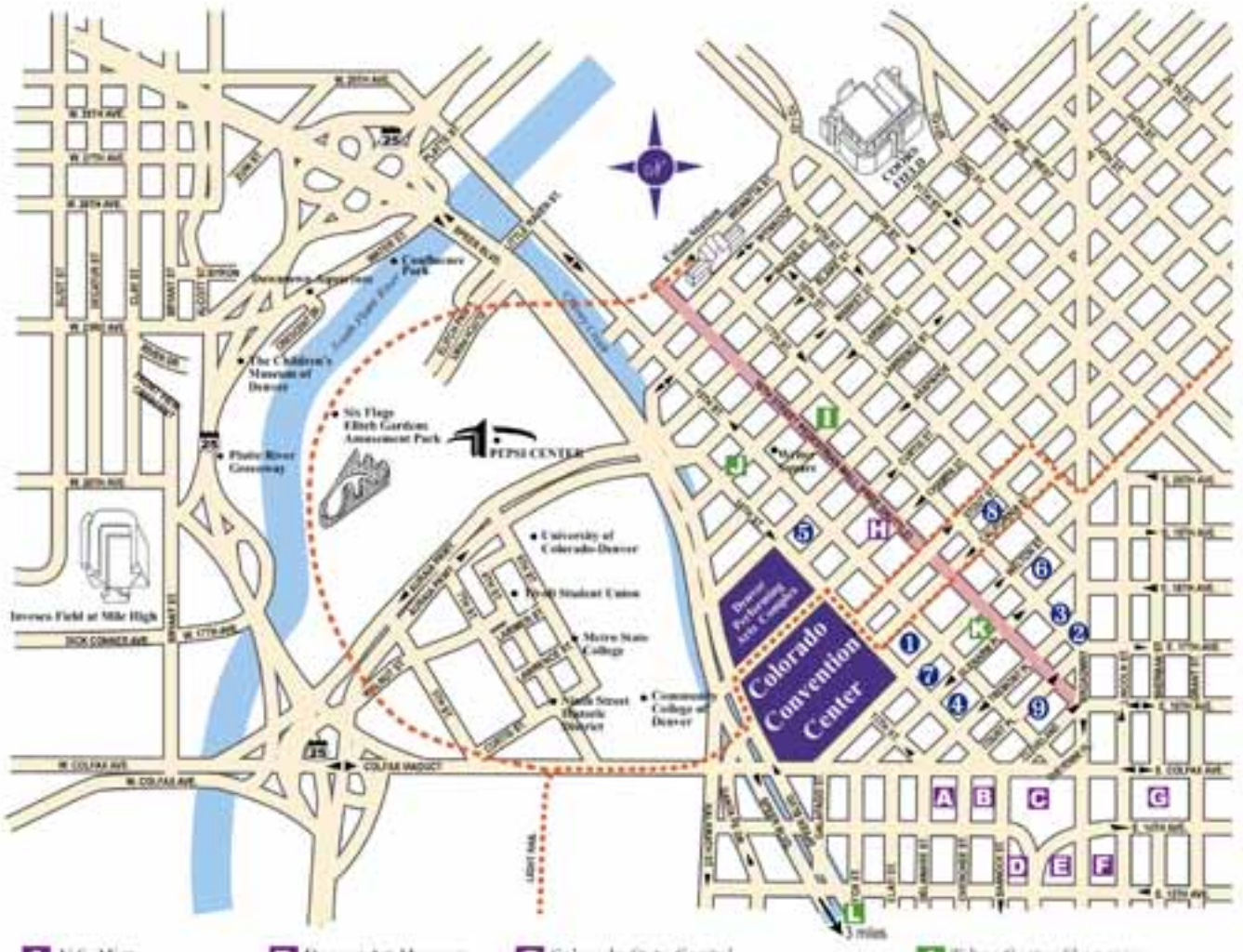
Hotels

Hotel	Cost*	Description	Parking*
Brown Palace Hotel 321 17th Street, Denver, CO 80202	Single: $189 Double: $189 Triple: $209 Quad: $209	The Brown Palace is Denver's only Forbes Four-Star *and* AAA Four-Diamond hotel and is a charter member of the National Trust Historic Hotels of America. Six blocks from the convention center, amenities at the Brown Palace include an on-site spa and salon (at additional cost), a complimentary fitness center, a full-service business center, 24-hour room service, and several restaurants. All guest rooms are non-smoking, and wireless Internet is $9.95 per 24-hour period.	On-site valet parking: $26/night.
Comfort Inn Downtown Denver 401 17th Street, Denver, CO 80202	Single: $129 Double: $129 Triple: $144 Quad: $159	The Comfort Inn is six blocks from the convention center and is connected to the Brown Palace, with the exclusive ability to charge services from the Brown Palace to your room at the Comfort Inn, including restaurants and room service. The Comfort Inn is non-smoking throughout and offers a daily complimentary full "American-style" breakfast and *free* high-speed Internet in all guest rooms.	On-site parking: $20/night.
Crowne Plaza Hotel Denver 1450 Glenarm Place, Denver, CO 80202	Single: $139 Double: $139 Triple: $149 Quad: $159	Located two blocks from the convention center, this all non-smoking hotel is designed for the traveling executive; each guest room includes a spacious, well-lit work area. The hotel has a full-service restaurant, and room service is available. All guest accommodations include *free* high-speed Internet and access to the fitness center.	On-site parking: $18/night.
Curtis – A Doubletree Hotel 1405 Curtis Street, Denver, CO 80202	Single: $143 Double: $143 Triple: $153 Quad: $163	Two blocks from the convention center, the Curtis is a unique boutique hotel with a fun pop-culture theme on each floor. The Curtis is non-smoking throughout and features a full-service restaurant, room service, and an on-site fitness center. All guest rooms include complimentary high-speed Internet access. Services in the hotel's business center are available at an additional cost.	On-site valet parking: $26/night; self-parking: $20/night
Co-Headquarters Hotel **Grand Hyatt Denver** 1750 Welton Street, Denver, CO 80202	Single: $172 Double: $172 Triple: $197 Quad: $222	The Grand Hyatt Denver, located three blocks from the convention center, is the annual meeting co-headquarters hotel. This AAA Four-Diamond hotel offers both smoking and non-smoking guest rooms, a full-service restaurant, and 24-hour room service. The Grand Hyatt features a fully equipped exercise facility with indoor pool, as well as a 24-hour business center (at additional cost). Rooms include high-speed Internet access for $9.99 per 24-hour period.	Valet parking: $28/night.
Hilton Garden Inn Denver Downtown 1400 Welton Street, Denver, CO 80202	Single: $155 Double: $155 Triple: $165 Quad: $175	Located across the street from the convention center, the Hilton Garden Inn has a contemporary design and is non-smoking throughout. The Hilton offers a full-service restaurant, room service from 4 to 10 p.m., a fully equipped self-service business center, and a 24-hour fitness center that includes an indoor pool and spa. All rooms feature complimentary high-speed wired and wireless Internet access along with a coffee maker, microwave, and mini refrigerator.	Valet parking: $26/night.
Headquarters Hotel **Hyatt Regency Denver at Colorado Convention Center** 650 15th Street, Denver, CO 80202	Single: $185 Double: $185 Triple: $210 Quad: $235	The Hyatt Regency Denver at Colorado Convention Center (directly across the street) is GSA's annual meeting headquarters hotel. This AAA Four-Diamond non-smoking hotel features a full-service restaurant, a 24-hour coffee & gift shop, and two bars, including one with views of the Denver and the Rocky Mountain skylines, plus room service from 6 a.m.–midnight. StayFit at Hyatt is a 24-hour exercise facility featuring an indoor lap pool and outdoor spa. There is a business center, FedEx Kinko's, and an Enterprise Rental Car desk in the lobby. Wired and wireless Internet access is $9.95 per 24-hour period.	Valet: daily, $18; overnight, $28. Self-parking: daily: $10 first hour/$2 each additional hour, with a $24 max.; overnight: $24.
Marriott City Center 1701 California Street, Denver, CO 80202	Single: $179 Double: $179 Triple: $189 Quad: $199	The Marriott City Center is three blocks from the convention center. All guest rooms are non-smoking and feature plush down comforters, custom duvets, and cotton-rich linens. Onsite restaurants serve breakfast and lunch, the hotel bar serves dinner, and room service is available 6 a.m.–11 p.m. The hotel has a business center (services at additional cost) as well as a fitness center. In-room high speed Internet is $12.95 per 24-hour period.	Valet parking: $27/night.
Sheraton Denver Downtown Hotel 1550 Court Place, Denver, CO 80202	Single: $155 Double: $155 Triple: $170 Quad: $185	The Sheraton, which recently completed a $70 million transformation, is three-and-a-half blocks from the convention center. It features a full-service restaurant, room service 6–11 a.m. & 5 p.m.–midnight, a 24-hour business center (at additional cost), a fitness center, and a heated roof-top pool. All guest rooms are non-smoking, and high-speed Internet is $10.74 per 24-hour period.	Self parking: $21/night.

* Prices are in U.S. dollars and do not include applicable taxes. All hotels are within two blocks of the 16th Street Mall.

Denver Hotel & Street Map

1. Hyatt Regency (Headquarters Hotel), 650 15th Street, Denver, CO 80202—US$185
2. Brown Palace, 321 17th Street, Denver, CO 80202—US$189
3. Comfort Inn, 401 17th Street, Denver, CO 80202—US$129
4. Crowne Plaza, 1450 Glenarm Place, Denver, CO 80202—US$139
5. Curtis (a Doubletree Hotel), 1405 Curtis Street, Denver, CO 80202—US$143
6. Grand Hyatt, 1750 Welton Street, Denver, CO 80202—US$172
7. Hilton Garden Inn, 1400 Welton Street, Denver, CO 80202—US$155
8. Marriott City Center, 1701 California Street, Denver, CO 80202—US$179
9. Sheraton Downtown, 1550 Court Place, Denver, CO 80202—US$155



Housing Information

Making Your Reservation

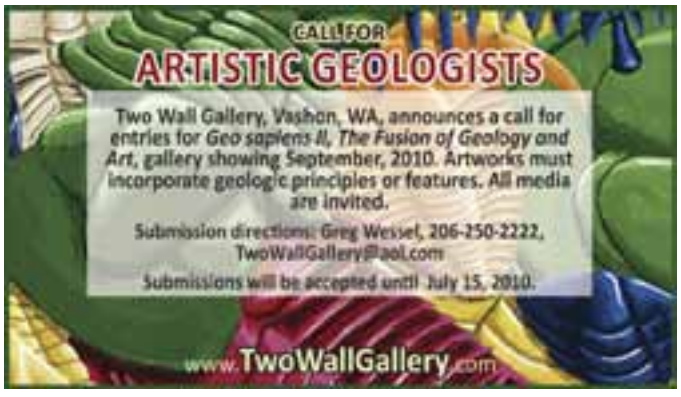
To take advantage of special meeting rates, please book your reservation by **27 September.** After this date, room blocks will be released and hotels may charge higher rates.

Please make your reservations using only *one* of the following options:

- Reserve online via link at www.geosociety.org/meetings/2010/
- By FAX to +1-303-571-9435
- Mail the housing form to GSA-Visit Denver Housing Bureau, 1555 California Street, Suite 300, Denver, CO 80202-4264, USA

Questions only: Send an e-mail to housing@visitdenver.com (reference the GSA Annual Meeting and include your acknowledgement number) or call the Visit Denver Housing Bureau at +1-303-892-1112 ext. 601 (Mon.–Fri., 9 a.m.–4:45 p.m. MDT, excluding holidays).

Standing 40 feet high, the big blue bear peers through the lobby of the Colorado Convention Center. Photo used with permission from the Denver Metro Convention & Visitors Bureau.



Modifying/Canceling Your Reservation

On or before 21 October: Changes to name, stay dates, or address, as well as special requests can be made via www.geosociety.org/meetings/2010/ or by contacting the Visit Denver Housing Bureau.

After 21 October: All changes and cancellations must be made directly with the assigned hotel. Please DO NOT contact the hotel directly until after 21 Oct. 2010

Cancellation requests received after **27 Sept. 2010** will be subject to a US$25 cancellation fee. Cancellations made within 72 hours of the scheduled arrival date are subject to a fee equal to one night's room rate plus tax. These fees will be charged to the credit card used to make the reservation.

Housing Alert!

Please note: GSA has selected Visit Denver as our official housing bureau. Neither GSA nor Visit Denver will telephone or send faxes offering "special" Denver hotel rates. In the event you have any problems with your reservation or accommodations, GSA can only assist in reconciling those issues if the reservation was booked through Visit Denver. If you have questions about an unauthorized solicitation, the online system, or about housing in general, please contact Becky Sundeen, bsundeen@geosociety.org.

GSA'S E-Bulletin Board —Room Sharing & More

Our annual meeting electronic bulletin board was a big success last year, thanks to you! With the GSA bulletin board, you have a chance to connect with other meeting attendees and talk about whatever you want, whenever you want. Meet new people, coordinate your schedules, and plan activities. You can even save money by arranging to share travel and lodging expenses.

THE GEOLOGICAL SOCIETY OF AMERICA®

Check it out at **www.geosociety.org/meetings/2010**

Thanks

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Check

www.geosociety.org/meetings/2010exhibits.htm

for an up-to-the-minute listing.

Call for GSA Committee Service

Impact the Future of Geoscience— Serve on a GSA Committee!

2011–2012 COMMITTEE VACANCIES

Deadline to apply or submit nominations: 15 July 2010

GSA invites you to volunteer or nominate one of your fellow GSA Members to serve on Society committees or as a GSA representative to other organizations. Students and younger members are especially encouraged to become involved in Society activities both as committee volunteers and as nominators.

If you volunteer or make recommendations, please give serious consideration to the specified qualifications for serving on a particular committee, as outlined in this article, and be sure that your candidates are GSA members or Fellows.

Learn more about each committee and access the nomination form at **www.geosociety.org/aboutus/committees/.** You can also download the form and send a hardcopy nomination to Pamela Fistell, GSA, P.O. Box 9140, Boulder, CO 80301-9140, USA; fax: +1-303-357-1074; phone +1-303-357-1044 or +1-800-472-1988, ext. 1044; pfistell@geosociety.org. *Please use one form per candidate.*

Nominations received at GSA headquarters by **15 July 2010** on the official one-page or online form will be forwarded to the Committee on Nominations. The committee will present at least two nominations for each open position to the GSA Council at its fall meeting. Appointees will then be contacted and asked to serve, thus completing the process of bringing new expertise into Society affairs. **Terms begin 1 July 2011** (unless otherwise indicated).

COMMITTEES REQUIRING VOLUNTEERS/NOMINEES

Academic and Applied Geoscience Relations (AM, T/E): Strengthens and expands relationships between GSA members in the academic and applied geosciences. Proactively coordinates the Society's effort to facilitate greater cooperation between academia, industry, and government geoscientists. **Qualifications:** Must be a member of academia, industry, or government who is committed to developing better integration of applied and academic science in our meetings, publications, short courses, field trips, and education and outreach programs; must also be a GSA Division member. **Vacancy/term:** One member-at-large/three years.

Annual Program (AM, B/E): Develops a long-range plan for increasing the quality of the annual meeting and other Society-sponsored meetings in terms of science, education, and outreach. Evaluates the technical and scientific programs of the annual meeting. **Qualifications:** Broad familiarity with different disciplines, previous program experience, or active involvement in applying geologic knowledge to benefit society and raising awareness of critical issues. **Vacancies/terms:** One student member/two years; one member-at-large/four years.

Arthur L. Day Medal Award (T/E): Selects candidates for the Arthur L. Day Medal Award. **Qualifications:** Knowledge of those who have made "distinct contributions to geologic knowledge through the application of physics and chemistry to the solution of geologic problems." **Vacancies/terms:** Two members-at-large/three years.

Diversity in the Geosciences (AM, T/E): Provides advice and support to GSA Council for undertaking activities and initiating programs that will raise opportunities and awareness in the geoscience community of the positive role that people of ethnic minority, women, and persons with disabilities play within the geosciences. Stimulates recruitment and promotes positive career development of minorities and women in the geoscience professions. **Qualifications:** Familiarity with the employment issues of minorities and women; expertise and leadership experience in such areas as human resources and education. **Vacancies/terms:** Two members-at-large/three years; one Councilor/three years.

Education (AM, B/E, T/E): Works with other members representing a wide range of education sectors in the development of informal, pre-college (K–12), undergraduate, and graduate earth-science education and outreach objectives and initiatives. **Qualifications:** Ability to work with other interested scientific organizations and science teachers' groups. **Vacancies/terms:** One student member/two years; one 4-yr faculty rep./four years; one member-at-large/four years.

Geology and Public Policy (AM, B/E, T/E): Provides advice on public policy matters to Council and GSA leadership; monitors and assesses international, national, and regional science policy; formulates and recommends position statements, and sponsors topical white papers; and encourages active engagement of GSA members in geoscience policy. **Qualifications:** Experience with public-policy issues involving the science of geology; ability to develop, disseminate, and translate information from the geologic sciences into useful forms for the general public and for GSA members; familiarity with appropriate techniques for the dissemination of information. **Vacancies/terms:** Two members-at-large/three years.

Joint Technical Program (T/E): Assists in finalizing the technical program of the Annual Meeting; reviews abstracts or provides names of reviewers to evaluate abstracts; participates in Web-based selection and scheduling of abstracts; participates in topical session proposal review. **Qualifications:** Must be familiar with computers and the Web, be a specialist in the specified fields, and be available in

mid-late July for the organization of the electronic technical program. **Vacancy/term:** One marine/coastal geology representative/three years, beginning 1 Jan. 2011.

Membership (B/E): Contributes to the growth of GSA membership and attends to members' changing needs. Focuses on attracting and retaining students, professionals working in industry, and those studying and working outside the United States. Reviews and makes recommendations for Fellowship to Council. **Qualifications:** Experience in benefit, recruitment, and retention programs. **Vacancies/terms:** One student/three years; one member-at-large from academia/three years; one member-at-large from industry/three years.

Nominations (B/E, T/E): Recommends nominees to GSA Council for the positions of GSA Officers and Councilors, committee members, and Society representatives to other permanent groups. **Qualifications:** Familiarity with a broad range of well-known and highly respected geoscientists. **Vacancy/term:** One member-at-large/three years.

Penrose Conferences and Field Forums (T/E): Reviews and approves Penrose Conference proposals and recommends and implements guidelines for the success of the conferences. **Qualifications:** Past convener of a Penrose Conference or a Field Forum. **Vacancy/term:** One member-at-large/three years.

Penrose Medal Award (T/E): Selects candidates for the Penrose Medal. Emphasis is placed on "eminent research in pure geology, which marks a major advance in the science." **Qualifications:** Familiarity with outstanding achievers in the geosciences who are worthy of consideration for the honor. **Vacancies/terms:** Two-members-at large/three years.

Professional Development (T/E): Directs, advises, and monitors GSA's professional development program; reviews and approves proposals; recommends and implements guideline changes; and monitors the scientific quality of courses offered. **Qualifications:** Familiarity with professional development programs or adult education teaching experience. **Vacancies/terms:** Two-members at large/three years.

Publications (AM, B/E, T/E): Nominates candidates for editor positions, reviews the quality and health of Society publications, and explores the initiation of new ventures. **Qualifications:** Extensive publications experience. **Vacancy/term:** One member-at-large/four years.

Public Service Award (T/E): Generates, receives, and evaluates candidates for the GSA Public Service Award and the AGI Outstanding Contribution to the Public Understanding of the Geosciences Award. The award will be given in recognition of outstanding individual contributions to either public awareness of the earth sciences or the scientific resolution of earth-science problems of significant societal concern. A crucial factor is to recognize an individual who highlights distinction between knowledge and understanding. **Qualifications:** Knowledge of those whose contributions and accomplishments have enhanced the public's understanding of earth science. **Vacancy/term:** One member at large/three years.

Research Grants (B/E): Evaluates student research grant applications and selects grant recipients. **Qualifications:** Should have experience in directing research projects and in evaluating research grant applications. An extensive time commitment is required during the application review period (15 Feb.–15 Apr.). **Vacancies/terms:** Eleven members-at-large/three years.

Young Scientist Award (Donath Medal) (T/E): Committee members investigate the achievements of young scientists who should be considered for this award and make recommendations to Council. **Qualifications:** Should have knowledge of young scientists with "outstanding achievement(s) in contributing to geologic knowledge through original research which marks a major advance in the earth sciences." **Vacancies/terms:** One member-at-large/three years; one Councilor or former Councilor/three years.

GSA REPRESENTATIVES TO OTHER ORGANIZATIONS

GSA Conferee to the AAPG Publication Pipeline Committee (B/E, T/E): Provide the best advice in assisting the committee in their efforts to improve the task process and to spread the word of their activities to retired or other GSA members who wish to dispose of books for donation to overseas libraries. **Vacancy/term:** One member/three years.

North American Commission on Stratigraphic Nomenclature (NACSN) (AM, possibly B/E): Develops statements of stratigraphic principles, recommends procedures applicable to classification and nomenclature of stratigraphic and related units, reviews problems in classifying and naming Stratigraphic and related units, and formulates expressions of judgment on these matters. **Vacancy/term:** One member/three years, beginning Nov. 2011.

COMMITTEE, SECTION, AND DIVISION VOLUNTEERS:

COUNCIL THANKS YOU!

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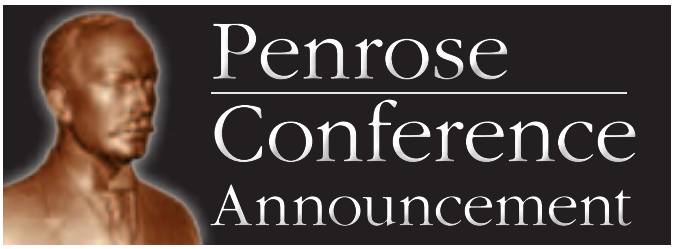

Google Earth: Visualizing the Possibilities for Geoscience Education and Research

4–8 January 2011

Google Inc. Headquarters (GooglePlex), Mountain View, California, USA

CONVENERS

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DESCRIPTION AND OBJECTIVES

Google Earth has emerged as one of the most powerful and easy-to-use tools for viewing, tracking, and analyzing planetary (and lunar) features, processes, and events. Since the application's release in 2005, Google Earth's use in the geosciences has evolved from simple "fly-bys" to world-class examples of geologically-induced landforms to dynamic KML files and COLLADA models displaying geologic processes. Applications of Google Earth in geoscience education and research* have been highlighted in well-attended AGU and GSA sessions in recent years, and informal discussions at these meetings have indicated the need for a specialized forum where development of virtual globe–based educational resources and visualizations can be coordinated among the greater geoscience community. The result is this Penrose Conference, which will bring together geoscience educators, researchers, and other professionals to discuss recent advances in the development of educational modules and research visualizations that use the Google Earth platform.

The conference will be held onsite at the Google Inc. headquarters in Mountain View, California, USA, and will focus on such themes as (1) broader dissemination of Google Earth–based educational materials throughout the geoscience community; (2) coordinated involvement of Google engineers and the Google Earth education team in the development of Google Earth–based geoscience education and research tools; (3) an opportunity to convey the wish-lists of solid-earth scientists to Google engineers; and (4) design of a central Web site and dedicated server for uploading and downloading Google Earth–based visualizations, educational modules, and user-support materials.

By pooling ideas and resources from the broader community, we hope to stimulate new initiatives and directions in using Google Earth in the geosciences, as well as encouraging the active participation of Google Inc. in the future development of geoscience research and education tools. A special volume summarizing cutting-edge research and educational uses of Google Earth is an anticipated follow-up to this conference.

PROPOSED ITINERARY

Monday, 3 Jan.: Arrive in Mountain View

Tuesday, 4 Jan.: "State of the Art in Google Earth" presentations by Google staff; posters by conference participants on uses of Google Earth

Wednesday, 5 Jan.: Google Earth in geoscience education and research; presentations and breakout discussions

Thursday, 6 Jan.: Field trip to local geologic sites in the Bay Area for hands-on demonstrations of field equipment relevant to Google Earth (GigaPan, LiDAR, etc.)

Friday, 7 Jan.: Integrating modern field datasets into Google Earth; creating and using field-oriented Google Earth modules

Saturday, 8 Jan.: Synthesis and future directions in education and research

Saturday evening (or Sunday, 9 Jan.): Depart Mountain View

ATTENDEES & ESTIMATED COST

Participants must make their own travel arrangements to arrive in Mountain View, California, USA, the night of 3 January. The registration fee will cover hotel lodging for five nights (3–7), all daytime meals, dinner on Day 2, all handouts and digital materials, and transportation from the hotels to Google headquarters and on the field day. Airfare is not included. The registration fee is estimated at US$700 per person (double occupancy).

REGISTRATION & APPLICATIONS

Deadline: 3 September 2010

The conference is limited to ~65 participants, and participants must apply to attend. Participants will have to commit to attending the full five days of the conference. Applications should be submitted online at the following address: **www.snap.uaf.edu/earth/penrose/.**

* Editor's note: See a thorough examination of this topic in the April/May 2010 issue of *GSA Today* (v. 20, no. 4/5, p. 4–10, doi: 10.1130/GSATG70A.1).

Donna L. Russell, *Director of Operations*

The International Section

John Wakabayashi

The Geological Society of America is continuing its effort to become more visible in the international earth-science community. This requires increased international participation at GSA's annual meetings. Over the past few years, the GSA International Section (formerly the International Division) has endeavored to facilitate this goal by providing travel support for students and young researchers from outside North America to attend the GSA meetings.

We have been increasingly successful in our funding efforts and, with the help of the GSA Foundation, raised US$12,000–US$20,000 to support international student travel to past GSA Annual Meetings in Denver, Salt Lake City, Philadelphia, Houston, and Portland. We want to continue the effort this year and are setting the target again at US$20,000. This will support the travel of 15 to 20 students and young researchers, depending on their locations.

Travel funds are needed for the 2010 GSA Annual Meeting in Denver, Colo., USA (www.geosociety.org/meetings/2010), as well as the first International Section Meeting, 4–8 Oct. 2010, in Ankara, Turkey (www.geosociety.org/meetings/2010turkey/).

We need your support to accomplish this goal. Any amount of contribution is welcome—it *will* make a difference!

You can contribute in two ways: (1) use the coupon below to send in your contribution by mail; please make your check out to the GSA Foundation, and specify on the check that it is for "I.S. Travel Grant"; or (2) go to the Foundation's Web site, gsafweb.org, and click on the "make a donation" tab near the top of the page.

In order to make these grants for the 2010 meetings, we need your donations by 1 July 2010.

Non–North American members of GSA: The International Section is your Section. We have over 1,300 international members in GSA, so if our average contribution from these 1,300 members is at least US$15, we will achieve our funding goal.

This is a good opportunity for you to help increase the international presence within GSA. We will also be able to obtain partial matching funds from the GSA Foundation if our donation drive is successful, so your donations will have an even greater impact than their face value.

For more information on international travel grants and how to apply, go to the International Section Web page, www.geosociety.org/sectdiv/International/travelGrants.htm.

On behalf of the GSA International Section Management Board, we thank you for your consideration and support.

John Wakabayashi, jwakabayashi@csufresno.edu
Chair, GSA International Section

Most memorable early geologic experience:

My first-grade teacher, Miss Raoul, bet me that she could make a rock float, then proceeded to demonstrate with a piece of pumice. I was hooked. The clincher came years later, though, in Ken Deffeyes' introductory class at Princeton. Ken was the first professor I'd ever seen in sneakers, and his enthusiasm was boundless. I was a geology major by the end of the semester.

—Jane Selverstone

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The application deadline is August 15, 2010.

All application materials should be sent to Office of the Secretary, FERC, 888 First Street N.E., Washington, DC 20246.

Please put docket AD04-4-001 in the subject line. For more information and application process, visit:

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Department of Geology and Geophysics

The Department of Geology and Geophysics at Louisiana State University, Baton Rouge, Louisiana, invites applications for the Billy and Ann Harrison Endowed Chair in Geology and Geophysics. The position is open to applicants at the associate- and full-professor rank and to all areas of sedimentology.

Our proximity to the Mississippi River and the Gulf Coast along with our strong ties to the oil and gas industry make LSU Geology and Geophysics ideal for researchers interested in sedimentology, including fluvial-deltaic and coastal problems. Additionally, this research field has been elevated by LSU to one of three university-wide focus areas with significant participation expected from the Department of Geology and Geophysics. Our locations, diverse research programs, and status as a land-, sea-, and space-grant institution make LSU and ideal and natural platform from which to design integrated research programs in sedimentology.

Currently within the department, our external funding for ongoing research includes support from federal, state, and industry sources. In addition, the department has a large and active alumni base. See www.geol.lsu.edu for more information regarding research programs, faculty, and facilities.

Required Qualifications: Associate- or Full-professor rank; Ph.D. or equivalent degree in geological sciences or a related field; strong record of published research; demonstrated ability to attract funding. **Additional Qualifications Desired:** Internationally recognized scientific reputation.

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An offer of employment is contingent on a satisfactory pre-employment background check. Application deadline is June 15, 2010 or until a candidate is selected. Nominations or inquiries should be directed to the **Endowed Chair Search Committee, at (225) 578-3353 or to geology@lsu.edu.**

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GROUNDWORK
Furthering the Influence of Earth Science

Innovations in the built environment for earth science

Marjorie A. Chan, *Dept. of Geology & Geophysics, University of Utah, Salt Lake City, Utah 84112, USA, marjorie.chan@utah.edu*

INTRODUCTION

Earth-science buildings, at their best, should showcase intriguing and visual elements of the science. Innovative approaches to the built environment encourage inquisitive students.

An energy-efficient geosciences building at the University of Utah, "The Frederick Albert Sutton Building," has become one of the most attractive destinations on campus. The award-winning structure, grounded in its sustainable construction and operation, is a dynamic platform for showcasing the earth sciences. This novel environment enhances the department's visibility, raises user productivity, and creates a powerful outreach tool that promotes earth-science education.

The new facility highlights the discipline's central role in bringing about a sustainable society, and the principles that governed construction are also relevant to improvements to older buildings. The structure facilitates modern science through centralized lab spaces, exposed ceiling mechanical systems for ease-of-access and flexibility, and reinforced concrete for vibration-free measurements and seismic safety. What also sets this structure apart from other buildings on campus is the architectural design of space and the beautiful, artistic displays that exemplify the work of the building's users.

The Dept. of Geology & Geophysics at the University of Utah was blessed with a generous major donor, Rev. Marta Sutton Weeks, who comes from a distinguished petroleum industry family. She wanted a permanent remembrance to her father, Frederick Albert Sutton, an exploration geologist who received his degree from the university in 1917. The end result is a LEED-certified (Leadership in Energy and Environmental Design), twenty-five-million-dollar, 91,000-square-foot inviting home for earth-science teaching and research (Figs. 1–3).

SUSTAINABILITY

Early in construction planning, our department offered a class on sustainability, through which students learned about "green" design principles and were encouraged to propose LEED-eligible projects to be incorporated into the building. Their proposals included solar tube lighting, low-emissivity glass, light sensors, xeric landscaping, a xeric roof garden, rainwater collection, pervious cement in the loading dock, covered bike racks, and energy monitoring. The up-front costs of green design are compared with potential savings in energy over the lifetime of the building. Designated recycling areas on each floor are centrally located and close to elevators for easy access.

EDUCATIONAL THEMES

Planned displays throughout the building are designed to illustrate geologic concepts and invite exploration. A cross-bedding design is molded into the concrete foundation, visible to passersby. As an acknowledgment of the role rivers played in carving Utah's landscape, a stylized river of pebble tile runs through the building, merging with river cobble patterns in the outside landscape. The large, light-filled, round entry (Fig. 1), called *The Confluence*, marks where the new building adjoins an existing structure. A large aerial image of the confluence of Utah's Green and Colorado Rivers is prominently placed, along with a quote from John Wesley Powell about his exploration of those rivers. Nearby, large, polished rock slabs of cobble conglomerates show the types of deposits rivers leave behind. The red, black, and green colors of the slabs indicate different geochemical states of iron and oxygen.

The major entry display has more than one-hundred Eocene Green River Formation fish arranged like a school (Fig. 2). The scene is framed by the same marlstone, tilted on edge to show the cyclic lacustrine laminations and fish coprolites. This wall includes donor names; it is a work of art and a teaching tool. An additional 150 plant fossils from the Green River Formation are arranged as leaves blowing in the wind. Visitors can touch and rotate a unique stainless-steel skull cast of Utah's official state fossil, *Allosaurus*. Two matched, translucent travertine slabs in front of a large west window catch sun rays in the afternoon, making the rock glow a bright golden orange (Fig. 3).

Spectacular rock slabs, minerals, and fossils are mounted on the stable seismic restraint walls throughout the building. Explanatory signs convey the experience of strolling through a museum. On field trips in the building, students in an earth materials class examine brittle versus ductile properties of deformation in polished rock slabs. They look for cataclasites, orientations of stretched pebbles, en echelon tensile fractures, mixed-mode cracks, foliation generations, and geopetal indicators. Sedimentary geology classes determine provenance and depositional conditions in clastic rock slabs; paleontology classes reconstruct the paleoecology represented in fossiliferous slabs. Visitors use small magnets to find the magnetite-rich layers in a slab of banded iron formation. A field methods class takes strike and dip measurements on rock slabs in the building's outdoor xeriscape.

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The building's four floors are topically stratified. The first floor houses the seismology unit, department collections, and storage areas that require access to the loading dock. The displayed rock slabs on this floor are basement lithologies (e.g., garnet-biotite gneiss). The second floor is the home of the geophysics faculty; rock slabs of pillow basalt and granites relate to the solid earth. The third floor exhibits sedimentary and fossiliferous rock slabs that reflect studies of earth history. Geochemical and analytical laboratories on the fourth floor are close to the faculty hydrologists, geological engineers, and geochemists. Correspondingly, rock slabs of travertine-spring deposits and framed satellite images illustrate water and surficial studies.

OUTCOMES

The building has a transformational effect on its occupants, visitors, and the campus at large. Light, open spaces and informal gathering areas on each floor, with sweeping view windows and comfortable seating, give students a place to meet or study. Students and faculty certainly feel and have expressed a heightened sense of interaction, learning, and discovery in this supportive physical environment.

This building is a long-term outreach venue that attracts many visitors. Students and faculty also show off the displays and their own related work to family and friends. In the year since opening, about 2,000 visitors (not including regular university students) have come through the building. Building occupants give 10–20 informal tours each month to off-campus visitors. Groups of grammar-school students, high-school science classes, and participants in Utah Museum of Natural History youth programs tour our displays, led by undergraduate or graduate students. The department accommodates special events (e.g., social gatherings), workshops for professional groups, and small, informal meetings. The university administration has also hosted business discussions, interviews, and board meetings in this building because of its warm and attractive setting. The university's Office of Sustainability has arranged visits for groups, including a Korean delegation, to see this example of energy-efficient construction. The building is clearly a recruiting tool and a catalyst for creating a strong department of faculty, students, friends, and alumni.

Figure 1. Inside *The Confluence* with a "sinuous river" (foreground) cutting into Precambrian slate of Brazil. Part of the wall of Eocene fish fossils is visible on the right. Photo by Paul Richer (2009).

SUMMARY

There has never been a more important time to understand Earth, teach, and inspire students. Our goal is to rise to the challenge of recruiting and educating the present and next generations on how crucial earth science is in the intersection of society and the environment. A creative building opens up multifaceted opportunities that strengthen the discipline. Geoscience can be a leader in transforming campuses through engaging and appealing visual material that is both educational and artistic. Innovations in earth-science buildings promote education and outreach and foster new approaches to interdisciplinary collaborations.

ACKNOWLEDGMENTS

I thank Eileen Van der Flier-Keller for her thoughtful review, fellow faculty members M. Dane Picard and Francis H. Brown for their input, and *GSA Today* science co-editor Stephen Johnston for his advice and editorial assistance. This building was only possible through the collaborative effort of faculty, students, friends of the department, and industry professionals.

Figure 2. Eocene Green River fish are arranged like a school in a curved, tile art wall. The background color variation in the host rock resembles the shoaling and light of a lake setting. Words from Albert Einstein, "It is every man's obligation to put back into the world at least the equivalent of what he takes out of it," blend donor names (not shown) with the idea of giving back.

Figure 3. Translucent calcite rocks slabs filter light from the west (right), near old seismic helicorders. A metasomatite from Australia is "down under" at the left. The sandstone bench has time capsules in its pedestals. The front pedestal is a salvaged piece of the 1927 building cornerstone, formerly part of the Oligocene Little Cottonwood Stock, Utah. Photo by Paul Richer (2009).

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