

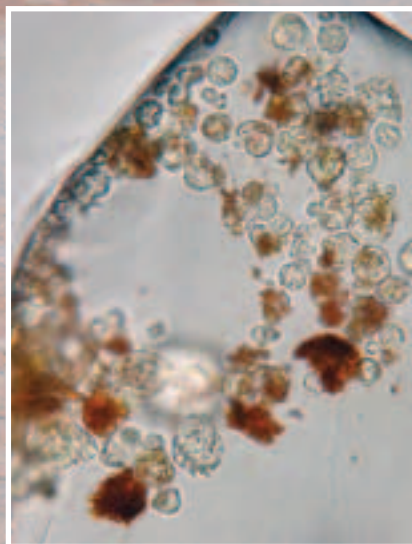
GSA TODAY

VOL. 21, NO. 1

A PUBLICATION OF THE GEOLOGICAL SOCIETY OF AMERICA

JANUARY 2011

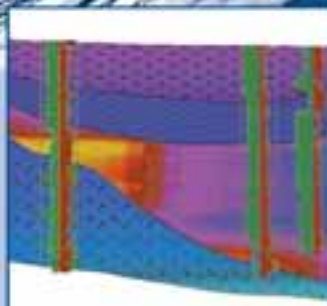
Microbial communities in fluid inclusions and long-term survival in halite



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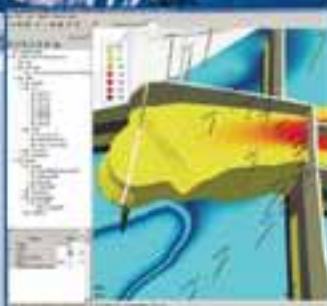
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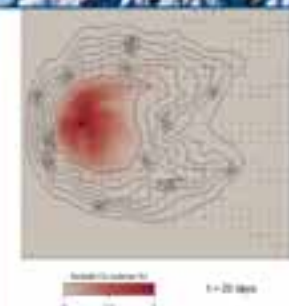
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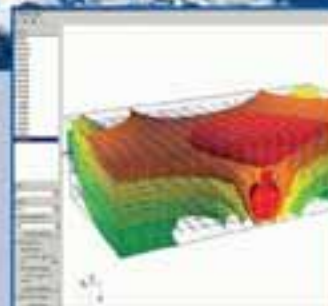
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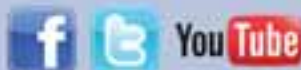
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Printed in the USA using pure soy inks.

4 Microbial communities in fluid inclusions and long-term survival in halite

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Cover: Saline Valley salt pan, October 2005, view to the northeast. The salt pan is covered with salt chips, sunken plates of coalesced halite crystals, formed in a hypersaline lake, now dry. Red coloration of halite is produced by organic pigments, such as β -carotene, used by halophilic microorganisms for protection from ultraviolet radiation. Color photomicrograph inset shows algal cells of the genus *Dunaliella*, some covered with β -carotene, inside a fluid inclusion in 34 ka subsurface halite from Death Valley, California, USA. The algae accumulate intracellular glycerol, which may be a food source used by prokaryotes for long-term survival in fluid inclusions in halite. See related article by T.K. Lowenstein et al., p. 4–9.



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Microbial communities in fluid inclusions and long-term survival in halite

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ABSTRACT

Fluid inclusions in modern and ancient buried halite from Death Valley and Saline Valley, California, USA, contain an ecosystem of “salt-loving” (halophilic) prokaryotes and eukaryotes, some of which are alive. Prokaryotes may survive inside fluid inclusions for tens of thousands of years using carbon and other metabolites supplied by the trapped microbial community, most notably the single-celled alga *Dunaliella*, an important primary producer in hypersaline systems. Deeper understanding of the long-term survival of prokaryotes in fluid inclusions will complement studies that further explore microbial life on Earth and elsewhere in the solar system, where materials that potentially harbor microorganisms are millions and even billions of years old.

INTRODUCTION

Microbes are known to exist in subsurface habitats, such as sub-seafloor sediments and continental and oceanic crust, to depths of up to ~3 km (Parkes et al., 2000; Kerr, 2002; Lin et al., 2006; Onstott et al., 2006). Prokaryotes (single-celled organisms lacking a nucleus and other membrane-bound specialized structures) in these subsurface environments live in water within sediment pores and rock fractures. Most are heterotrophic and depend upon preexisting organic matter around them for metabolism, but some are autotrophic and can use non-photosynthetically derived energy sources (Lin et al., 2006). Other prokaryotes that live in Earth's subsurface under such so-called “extreme” conditions have been found in ice as old as 120 ka from Antarctica, Greenland, and mountain glaciers, and in permafrost, perhaps as old as 8 Ma (Christner et al., 2000; Miteva et al., 2004, 2005; Bidle et al., 2007; Johnson et al., 2007). Collectively, these discoveries have extended the realm of the biosphere into Earth's crust and have given hope for finding life beneath the surface of other planets, moons, asteroids, and comets of our solar system where present surface conditions are inhospitable.

The world's “oldest living organisms” come from another subsurface setting, buried salt deposits. Over the past 50 years, a series of papers have claimed long-term survival of prokaryotes (*Bacteria* and *Archaea*) in these deposits, in some cases for >250 m.y. (Reiser and Tasch, 1960; Dombrowski, 1963; Norton and Grant, 1988; Grant et al., 1998; Stan-Lotter et al., 1999;

McGenity et al., 2000; Vreeland et al., 2000, 2007; Radax et al., 2001; Mormile et al., 2003; Schubert et al., 2010a). Prokaryotes in ancient salt deposits also apparently survived in water, but in this case were confined to brine-filled “fluid inclusions” in the halite itself, isolated from surrounding pore- and fracture-filling waters.

Reports of extreme microbe longevity in salt are controversial. The well-known Permian bacterium from the Waste Isolation Pilot Plant (WIPP) site, Salado Formation, New Mexico, USA (Vreeland et al., 2000), for example, comes from a brine inclusion within a large, diagenetically formed halite crystal. That brine inclusion could have been trapped after the Permian during burial cementation and recrystallization processes (Hazen and Roedder, 2001). Later study of those fluid inclusions, however, shows that they most likely contain evaporated

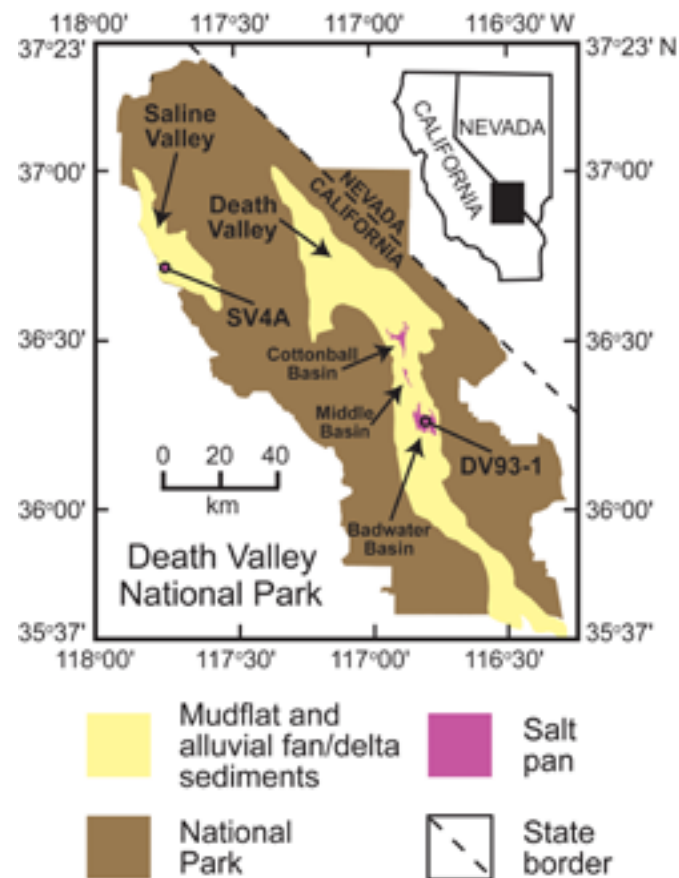


Figure 1. Map of Death Valley and Saline Valley, California, USA, with locations of cores DV93-1 and SV-4A; modified from Schubert et al. (2009a).

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Permian seawater, which supports their 250 Ma age and the antiquity of the trapped bacterium (Satterfield et al., 2005). The strongest criticism of the antiquity of prokaryotes recovered from ancient salt deposits has come from the biological science community, which maintains that deoxyribonucleic acid (DNA) should degrade over time scales far shorter than 250 m.y. in the absence of a repair mechanism (Willerslev et al., 2004; Hebsgaard et al., 2005; Willerslev and Hebsgaard, 2005). In addition, DNA from the Permian bacterium is nearly identical to a modern bacterium, *Virgibacillus marismortui*, sampled from the Dead Sea (Arahal et al., 1999, 2000), which suggests to some that the Permian bacterium is a laboratory contaminant (Graur and Pupko, 2001).

Other reputed ancient *Archaea* occur in bedded halite with primary growth textures and banded arrays of primary fluid inclusions parallel to crystal growth faces, indicating that

the inclusions were trapped during growth of halite from surface brines (Mormile et al., 2003; Vreeland et al., 2007; Schubert et al., 2009a, 2010a). It is now certain that some ancient bedded halite, and the included brines and microorganisms, can remain undisturbed for millions of years (Lowenstein et al., 2001). The problem confronting all studies of prokaryotes trapped in fluid inclusions from ancient halite is understanding how these microorganisms survive for prolonged periods and how they obtain energy to perform necessary functions, such as repair of damaged DNA.

Here we examine microorganisms trapped in fluid inclusions in halite, summarizing results from modern environments (Saline Valley, California, USA) and buried deposits up to 100 ka from Death Valley, California, USA (Schubert et al., 2009a, 2009b, 2010a, 2010b). We also present new, unpublished information from the subsurface salts of Saline Valley, which are up to 150 ka. These modern and Pleistocene deposits contain significant numbers of prokaryotes in fluid inclusions, a small number of which are clearly alive. Microscopy has revealed a remarkable “ecosystem” within fluid inclusions, composed of “salt-loving” (halophilic) prokaryotes and eukaryotes (complex cells containing a nucleus and specialized structures, such as chloroplasts) that may hold key information about long-term survival. We hypothesize that prokaryotes survive inside fluid inclusions for prolonged periods using carbon and other metabolites supplied by members of the trapped microbial community, most notably the single-celled alga *Dunaliella*, an important primary producer in hypersaline systems.

HALOPHILIC MICROORGANISMS IN MODERN HYPERSALINE SYSTEMS

The starting point for evaluating long-term survival of microorganisms in fluid inclusions in salt is to examine modern evaporite systems and the processes by which organisms are preserved in halite there. We illustrate a typical hypersaline environment, Saline Valley, where, under certain conditions, surface brines host prolific numbers of halophilic microorganisms. Saline Valley is a closed-basin saline pan in eastern California that contains surface brines up to 0.5 m deep, fed by groundwaters (Figs. 1 and 2A) (Hardie, 1968; Howe, 1998). A bloom of planktonic halophiles, developed in March 2004, contained one type of photosynthetic autotroph, the single-celled alga *Dunaliella*, and many heterotrophs (prokaryotic *Archaea* and *Bacteria*, that thrived in bright red brines at salinities of 26%–30%, seven to eight and a half times more concentrated than seawater (Fig. 2B). The pink/red brine color is due to the carotenoids (organic pigments, including β -carotene used by microorganisms for protection from ultraviolet radiation) in halophilic *Archaea* and *Bacteria* and *Dunaliella* (Teller, 1987; Pedrós-Alió et al., 2000; Oren and Rodríguez-Valera, 2001; Oren, 2002b). Wet mounts prepared from Saline Valley brines contained rod- and coccoid-shaped prokaryotes and larger spherical and ellipsoid-shaped cells of *Dunaliella*, some of which were motile one year after collection (Figs. 2C and 2D).

When surface brines from Saline Valley evaporated to salinities greater than ~30% during March 2004, halite saturation was reached and halite crystals nucleated at the air-brine interface, forming floating masses of linked crystal rafts; vertically oriented crystals also grew off the brine bottom (Fig. 2E). The

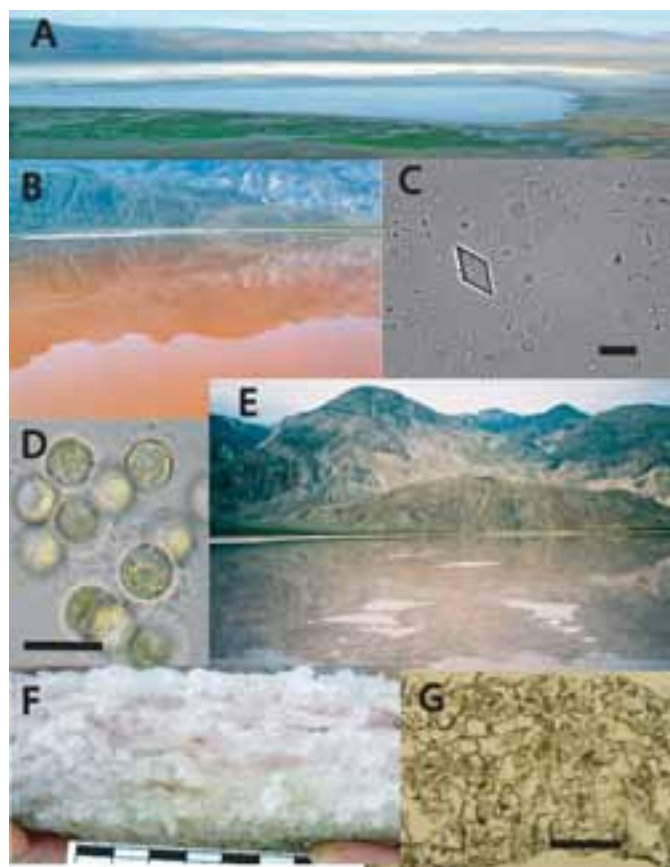


Figure 2. Saline Valley, California, USA, March 2004. (A) Saline pan and surrounding mudflats, with surficial salt crust (white) and shallow saline lake in foreground. (B) Halophile bloom in saline lake. (C) Photomicrograph of wet mount slide prepared from Saline Valley brine (Oct. 2005), with rod- and spherical (cocci) shaped microbes distinct from diamond-shaped crystal of glauberite ($\text{CaSO}_4 \cdot \text{Na}_2\text{SO}_4$). Scale bar is 10 μm . Modified from Schubert et al. (2009a). (D) Photomicrograph of wet mount slide prepared from Saline Valley brine, with spherical green cells of *Dunaliella*. Scale bar is 10 μm . (E) Large rafts (up to 1 m) of laterally linked halite crystals on the brine surface and halite chevrons crystallizing at the brine bottom. (F) Cross section of halite crust formed in 2004, pink from trapped microorganisms. Small divisions on ruler are millimeters. (G) Thin-section photomicrograph of halite crust shown in F. Vertically oriented halite crystals grew upward from the saline lake bottom. Fluid inclusion bands (gray) in some halites outline primary crystal growth directions. Scale bar is 10 mm.

halite crust formed by these processes contained large numbers of brine inclusions trapped during crystal growth, and the salt crust was pink because microbes from the water column were incorporated into the halite inclusions (Figs. 2F and 2G). Individual fluid inclusions housed a community of prokaryotes and *Dunaliella*, the same shape and size as observed in Saline Valley brines (Fig. 3). Microscopic study of >1000 brine inclusions from 10 halite-crust crystals showed that >20% contained prokaryotes (Schubert et al., 2009a). The calculated prokaryote abundance of 6×10^8 microbes/mL of inclusion brine is similar to that reported from red halophile-rich brines in many modern settings (Larsen, 1980; Teller, 1987; Oren, 2002a, 2002b; Pedrós-Alió, 2004). This means that one halite cube from Saline Valley, 1 cm per side, with a typical volume of fluid inclusions of 1% (Roedder and Bassett, 1981) contains six million trapped microbes.

Experiments show that prokaryotes (*Archaea* and *Bacteria*) trapped in fluid inclusions in halite from Saline Valley for up to 15 years can be readily cultured when placed in nutrient-rich media. These results are consistent with data from laboratory experiments and other modern surface halite deposits, all of

which show that prokaryotes can remain alive inside fluid inclusions in halite for many years (Norton and Grant, 1988; Grant et al., 1998; McGenity et al., 2000; Mormile et al., 2003; Adamski et al., 2006; Fendrihan et al., 2006). The next step is to ascertain if prokaryotes remain alive in fluid inclusions following burial.

HALOPHILIC MICROORGANISMS IN BURIED PLEISTOCENE SALT

Borehole cores from Death Valley and Saline Valley, composed of interbedded salt and mud, provide ideal materials for assessing the fate of microbial communities trapped in fluid inclusions in halite in the subsurface for periods of up to 150 k.y. (Fig. 4). The cored sediments contain a dated record of Pleistocene paleoenvironments that varied from saline pans and dry mudflats to deep, perennial lakes (Li et al., 1996; Howe, 1998; Lowenstein et al., 1999). Evaporites accumulated in two settings: (1) bedded halite with abundant primary growth textures formed in perennial saline lakes (i.e., Great Salt Lake, Utah, USA); and (2) massive halite formed in salt pans (i.e., Badwater Basin, Death Valley, USA) (Li et al., 1996; Lowenstein et al., 1999). Microorganisms in fluid inclusions were almost exclusively found in halites deposited in perennial saline lakes in Death Valley (ca. 10–35 ka) and Saline Valley (ca. 20 ka, 75 ka, and 150 ka). Some of these halites have prokaryotes in fluid

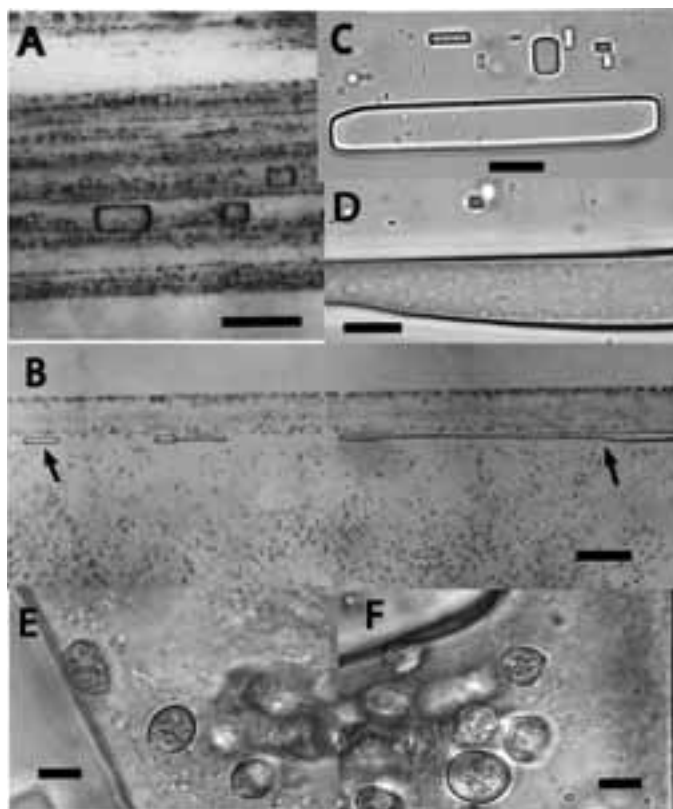


Figure 3. Photomicrographs of fluid inclusions in halite, collected in Saline Valley California, USA, in 2004 and 2005. (A) Horizontal band rich in rectangular prism-shaped brine inclusions, surrounded above and below by bands containing fewer inclusions. Scale bar is 100 μ m. (B) Tubular fluid inclusions and evenly distributed cubic and rectangular prism-shaped inclusions. Arrows point to inclusions shown at higher magnification in C and D. Scale bar is 100 μ m. (C) and (D) Fluid inclusions with rod- and coccoid-shaped prokaryotes. Scale bars are 10 μ m. (E) and (F) Portions of large fluid inclusions in halite with ellipsoidal and spherical cells of *Dunaliella* and numerous smaller prokaryotes. Scale bars are 5 μ m.

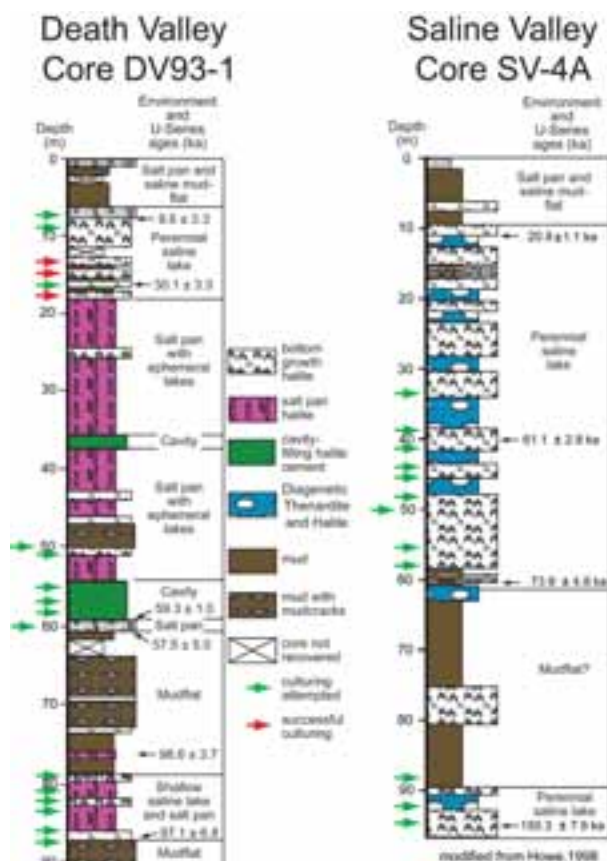


Figure 4. Stratigraphic columns of cores DV93-1 and SV-4A showing sediment types, uranium-series ages, and paleoenvironments. Modified from Howe (1998) and Lowenstein et al. (1999). Note depths (arrows) where samples were taken for culturing experiments: green—unsuccessful; red—successful.

inclusions comparable in abundance to those found in modern halites formed during the 2004 Saline Valley halophile bloom, which suggests that ancient saline lakes of Death Valley and Saline Valley were at times teeming with microorganisms (Schubert et al., 2009a).

Dunaliella cells trapped in fluid inclusions up to 150 ka may appear virtually the same as those from modern halite (compare Fig. 5A to Figs. 3E and 3F). Remarkably, some ancient *Dunaliella* cells contain a cup-shaped chloroplast and are green and orange, which suggests preservation of pigments, including carotenoids and chlorophyll (Fig. 5B) (Schubert et al., 2010b). Other ancient *Dunaliella* cells, particularly in fluid inclusions in halite from the Saline Valley core, form a “stew” in various stages of disintegration, with cell coats separated from cell contents (Fig. 5F).

Prokaryotes found in buried halites (>10 ka) appear quite different from those trapped in fluid inclusions in modern halite. Ancient prokaryotes are coccoid-shaped and “miniaturized,” with

cell diameters <1 μm (Figs. 5A, 5C, and 5D), much smaller than the straight or curved rods (1–10 μm long, ~0.5–1 μm wide) and coccoid-shaped prokaryotes (typically ~1 μm diameter), of their surface counterparts (Figs. 3C and 3D). The differences in size and shape between modern and ancient prokaryotes trapped in fluid inclusions resemble the “starvation-survival” forms reported for prokaryotes living in soils and in the ocean (Novitsky and Morita, 1976; Morita, 1982, 1997; Grant et al., 1998). It is widely known that some prokaryotes living under nutrient-poor conditions adjust by changing shape—that is, “rounding” from rod-shaped to coccoid-shaped, and reducing their size (Kjelleberg et al., 1983). We postulate that once trapped inside fluid inclusions for long periods of time, prokaryotes resort to starvation-survival strategies, but the timing and triggering mechanisms are not known. Trapping of halophilic *Archaea* in nutrient-free fluid inclusions in experimentally grown halite also led to rounding and cell-size reduction over periods of weeks to years (Norton and Grant, 1988; Fendrihan and Stan-Lotter, 2004), but more research on starvation-survival of prokaryotes in fluid inclusions is clearly needed.

Long-term survival of miniaturized prokaryotes in fluid inclusions in buried halite from Death Valley and Saline Valley was tested with culturing experiments designed to grow halophilic microorganisms. One procedure used previously by microbiologists involves surface sterilization of a halite crystal, followed by dissolution of that crystal in a liquid medium composed of Na^+ , Cl^- , inorganic nutrients, and a carbon source (Vreeland et al., 2007; Schubert et al., 2009b, 2010a). During the dissolution process, the Na^+ , Cl^- , inclusion brines, and trapped microorganisms mixed with the growth medium. Incubation under aerobic conditions for periods of up to 90 days led to the growth of cultures from five halite crystals (13.0–17.9 m; 22 ka to 34 ka) out of ~900 tested from the Death Valley core (Fig. 4) (Schubert et al., 2009b, 2010a). For unknown reasons, no prokaryotes were cultured from >500 halite crystals (12 intervals between 34 and 93 m) up to 150 ka from the Saline Valley core. It is clear from these experiments that cultivation of prokaryotes sampled from fluid inclusions in halite between 10 ka and 150 ka is rare, occurring in only 0.4% of the crystals tested. These results, coupled with the large number of cells observed in situ within fluid inclusions (Fig. 5), suggest that most ancient prokaryotes in halite are dead or viable but nonculturable, or that our culturing conditions were simply not suitable (Amann et al., 1995). Nevertheless, the DNA from the five cultured organisms from the Death Valley core shows that they are halophilic *Archaea* from the genera *Haloterrigena*, *Natronomonas*, and *Halorubrum*, all organisms expected in hypersaline lakes (Schubert et al., 2009b, 2010a).

MECHANISM FOR LONG-TERM SURVIVAL OF PROKARYOTES IN FLUID INCLUSIONS

All *Archaea* from the Death Valley core we have cultured so far came from one stratigraphic interval (Fig. 4) in which prokaryotes and *Dunaliella* were observed in situ within fluid inclusions. Closer inspection of those fluid inclusions, coupled with what is known about the ecology of modern hypersaline systems, has led us to hypothesize a mechanism that may allow prokaryotes to survive inside fluid inclusions for millennia.

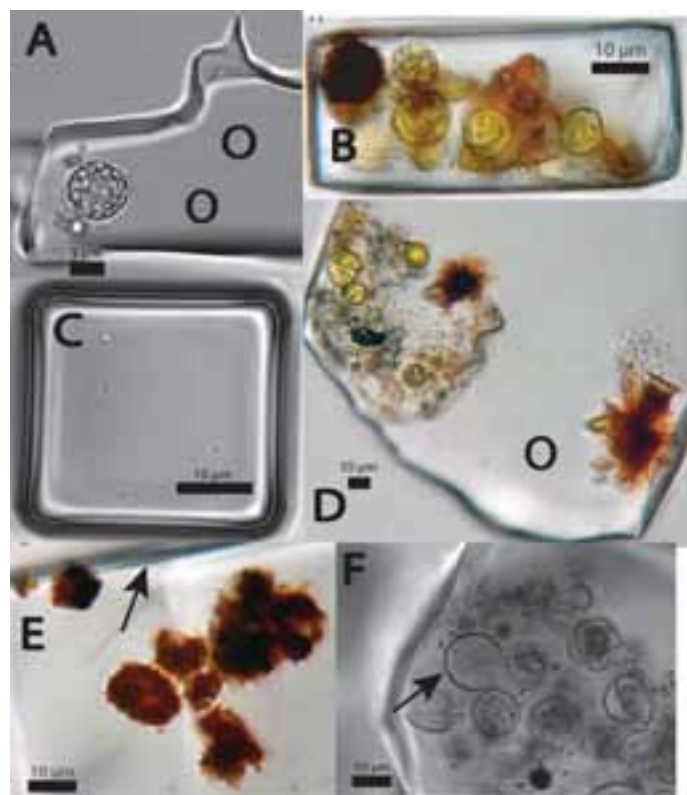


Figure 5. Photomicrographs of fluid inclusions in ancient halite from Saline Valley and Death Valley (Calif., USA) cores. (A) *Dunaliella* cell (left) and miniaturized prokaryotes (circled), in irregularly shaped fluid inclusion, Saline Valley core, 93 m, 150 ka. (B) Light green and orange *Dunaliella* cells suggest preservation of chlorophyll and β -carotene, Death Valley core, 17.8 m, 34 ka. Modified from Schubert et al. (2010b). (C) Miniaturized prokaryotes in cubic fluid inclusion, Death Valley core 16.5 m, 31 ka. Modified from Schubert et al. (2009a). (D) Portion of large fluid inclusion containing yellow-green *Dunaliella* cells and two cells coated with outward radiating crystals of β -carotene (brown). Miniaturized prokaryote is circled. Death Valley core 15.7 m, 29 ka. (E) Portion of fluid inclusion showing *Dunaliella* cells heavily coated with crystalline β -carotene, Death Valley core 15.7 m, 29 ka. Arrow shows the boundary between the fluid inclusion and the host halite crystal. (F) *Dunaliella* cells in various stages of degradation within a large fluid inclusion, Saline Valley core, 44 m, ca. 70 ka. Arrow shows ruptured glycocalyx (cell coat) of one *Dunaliella* cell.

Modern hypersaline environments near halite saturation contain a productive but relatively simple community of planktonic microorganisms, with *Dunaliella* the only primary producer and a number of different heterotrophic *Archaea* and subordinate *Bacteria* (Pedrós-Alió et al., 2000; Elevi Bardavid et al., 2008). Much is still unknown about the prokaryotes because these ecosystems are dominated by nonculturable microbes (Oren, 2002b). Regardless, it has long been postulated that the heterotrophic community of prokaryotes in these extreme environments obtains most of its carbon requirements from glycerol, a sugar alcohol with the chemical formula $C_3H_5(OH)_3$ (Borowitzka, 1981; Elevi Bardavid et al., 2008). Glycerol is produced in large quantities by *Dunaliella* because it is used for osmoregulation to reduce the chemical potential gradient of H_2O and to prevent the loss of water from cells. In fact, *Dunaliella* may have concentrations of 6–7 M glycerol in their cytoplasm to counteract the chemical gradients (Elevi Bardavid et al., 2008). This glycerol apparently leaks out of healthy *Dunaliella* cells into surrounding brines or may enter brines following death and disintegration (lysis) of the cells (Elevi Bardavid et al., 2008). In either case, glycerol constitutes a major source of carbon for the prokaryote community in modern hypersaline systems (Borowitzka, 1981; Elevi Bardavid et al., 2008). We hypothesize that the same relationships hold true inside fluid inclusions and that glycerol and other metabolites leaked out of *Dunaliella* cells have supplied associated heterotrophic prokaryotes with the carbon and energy sources required for their prolonged survival. Close inspection shows that *Dunaliella* commonly occur with prokaryotes in fluid inclusions (Figs. 5A and 5D). Some *Dunaliella* are in various stages of disintegration, indicating leakage of biomaterials, including glycerol, from cells into the surrounding brine (Fig. 5F). Other *Dunaliella* contain a crust of crystalline β -carotene on their exteriors (Figs. 5B, 5D, and 5E) (Schubert et al., 2009b, 2010b). β -carotene is produced by certain species of *Dunaliella*, so finding it precipitated outside the cell is direct evidence that intracellular materials have leaked into fluid inclusions. Solid crystals apparently formed as a crust on *Dunaliella* cells because β -carotene is insoluble in water and thus crystallized when extruded from cells. Glycerol, however, is soluble in water and thus would be completely dissolved in fluid inclusion brines, where it would be available for heterotrophic microorganisms. Support for our “glycerol” hypothesis comes from the five halophilic *Archaea* revived from fluid inclusions in Death Valley halite, all of which were cultured in media containing glycerol as a carbon source (Schubert et al., 2009b, 2010a). Two of these strains grew in media containing glycerol as the only carbon source; the other three are yet to be tested.

CONCLUSIONS

Although we are beginning to understand the community of microorganisms inside modern and ancient fluid inclusions, much more needs to be learned about how they survive. Miniaturized prokaryote cells suggest starvation-survival, despite the availability of carbon. We do not know why prokaryotes in fluid inclusions miniaturize, what factors trigger miniaturization, and what functions miniaturized cells are able to perform in fluid inclusions (e.g., repair of DNA and cell membranes) (Grant et al., 1998; Johnson et al., 2007).

Alternatively, prokaryotes may form spores and survive for long periods in a dormant state, as has been claimed for the bacterium cultured from the Permian fluid inclusion by Vreeland et al. (2000). But none of the halophilic *Archaea* cultured from the Death Valley core formed endospores, nor do any *Archaea*. We thus need to learn more about long-term survival of spore-forming prokaryotes as well as miniaturized forms trapped in fluid inclusions. Such knowledge will be vital as studies further explore deep life on Earth and elsewhere in the solar system, where materials that potentially harbor microorganisms are millions and even billions of years old.

ACKNOWLEDGMENTS

Many thanks to Matthew Parker for guidance on PCR amplification and DNA sequencing, Jürgen Polle for teaching us about *Dunaliella*, Aharon Oren for insights on halophiles, Richard Ku and Shangde Luo for age dating the salt cores, Robert Demicco for his review of this manuscript, and Russell Vreeland for getting us started on the problem. Current and former graduate students Kathy Benison, Chris Brown, Jianren Li, Laura Howe, Sean Brennan, Cindy Satterfield, Kathryn Gragg, Yaicha Winters, Deidre LaClair, and Elliot Jagniecki contributed to the ideas developed in this paper. This project was supported by U.S. National Science Foundation Biogeosciences Grants EAR-0433802 and EAR-1024692.

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Manuscript received 19 Sept. 2009; accepted 25 Apr. 2010



Reaching New Peaks in Geoscience

2010 GSA Annual Meeting & Exposition Wrap-Up

31 Oct.–3 Nov. 2010 • Denver, Colorado, USA

Over 6,500 people made the ascent to Colorado's Mile High City for GSA's 122nd Annual Meeting & Exposition. Science presentations, job and graduate school interviews, continuing education short courses, and field trips made up the core of activities at this year's meeting, with numerous social receptions, mentor programs, networking opportunities, and guest events rounding things out.

Whether in the halls of the Colorado Convention Center or on the streets of downtown Denver, attendees could be heard noting that *coming to GSA was like coming home*, with many reminiscing about their first GSA meeting 20 or 30 years ago.

Thousands took time to cruise the Geoscience Highway in the sold-out Exhibit Hall, and just as many found themselves intrigued by the daily poster sessions (along with the afternoon beer receptions!). People also found time to view the newly reformatted *digital* Hall of Fame, which recognized the achievements of awardees from GSA, GSA Divisions, and GSA Associated Societies, as well as the newly elected GSA Fellows. If you missed this highlight of the meeting, you can see the full list of awardees at www.geosociety.org/awards/.

Media/Social Media

Sixteen registered media representatives were working onsite, representing *Nature*, *Science News*, *American Scientist*, *Earth*, and About:Geology.com, among others. Many other agencies around the world picked up news releases and covered science from this year's meeting. Conversation flourished under the meeting's Twitter hashtag (#GSA5280), with tweets visible on a scrolling feed in the registration lobby.

See the online newsroom for press releases, a sampling of coverage, and blogs about the meeting at www.geosociety.org/meetings/2010/mediaCoverage.htm.

Sponsors

We especially acknowledge our 2010 Annual Meeting sponsors, whose support enables GSA to continue its tradition of serving science and the profession as well as to encourage growth and instill inspiration among current and future leaders in the geosciences (see p. 11).

Volunteers

Finally, a huge thank you goes out to all the people who made this meeting so successful. All GSA meetings are built from the ground up by volunteers. This includes the hundreds who submit session ideas and the individuals who present their research at the meeting. As well, the tireless volunteers on the Joint Technical Program Committee and in GSA's Divisions and Associated Societies are invaluable in building the scientific portion of the meeting. GSA gives a special shout out to Dick Berg, 2010 Technical Program Chair; Lisa Morgan and Steve Quane, 2010 Field Trip Chairs; and all field trip and short course leaders. And to everyone else who had a part in helping to shape this meeting: Thank you. This meeting is truly *a meeting for scientists created by scientists*.

By the Numbers

Total attendance: 6,536
Number of countries represented: 49
Professional attendees: 3,131
K–12 professionals: 62
Student attendees: 2,511
Student volunteers: 250
Abstracts: 3,691
Oral presentations: 189
Poster sessions: 103
Exhibit booths: 256 (sold out)
Exhibiting companies: 185
Schools in the Graduate School Information Forum: 78 (sold out)
Short Courses: 17
Short Course participants: 324
Field Trips: 22
Field Trip participants: 540
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Rock glacier, northern Colorado. Photo by Marli Bryant Miller, University of Oregon. www.marlimillerphoto.com.

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CALL FOR NOMINATIONS

2011 GSA DIVISION AWARDS

GSA Division: Sedimentary Geology

LAURENCE L. SLOSS AWARD FOR SEDIMENTARY GEOLOGY

Nominations due 20 February 2011

Submit (1) a cover letter describing the nominee's accomplishments in sedimentary geology and contributions to GSA and (2) a curriculum vitae via e-mail to Paul Link, secretary, Sedimentary Geology Division, linkpaul@isu.edu.

The Laurence L. Sloss Award for Sedimentary Geology is given annually to a sedimentary geologist whose lifetime achievements best exemplify those of Larry Sloss—i.e., achievements that contribute widely to the field of sedimentary geology and service to GSA. The Sedimentary Geology Division's management board will choose the recipient from two nominees selected by the nominations committee, and the award will be presented at the 2011 GSA Annual Meeting in Minneapolis. Monies for the award are derived from the annual interest income of the Laurence L. Sloss Award for Sedimentary Geology Fund, which is administered by the GSA Foundation.

GSA Division: Coal Geology

GILBERT H. CADY AWARD

Nominations due 28 February 2011

Submit three copies of the following to Jack C. Pashin, Energy Investigations Program, Geological Survey of Alabama, P.O. Box 869999, Tuscaloosa, AL 35486-6999, USA; jpashin@gsa.state.al.us: (1) name, office or title, and affiliation of the nominee; (2) date and place of birth; (3) education, degree(s), and honors and awards; (4) major events in his or her professional career; and (5) a brief bibliography noting outstanding achievements and accomplishments that warrant nomination.

The Gilbert H. Cady Award is given for outstanding contributions in the field of coal geology. The first award, established by the Division in honor of Gilbert H. Cady, was presented in 1973. The award recognizes contributions that advance the field of coal geology within and outside North America and will be presented at the Coal Geology Division Business Meeting at the 2011 GSA Annual Meeting in Minneapolis. Nominations will be evaluated by the Gilbert H. Cady Award Panel. Monies for the award are derived from the annual interest income of the Gilbert H. Cady Memorial Fund, administered by the GSA Foundation.

GSA Division: Geophysics

GEORGE P. WOOLLARD AWARD

Nominations due 15 February 2011

Submit online via link at www.gsageop.org. Nominations should include a description of the nominee's specific contributions and their scientific impact.

The George P. Woollard Award recognizes outstanding contributions to geology through the application of the principles and techniques of geophysics. The award is presented at each annual GSA meeting in conjunction with the Geophysics Division and the Structural Geology and Tectonics Division business meetings. A highlight of the presentation is the honorary George P. Woollard Technical Lecture by the recipient before the award ceremony. Award funds are administered by the GSA Foundation.

GSA Division: Geoscience Education

BIGGS AWARD FOR EXCELLENCE IN EARTH SCIENCE TEACHING

Nominations due 1 February 2011

Submit nominations to <http://gsaged.org/biggsaward/award2010.htm>. Any supplemental materials should be sent to Dean Moosavi, smoosavi@umassd.edu.

The Biggs Award recognizes innovative and effective teaching in college-level earth science. Earth-science instructors and faculty members from any academic institution engaged in undergraduate education who have been teaching full-time for 10 years or fewer are eligible (part-time teaching is not counted in this requirement). Both peer- and self-nominations will be accepted.

This award, administered by the GSA Foundation, is made possible by support from the Donald and Carolyn Biggs Fund, the GSA Geoscience Education Division, and GSA's Education and Outreach Program. An additional travel reimbursement is also available to the recipient to enable him or her to attend the award presentation at the GSA Annual Meeting.



GSA Division: Quaternary Geology and Geomorphology

**FAROUK EL-BAZ AWARD
FOR DESERT RESEARCH**

Nominations due 2 April 2011

Submit nominations, including (1) a statement of the significance of the nominee's research, (2) a curriculum vitae, (3) letters of support, and (4) copies of no more than five of the nominee's most significant publications related to desert research to Sara Rathburn, Dept. of Geosciences, Colorado State University, Fort Collins, CO, 80523-1482, USA; rathburn@cnr.colostate.edu. Please submit electronically unless hard-copy previously approved.

The Farouk El-Baz Award for Desert Research rewards excellence in desert geomorphology research worldwide. It is intended to stimulate research in desert environments by recognizing an individual whose research has significantly advanced the understanding of the Quaternary geology and geomorphology of deserts. Although the award primarily recognizes achievement in desert research, the funds that accompany it may be used for further research. The award is normally given to one person but may be shared by two people if the recognized research was the result of a coequal partnership. Any scientist from any country may be nominated. Because the award recognizes research excellence, self-nomination is not permitted. Neither nominators nor nominees need be GSA Members. Monies for the award are derived from the annual interest income of the Farouk El-Baz Fund, administered by the GSA Foundation.

GSA Division: History and Philosophy of Geology

**MARY C. RABBITT HISTORY AND
PHILOSOPHY OF GEOLOGY AWARD**

Nominations due 1 February 2011

Submit nominations to Jane P. Davidson, University of Nevada, Reno, NV 89557-0001, USA; +1-775-747-2252; jdhxexen@unr.edu.

The Mary C. Rabbitt History and Philosophy of Geology Award is presented annually to recognize an individual for exceptional scholarly contributions of fundamental importance to our understanding of the history of the geological sciences. Achievements deserving of the award include, but are not limited to, publication of papers or books that contribute new and profound insights into the history of geology based on original research or a synthesis of existing knowledge. The award was established by the History and Philosophy of Geology Division in 1981 and renamed in memory of Mary C. Rabbitt in 2005. For more information, please see <http://gsahist.org/HoGaward/awards.htm>. Neither the nominator nor the nominee need be a member of the Division or of GSA. Monies for the award are administered by the GSA Foundation.

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2011 GSA Medals and Awards (due 1 Feb.): Submit nominations to www.geosociety.org/awards/nominations.htm for the Penrose Medal, Day Medal, Young Scientist Award (Donath Medal), GSA Public Service Award, GSA Distinguished Service Award, Bromery Award for the Minorities, and the Subaru Outstanding Woman in Science Award.

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AGI Medal in Memory of Ian Campbell (due 1 Feb.): Submit nominations to www.agiweb.org/direct/awards.html. Contact GSA if you would like to submit your nomination through the GSA External Awards Committee.

AGI Marcus Milling Legendary Geoscientist Medal (due 1 Feb.): Submit to <http://www.agiweb.org/direct/awards.html#legend>. Contact GSA at awards@geosociety.org if you would like to submit your nomination through the GSA External Awards Committee.

John C. Frye Environmental Geology Award (due 31 March). See www.stategeologists.org/awards_honors.php?id=19&award_information=details for full details.



2011 STUDENT Grants, Awards, & Scholarships



Graduate Student Research Grants

Applications due **1 Feb. 2011**

This Geological Society of America and GSA Foundation program is a key part of GSA's mission and vision (see www.geosociety.org/aboutus/). These grants have for years provided partial funding for master's and doctoral thesis research in the geological sciences. Graduate students enrolled in universities in the United States, Canada, Mexico and Central America are invited to apply and in 2011 may receive up to US\$4,000 in support of their work. Details and the application form are online at www.geosociety.org/grants/gradgrants.htm. Award notifications will be made via post in late April. *Questions?* E-mail awards@geosociety.org or call +1-303-357-1028.

Farouk El-Baz Student Award

Applications due **1 Feb. 2011**

The Farouk El-Baz Student Award, established through the GSA Foundation, is intended to encourage and promote desert research in its broadest sense. Based on proposals for arid land research and advisor recommendations, one or two recipients will be awarded an honorarium at the 2011 GSA Annual Meeting in Minneapolis, Minnesota, USA. Selection will be made by a GSA International Section-appointed committee. Guidelines and the application form are online at <http://rock.geosociety.org/forms/el-bazGrant.asp>. *Questions?* Please e-mail awards@geosociety.org or call +1-303-357-1028.

Antoinette Lierman Medlin Scholarship in Coal Geology

Applications due **15 Feb. 2011**

GSA's Coal Geology Division is pleased to offer the Antoinette Lierman Medlin Scholarship in Coal Geology for the 2010–2011 academic year. The scholarship will provide one full-time student involved in coal geology research (origin, occurrence, geologic characteristics, or economic implications of coal and associated rocks) with up to US\$2,000 in financial support for his or her project for one year. This year's scholarship recipient may also be provided with a stipend to present results at the 2011 or 2012 GSA Annual Meeting.

For the academic year 2010–2011, the Coal Geology Division is also offering a field study award of up to US\$1,500. The recipient of this award will also be eligible to receive travel funds to present the results of his or her study at the 2011 or 2012 GSA Annual Meeting.

A panel of coal geoscientists will evaluate proposals for the scholarship and the field study award. Students may apply for the scholarship award, the field study award, or both; however, only one award will be made to a successful applicant.

To apply, submit five copies of the following to Sharon M. Swanson, U.S. Geological Survey, 956 National Center, Reston, VA 20192, USA; smswanson@usgs.gov: (1) a cover letter

indicating which award(s) is(are) sought; (2) a concise (no more than five double-spaced pages, including references) statement of objectives and methods and a summary of how the scholarship funds will be used to enhance the project; and (3) a letter of recommendation from the student's immediate advisor that includes a statement of financial need and the amount and nature of other available funding for the research project.

Stephen E. Dwornik Student Paper Award

GSA's Planetary Geology Division encourages applications for the Stephen E. Dwornik Student Paper Award, established in 1991 to provide encouragement, motivation, and recognition to outstanding future planetary scientists. Two awards are given each year—one for the best oral presentation, the other for the best poster presentation.

The 2011 Dwornik award applies to papers presented at the 41st Lunar and Planetary Science Conference on 7–11 March 2011 in The Woodlands, Texas, USA. Student applicants must be (1) the senior author on the presentation; (2) a U.S. citizen; and (3) enrolled in a college or university, at any level of their education, with a focus on planetary geoscience. Papers are judged on the quality of the scientific contribution, methods and results, clarity of material presented, and manner of delivery (oral or poster).

Go to www.lpi.usra.edu/meetings/lpsc2011/ for instructions, an application form, and further information. The Dwornik award is administered through GSA's Planetary Geology Division; the GSA Foundation manages the award funds.

History and Philosophy of Geology Student Award

Applications due **3 May 2011**

This award, established by GSA's History and Philosophy of Geology Division in 2004, is made possible by a bequest from the estate of Mary C. Rabbitt. The award applies to GSA Annual Meeting paper proposals based on the following topics: (1) the history of geology; (2) a literature review of ideas for a technical work or thesis/dissertation; and/or (3) some imaginative aspect of the history of geology not previously thought of. Consideration will be given to both undergraduate and graduate students who are in good standing at the time of application; the presentation may take place after the student has graduated. Students must be lead authors on the paper (faculty advisors may be listed as second authors), and while both oral and poster presentations are acceptable, oral presentations are preferred. Applicants need not be GSA members or members of the History and Philosophy of Geology Division.

Further guidelines and the application form are online at <http://gsahist.org/HoGaward/awards.htm>. *Questions?* Contact the Division secretary-treasurer, Jane P. Davidson, at jdhx@unr.edu.

2010 SUBARU Minority Student Scholarship Recipients

Subaru of America, Inc., in partnership with the GSA Foundation, has generously funded a scholarship program to benefit minority undergraduates considering a degree in the geosciences. The Subaru Minority Student Scholarship Program provides US\$1,500 to one student (nominated by a GSA Campus Representative) at an accredited university or college in each of GSA's six North American regional Sections and to one student in a non-high-income country (as defined by the World Bank) from GSA's International Section. The student also receives free registration to the GSA Annual Meeting and a one year complimentary membership to GSA.

The purpose of this scholarship is to encourage minority students to continue studies in the geosciences as a degree choice. Nomination forms for the 2011 program will be e-mailed to GSA Campus Reps this month. *Questions?* Contact Diane Lorenz-Olsen, dlorenz@geosociety.org, +1-303-357-1028.

2010 RECIPIENTS

Karesse A. Lockard

Rutgers University (Northeastern Section)

Hehewutei Amakali

Appalachian State University (Southeastern Section)

Brittnei M. Sherrod

Oberlin College (North-Central Section)

Carlos Ruben Sayavedra

Angelo State University (South-Central Section)

Gabriela St. Pierre

New Mexico State University (Rocky Mountain Section)

Gabriella Rae McDaniel

University of the Pacific (Cordilleran Section)



SUBARU

LAST CALL FOR APPLICATIONS

2011-2012 GSA-USGS Congressional Science Fellowship



Bring your science and technology expertise to Capitol Hill to work directly with national leaders at the interface between geoscience and public policy.

Deadline for application: 1 February 2011

This GSA-USGS Congressional Science Fellowship provides a rare opportunity for a unique individual. Prospective candidates are GSA Members with a broad geoscience background and excellent written and oral communication skills. The fellowship is open only to U.S. citizens or permanent U.S. residents, with a minimum requirement of a master's degree with at least five years professional experience or a Ph.D. at the time of appointment.

Learn more at www.geosociety.org/csf/ or contact Ginger Williams, +1-303-357-1040, gwilliams@geosociety.org.

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Second Announcement

SOUTHEASTERN

60th Annual Meeting of the
Southeastern Section, GSA
Wilmington, North Carolina, USA

23–25 March 2011



Exploration to Exploitation: Geosciences' Role in Natural Resource Stewardship

LOCATION

The Dept. of Geography and Geology at the University of North Carolina–Wilmington is pleased to host the 60th Annual Meeting of GSA's Southeastern Section at the new Wilmington Convention Center, located on the banks of the scenic Cape Fear River.

REGISTRATION

Early registration deadline: 22 Feb. 2011

Cancellation deadline: 28 Feb. 2011

Register at www.geosociety.org/Sections/se/2011mtg/.

On-site registration and badge pick up will be in the Main Lobby of the Wilmington Convention Center on Wed., 23 March, 4–7:30 p.m.; Thurs., 24 March, 7 a.m.–5 p.m.; and Fri., 25 March: 7 a.m.–noon.

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

	Early		Standard	
	Full Mtg	One day	Full Mtg	One day
Professional Member	\$180	\$100	\$210	\$110
Professional Nonmember	\$200	\$120	\$220	\$130
Student Member	\$70	\$50	\$75	\$55
Student Nonmember	\$80	\$60	\$110	\$80
K–12 Teacher	\$30	\$20	\$35	\$25
Guest	\$50		\$60	
Short Course/Field Trip only	\$35		\$45	

ACCOMMODATIONS

Hotel registration deadline: 21 Feb. 2011

A block of rooms has been reserved at the **Hilton Wilmington Riverside**, 301 N. Water Street, Wilmington, NC 28401-3834, USA; +1-910-763-5900; the Hilton is within walking distance of the convention center. Single/double: US\$124; triple: US\$134; quad: US\$144. To qualify for these rates, please identify yourself as an **SEGSA** attendee when making your reservation.

TECHNICAL PROGRAM

Abstract deadline: 14 Dec. 2010

Keynote Speaker: William G. Ross Jr., Duke University professor, environmental lawyer, and former secretary of the North Carolina Dept. of Environment and Natural Resources.

Symposia

1. **From Triassic Basins to Hydrogeological and Environmental Characterization of Coastal Plain Environments: A Tribute to the Illustrious Geoscience Career of Paul A. Thayer.** *Cosponsored by AAPG Division of Environmental Geosciences.* Mary Harris, Savannah River National Laboratory, mary.harris@srnl.doe.gov; Harry Roberts, Louisiana State Univ., hrober3@lsu.edu.
2. **Coastal Response to Sea-Level and Climate Changes: A Tribute to the Career of Stan Riggs.** *Cosponsored by Eastern Section SEPM.* David Mallinson, East Carolina Univ., mallinsond@ecu.edu; Dorothea Vonderporten Ames, East Carolina Univ., amesd@ecu.edu.
3. **Coastal Response to Tidal Inlets: A Tribute to the Career of Bill Cleary.** *Cosponsored by Eastern Section SEPM.* Spencer Rogers, North Carolina Sea Grant, rogerssp@uncw.edu; Duncan Fitzgerald, Boston Univ., dunc@bu.edu.
4. **Significant Fossil Sites in the Southeast: Why They Are Important and How They Contribute to Our Knowledge of the Fossil Record.** *Cosponsored by The Paleontological Society.* Sandy Ebersole, Alabama Geological Survey, sebersole@gsa.alabama.gov; Melanie Devore, Georgia College and State Univ., melanie.devore@gcsu.edu.

Theme Sessions

1. **Surficial and Subsurface Geology and Hydrogeology of the Cape Fear River Basin.** *Cosponsored by Eastern Section SEPM.* Jean Self-Trail, USGS, jstrail@usgs.gov; Kathleen Farrell, North Carolina Geological Survey (NCGS), kathleen.farrell@ncdenr.gov.
2. **Practical Applications of Engineering and Environmental Geology.** Brad Worley, North Carolina Dept. of Transportation, bdworley@ncdot.gov; Paul Weaver, Kleinfelder Engineering, chair@aegcarolinas.org.
3. **Piedmont Geology: New Mapping and New Perspectives.** *Cosponsored by North Carolina Geological Survey.* David Blake, Univ. of North Carolina–Wilmington, blaked@uncw.edu; Edward F. Stoddard, NCGS, skip_stoddard@ncsu.edu; Phil Bradley, NCGS, pbradley@ncdenr.gov.
4. **Watershed Processes.** Weston Dripps, Furman Univ., weston.dripps@furman.edu; Jeff Wilcox, Univ. of North Carolina–Asheville, jwilcox@unca.edu.
5. **Micropaleontology of the Southeast.** *Cosponsored by The Paleontological Society.* Ronald Lewis, Auburn Univ., lewisrd@auburn.edu; Steve Culver, East Carolina Univ., culvers@ecu.edu.
6. **Geologic Maps, Geophysical Maps, Digital Geologic Maps, and Derivatives from Geologic and Geophysical Maps (Poster Session).** Michael W. Higgins, The Geologic Mapping Institute, mhiggins@mindspring.com; Ralph F. Crawford, The Geologic Mapping Institute, crawford@sprintmail.com.
7. **Macropaleontology of the U.S. Coastal Plain.** *Cosponsored by The Paleontological Society; Paleontological Research Institution.* Patricia Kelley, Univ. of North Carolina–Wilmington, kelley@uncw.edu; Gregory Dietl, Paleontological Research Institution, gpd3@cornell.edu.
8. **Graduate and Undergraduate Research (Poster Session).** Lee Phillips, Jr., Univ. of North Carolina–Pembroke, lee.phillips@uncp.edu.
9. **From the Mason-Dixon to the Caribbean: The Historic Development of Geology in the American South.** *Cosponsored by GSA History and Philosophy of Geology Division; History of Earth Sciences Society.* Michael Smith, Univ. of North Carolina–Wilmington, smithms@uncw.edu; Anne Whitt, NCGS, anne.whitt@ncmail.net.
10. **Karst Geology and Hydrology.** *Cosponsored by Eastern Section SEPM.* Lee Florea, Western Kentucky Univ., lee.florea@wku.edu; Douglas Gamble, Univ. of North Carolina–Wilmington, gambled@uncw.edu.
11. **Estuarine Shoreline Dynamics: Delineation Methods, Results, and Management.** Scott Howard, SCGS, howards@dnr.sc.gov; Scott Geis, N.C. Dept. of Environment & Natural Resources, scott.geis@ncdenr.gov; J.P. Walsh, East Carolina Univ., walshj@ecu.edu; Matt Slagel, S.C. Dept. of Health and Environmental Control, slagelmj@dhec.sc.gov.
12. **Building a Foundation in Geoscience Education: Gathering Educators with Professionals to Create a Geoscience Literate Public.** *Cosponsored by National Association of Geoscience Teachers Southeastern Section; North Carolina Geological Survey; Association of Environmental and Engineering Geologists Carolinas Section.* Randy Bechtel, NCGS, randy.bechteln@ncdenr.gov; Bill Witherspoon, Fernbank Science Center, billspoon1@gmail.com; Andy Heckert, Appalachian State Univ., heckertab@appstate.edu.
13. **Legacy Sediments and Piedmont Streams: Anthropogenic Impacts to Geomorphic and Aquatic Systems.** *Cosponsored by University of North Carolina Water Resources Research Institute.* Karl Wegmann, North Carolina State Univ., karl_wegmann@ncsu.edu; Christopher L. Osburn, North Carolina State Univ., closburn@ncsu.edu; Martha C. Eppes, Univ. of North Carolina–Charlotte, meppes@uncc.edu.
14. **Energy Sources and Issues: “Offshore and Unconventional.”** *Cosponsored by Eastern Section SEPM.* Roger Shew, UNCW, shewr@uncw.edu.
15. **Reducing Carbon Dioxide Emissions in the Southeast: Advances in Geologic Carbon Sequestration and CO₂-Enhanced Oil Recovery.** *Cosponsored by Eastern Section SEPM.* Tina Roberts-Ashby, Univ. of South Florida, oxbowlk@yahoo.com.
16. **Hydrogeology and Environmental Remediation.** William E. Jones, Savannah River National Laboratory, w02.jones@srnl.doe.gov; Margaret R. Millings, Savannah River National Laboratory, margaret.millings@srnl.doe.gov.

WORKSHOPS

1. **Standardized Core Logging Techniques for Students.** *Cosponsored by SEPM.* Sat., 26 March, 8:30 a.m.–5 p.m. Kathleen Farrell, NCGS, kathleen.farrell@ncdenr.gov; Jean Self-Trail, USGS, jstrail@usgs.gov; Scott Bruce, Virginia Dept. of Environmental Quality, taylor.bruce@deq.virginia.gov.
2. **Surface and Subsurface Geological and Environmental Issues in the Coastal Plain.** *Cosponsored by UNCW Science and Mathematics Education Center.* Sat., 26 March, 8:30 a.m.–12:30 p.m. Roger Shew, Univ. of North Carolina–Wilmington, shewr@uncw.edu.
3. **Developing and Using Conceptest Questions and Electronic Response Systems in the Classroom.** Thurs., 24 March, noon–1:30 p.m. Ann Holmes, Univ. of Tennessee–Chattanooga, ann-holmes@utc.edu; Jake Armour, Univ. of North Carolina–Charlotte, jarmour@uncc.edu.



Blue Ridge Parkway; image courtesy SEGSA Local Committee.

FIELD TRIPS

1. **Plio-Pleistocene Stratigraphy and Paleontology of Southeastern North Carolina.** *Cosponsored by The Paleontological Society; National Association of Geoscience Teachers (NAGT).* Sat., 26 March. US\$75. Max.: 15. Greg Dietl, Paleontological Research Institution; Lauck Ward, Virginia Museum of Natural History; Tricia Kelley, UNCW.
2. **Natural Gas Resource Potential of the Sanford Sub-Basin of the Deep River Triassic Rift Basin.** *Cosponsored by Eastern Section SEPM.* Sat., 26 March. US\$80; includes lunch and breaks. Max.: 50. Jeff Reid, NCGS; Kenneth Taylor, NCGS. After the field trip, the Eastern Section of the Society for Sedimentary Geology (SEPM) will partially reimburse each participating student member. For information, go to www.essepm.org.
3. **Transition between the Raleigh and Carolina Terranes in North-Central North Carolina.** Sat., 26 March. US\$85; includes lunch. Max.: 24. David Blake, UNCW; Skip Stoddard, NCGS; Phil Bradley, NCGS.

OPPORTUNITIES FOR STUDENTS

Mentor Programs: *Cosponsored by GSA Foundation.* Learn more at www.geosociety.org/mentors/.

1. **Roy J. Shlemon Mentor Program in Applied Geoscience.** Thurs., 24 March, noon–1:30 p.m. Students will have the opportunity to discuss career prospects and challenges with professional geoscientists from multiple disciplines over a FREE lunch.
2. **John Mann Mentors in Applied Hydrogeology Program.** Fri., 25 March, noon–1:30 p.m. Students interested in applied hydrogeology or hydrology as a career will have the opportunity to network with professionals in these fields over a FREE lunch.

Travel Grants: Application deadline: 22 Feb. 2011; applications and information are online at www.geosociety.org/sections/se/students.htm.

Volunteers: The local committee and officers of GSA's Southeastern Section offer free meeting registration to student volunteers in return for ~6 hours of work. Contact student volunteer coordinator Patricia Kelley at kelleyp@uncw.edu; please volunteer by 1 Feb. 2011.

LOCAL COMMITTEE

General chair: Richard Laws, laws@uncw.edu

Technical program chair: William Harris, harrisw@uncw.edu

Field trip chair: Kenneth Taylor, kenneth.b.taylor@ncdenr.gov

Exhibits chair: John Huntsman, huntsmanj@uncw.edu

Student volunteers: Tricia Kelley, kelleyp@uncw.edu

Guest activities: W. Frank Ainsley (deceased)

MEETING SPONSORS



Dogwood tree; image courtesy SEGSA Local Committee.



Sunrise on a North Carolina beach; image courtesy SEGSA Local Committee.

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Deadline: 1 February 2011

Learn more and apply at

www.geosociety.org/geocorps/



Inset 1: Mark Hagemann, Cave Resources Technician at Tongass National Forest, Summer 2010. **Background:** Erin Lynch, Cave Resources Technician at Tongass National Forest, Summer 2010. **Inset 2:** Andrea Johnson, Geology Education Specialist at Rocky Mountain National Park, Summer 2010.



Deformation Localization in Rocks: New Advances

Cadaqués & Cap de Creus Peninsula, Catalonia, Spain
27 June–2 July 2011

CONVENERS

Elena Druguët, *Depto. de Geologia, Universitat Autònoma de Barcelona, Spain; elena.druguët@uab.cat*

Jordi Carreras, *Depto. de Geologia, Universitat Autònoma de Barcelona, Spain; jordi.carreras@uab.cat*

G. Ian Alsop, *Dept. of Geology & Petroleum Geology, School of Geosciences, University of Aberdeen, UK; ian.alsop@abdn.ac.uk*

Paul D. Bons, *Institut für Geowissenschaften, Eberhard Karls Universität Tübingen, Germany; paul.bons@uni-tuebingen.de*

Dyanna M. Czeck, *Dept. of Geosciences, University of Wisconsin, Milwaukee, Wisconsin, USA; dyanna@uwm.edu*

Peter J. Hudleston, *Dept. of Geology and Geophysics, University of Minnesota, Minneapolis, Minnesota, USA; hudle001@umn.edu*

Christine S. Siddoway, *Geology Dept., Colorado College, Colorado Springs, Colorado, USA; csiddoway@coloradocollege.edu*



DESCRIPTION AND OBJECTIVES

The subject of this conference is the localization of deformation in rocks, with special emphasis on shear zones as physical expressions of strain localization in orogens at the level of the middle and lower lithosphere. In the past two decades, there have been important advances in laboratory and numerical modeling studies of the way that deformation localizes in Earth's crust. These are accompanied by advances in imaging of lithospheric structure, including the distribution of fluids and melts, using seismological techniques that provide access to the depths of active tectonic zones. Innovative new techniques in thermochronology aid our understanding of the temporal evolution of the crustal scale zones of strain localization. An aim of the conference is to juxtapose the results of new theoretical, analytical, and laboratory research with the natural world relationships observed in the exemplary field setting of Cap de Creus, northeastern Spain. The conference will offer the opportunity for researchers who employ different approaches (e.g., theory, experimentation, seismological, petrological, and field methods) to integrate results, address controversies, and identify new opportunities for interdisciplinary research to advance our understanding of localization of deformation in shear zones at multiple scales.

This six-day conference will include alternating field trips and presentations (invited and contributed lectures and poster sessions). The charming village of Cadaqués has been chosen as the conference location because it allows ready access to shear zones and other strain localization structures in what is recognized as one of the best natural laboratories in the world: the Cap de Creus peninsula.

Over a comparatively small area on the peninsula, there is access to structures that will allow the Penrose participants to observe and discuss the geometry, kinematics, and mechanics of shear zones; triggers and mechanisms for folding and boudinage and development of kink bands, shear bands, and brittle fractures; the influence of rigid versus deformable objects in shear zone localization; and the role and interaction of fluids, melts, and metamorphism. Another aim of the meeting is to bring about greater integration of the results of contemporary physical and numerical investigations with the field observations of strain localization in orogens.

Now is an opportune time to place the heightened understanding from theoretical and quantitative approaches into juxtaposition with direct field observations that offer "ground truth" for interpretation of the combination of factors that lead to localization of deformation within shear zones. The principal proposed topics for presentation of laboratory, theoretical, and field studies are

- Shear zones: new perspectives on geometry, kinematics, and mechanics;
- Field, numerical, and analog modeling of mesoscopic elements of shear zones: folding and boudinage, kink bands and shear bands, and rigid and deformable objects;
- Insights on the role and interaction of fluids, melts, and metamorphism in strain localization;
- Physical and numerical experiments of strain localization; and
- Interdisciplinary approaches to the study of strain localization in orogens.

PRELIMINARY LIST OF KEY SPEAKERS

John Cosgrove (Imperial College London), Laurel B. Goodwin (University of Wisconsin–Madison), Scott E. Johnson (University of Maine), Neil Mancktelow (ETH Zürich), and Cees W. Passchier (Johannes Gutenberg Universität Mainz).

PRELIMINARY OUTLINE OF SESSIONS AND FIELD TRIPS

Day 1: *Field trip:* “Simple” and complex shear zones: Roses and Culip.

Day 2: *Session 1:* Shear zones: geometry and kinematics—includes micro- to macro-scale analyses. *Session 2:* Shear zones: initiation and development—includes micro- to macro-scale analyses.

Day 3: *Field trip:* Classical shear zone itinerary: Serena-Prona-Punta dels Farallons.

Day 4: *Session 3:* Strain localization with regard to fluids, magmas/melt, and metamorphism. *Session 4:* Structures related to strain localization—rigid and deformable objects (e.g. porphyroclasts, conglomerates), folds, boudinage, shear bands, brittle fractures, etc.

Day 5: *Field trip:* Strain localization due to strong competence contrast (Tudela) and localization at high temperature and magma intrusion (Cap de Creus Lighthouse).

Day 6: *Session 5:* Physical and numerical experiments of strain localization. *Session 6:* Strain localization in orogens—space (regional) thermal and time constraints/evolution.

ATTENDEES & ESTIMATED COST

The registration fee (which has not yet been finalized but is estimated at US\$750 to US\$800 per person) will cover hotel lodging (double occupancy), all meals for six days, all hand-outs and digital materials, and transportation from Cadaqués to the field areas. Airfare is not included. Participants must make their own travel arrangements to arrive in Cadaqués, Girona, Spain, the evening of 26 June.



Please check the GSA website at www.geosociety.org/penrose/ for updates. Information is also available at http://www.wix.com/mietgroup/penroseconf_capdecreus.

APPLICATIONS & REGISTRATION

Application deadline: 25 Feb. 2011

Registration deadline: 28 Apr. 2011

This conference is limited to 55 participants. Participants will have to commit to attending the full six days. **To apply**, please contact the conveners at elena.druguet@uab.cat with a letter of intent that includes a brief statement of interests, the relevance of your recent work to the themes of the conference, the subject of your proposed presentation, and contact information. Graduate students are strongly encouraged to apply. Once you have been selected to participate, you will be sent registration information.

Penrose Conference and Field Forum Proposals Encouraged

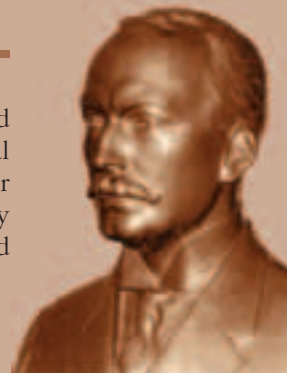
PENROSE CONFERENCES

GSA's Penrose Conferences were established in 1969 to provide opportunities for the exchange of current information and exciting ideas in geology and related fields and to stimulate and enhance individual and collaborative research. Go to www.geosociety.org/Penrose/ for guidelines and a proposal form.

FIELD FORUMS

Have a great idea for a Penrose Conference that would be much more effective in a field setting or a field trip idea that captures the essence of new discoveries or a controversial topic? Then submit a Field Forum proposal! Field Forums provide an opportunity for the exchange of current knowledge and ideas that are well expressed by the geology of a specific area. Go to www.geosociety.org/fieldforums/ for proposal guidelines and more information.

QUESTIONS? Contact Becky Sundeen, +1-303-357-1041, bsundeen@geosociety.org.





Mark G. Little

Congressional Oversight and Improved Decisions

The Congress shall have Power – To make all Laws which shall be necessary and proper for carrying into Execution the foregoing Powers, and all other Powers vested by this Constitution in the Government of the United States, or in any Department or Officer thereof.

—United States Constitution

I came to the GSA-USGS Congressional Science Fellowship with little understanding or awareness of the role that Congress plays in monitoring and evaluating the programs of the federal agencies. Its authority is derived from the *Necessary and Proper Clause*, quoted above, and the numerous enumerated powers of Congress. As the author of federal laws, Congress has the wherewithal to ensure that implementation of those laws is in accordance with the spirit in which they were written. This oversight capacity takes the form of hearings, briefings, and reports to Congress. These interactions are sometimes hostile (e.g., the recent Gulf oil spill hearings); however, a mutually respectful and informed exchange has typified my experience with executive branch oversight on the House Committee on Foreign Affairs.

Most committees with the power to introduce legislation exercise oversight responsibility over the federal agencies within their purview. The State Department, the United States Agency for International Development (USAID), the Overseas Private Investment Corporation (OPIC), and the Trade and Development Agency (TDA) are subject to the scrutiny of the Committee on Foreign Affairs and its Senate counterpart, the Committee on Foreign Relations. Practically, this means that any specific program or policy that is conceived or implemented by one of these agencies is subject to Committee investigation. For example, when the State Department launched its Global Shale Gas Initiative in May of 2010, it briefed committee staff. The program leverages government-wide expertise, including that of the U.S. Geological Survey (USGS), to assist foreign countries seeking to utilize their unconventional natural gas resources to achieve greater energy security, meet environmental objectives, and further U.S. economic and commercial interests.

Sometimes, the chain of programs and responsibilities is convolute. For example, a developing country may seek a loan from the World Bank for an infrastructure project that promises a substantial improvement in living standards and a reduction in poverty but could engender significant environmental impacts. The World Bank evaluates the financial merits of the project, completes an environmental impact assessment, and prepares its member countries for a vote on approval of the loan. The U.S. vote—yes, no, or abstain—is proportional to its financial contribution (17% of the total vote) and is determined by the U.S. Treasury Department. USAID steps in to amend the Treasury's lack of deep environmental expertise by reviewing the World Bank's impact assessment for compliance with U.S. standards, which may differ from that of the World Bank and the host country. In turn, the Committee on Foreign

Affairs may ask USAID to explain their concerns about the project's environmental impact. To complete the circle, the World Bank and the developing country seeking the loan may provide additional information to all involved parties, including the committee. These intertwined responsibilities are complex, but so are international environmental and natural resource issues, and the best decisions are founded on good data and diverse consultation.

After some data collection and consultation of my own, I have accepted a staff position on the Committee on Foreign Affairs. The opportunity to continue with the committee is a testament to the reputation of the Congressional Science Fellows program and to the open-mindedness of the committee staff, who have always treated me as their colleague. I am also grateful to GSA and USGS for this opportunity, to AAAS for warmly welcoming me into the community of science fellows, and to Committee Chair Howard L. Berman, whose informed and reasoned approach to legislating is far too uncommon. If I might offer one piece of advice to the reader: Seek out a first-hand experience working with or volunteering for a legislative body, be it your town council, state House, or the U.S. Congress. While I have given an honest recounting in these reports, the most powerful and curious insights remain yours to discover.

This manuscript is submitted for publication by Mark G. Little, 2009–2010 GSA-USGS Congressional Science Fellow, with the understanding that the U.S. government is authorized to reproduce and distribute reprints for governmental use. The one-year fellowship is supported by GSA and by the U.S. Geological Survey, Department of the Interior, under Assistance Award No. G09AP00158. The views and conclusions contained in this document are those of the author and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. government. Little is working on the staff of the House Committee on Foreign Affairs. He can be reached at MarkGabriel.Little@mail.house.gov.



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2010 Exceptional Reviewers

GSA appreciates the many people who make its peer-reviewed journals possible: the authors, science editors, editorial board members, associate editors, and most of all, the reviewers. Peer review of papers is the cornerstone of scientific publishing, but reviewing papers is all too often a thankless task. To those reviewers who complete timely, thorough, and even-handed reviews, GSA extends its heartfelt appreciation. In that spirit, GSA's journals science editors have selected the following people for special recognition of their many prompt, insightful, meticulous, and tactful reviews during the past year. Photos of these colleagues are posted at www.geosociety.org/pubs/reviewers.htm.



GEOLOGY

Gerald (Jerry) Dickens, Rice University
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2011



**NORTHEASTERN/
 NORTH-CENTRAL
 Joint Section Meeting**
 Pittsburgh, Pennsylvania, USA
 20–22 March 2011

**SOUTHEASTERN
 Section Meeting**
 Wilmington, North Carolina, USA
 23–25 March 2011

**SOUTH-CENTRAL
 Section Meeting**
 New Orleans, Louisiana, USA
 27–29 March 2011

Abstract deadline:
 18 January 2011

**ROCKY MOUNTAIN/
 CORDILLERAN
 Joint Section Meeting**
 Logan, Utah, USA
 18–20 May 2011

Abstract deadline:
 15 February 2011

GSA Section Meeting Schedule



GSA Foundation Update

Donna L. Russell, Director of Operations

Trustee Changes

During the October 2010 GSA Foundation Trustee Meeting, we welcomed two new Trustees to the Board.



Thomas L. Holzer

Thomas L. Holzer is a research geologist with the U.S. Geological Survey in Menlo Park, California, USA, and is a consulting professor to both the Geological and Environmental Sciences and the Civil and Environmental Engineering departments at Stanford University. Holzer received a B.S.E. in geological engineering with honors from Princeton University in 1965, an M.S. in hydrology 1966,

and a Ph.D. from Stanford University in 1970. He joined the USGS in 1975 after teaching at the University of Connecticut. Holzer's research interests focus on geologic hazards; he is currently developing a probabilistic framework for mapping earthquake-induced liquefaction and recently published the first liquefaction probability curves for surficial geologic units in the journal *Environmental and Engineering Geoscience*.

development, and geoarchaeology. He is co-chair of the NASA- and USGS-supported Global Land Ice Measurements from Space (GLIMS) Regional Center for Southwest Asia (Afghanistan and Pakistan), which is actively dealing with ice, snow, and meltwater resources.

In Other Trustee News

The five-year terms of Robert Rutherford and Elaine R. Padovani and the ten-year term of Virginia B. Sisson have ended. Rutherford served as Chair of the Board from 2007–2010, and Sisson chaired the Nominating Committee from 2007–2010. Margaret R. Eggers was named as Chair of the Board, and George O. Linkletter will serve as Vice Chair.

For additional information on the Foundation's entire Board of Trustees, please go to gsafweb.org and click on the Trustee Tab.



John F. Shroder Jr.

John F. Shroder, Jr., known as "Jack" to his friends, is currently Special Assistant to the Dean of International Studies and Regents Professor of Geography & Geology at the University of Nebraska–Omaha, where he has taught since 1969. Shroder has plentiful research experience in South Asia, the Middle East, and Africa. Author and/or editor of 15 books and monographs, 40 unpublished environmental consulting reports, and over 130 papers, Shroder has published on a variety of scientific topics dealing with land-

slides, glaciers, water supplies, floods, natural resources,



Most memorable early geologic experience:

An early geology memory I have is collecting Devonian fossils with my brother when I was 13 years old. We were written up in the local newspaper and our collection was displayed in the Wyckoff, N.J., Library. WOW!

—Arthur P. Schultz

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2011 GSA Section Meeting Mentor Programs

STUDENTS—Meet Your Career Mentors!

Plan now to attend a Shlemon Mentor Program and/or a Mann Mentor Program in Applied Hydrogeology at your 2011 Section Meeting to talk one-on-one with practicing geoscientists. These volunteers will answer your questions and share insights on how to get a job after graduation.

Roy J. Shlemon Mentor Program in Applied Geoscience. *Sponsored by the GSA Foundation.* This is a chance for students to discuss career opportunities and challenges with professional geoscientists from multiple disciplines. Students will receive FREE lunch tickets in their registration packets to attend this program.

The John Mann Mentors in Applied Hydrogeology Program. *Sponsored by the GSA Foundation.* This event presents opportunities for students interested in applied hydrogeology or hydrology as a career to interact and network with practicing hydrogeologic professionals. Whether you've already decided to head down the hydro career path or whether you just would like to know more about these career options, this meeting is for you! This program is a focused, small-scale event that features a FREE lunch for participants. Students will receive a ticket to attend in their registration packets.

Space for these events is limited, so plan to arrive early: first come, first served. For further information, contact jnocerino@geosociety.org.



NORTHEASTERN/ NORTH-CENTRAL JOINT SECTION MEETING

Pittsburgh, Pennsylvania, USA

Shlemon Mentor Luncheons

Sun., 20 March, and Mon., 21 March, noon–1:30 p.m.

Mann Mentors in Applied Hydrogeology Luncheon

Tues., 22 March, noon–1:30 p.m.

SOUTHEASTERN SECTION MEETING

Wilmington, North Carolina, USA

Shlemon Mentor Luncheon

Thurs., 24 March, noon–1:30 p.m.

Mann Mentors in Applied Hydrogeology Luncheon

Fri., 25 March, noon–1:30 p.m.

SOUTH-CENTRAL SECTION MEETING

New Orleans, Louisiana, USA

Shlemon Mentor Luncheon

Mon., 28 March

Mann Mentors in Applied Hydrogeology Luncheon

Tues., 29 March

ROCKY MOUNTAIN/ CORDILLERAN JOINT SECTION MEETING

Logan, Utah, USA

Shlemon Mentor Luncheon

Wed., 18 May, and Thurs., 19 May, 11:45 a.m.–1:15 p.m.

Mann Mentors in Applied Hydrogeology Luncheon

Thurs., 19 May, 11:45 a.m.–1:15 p.m.



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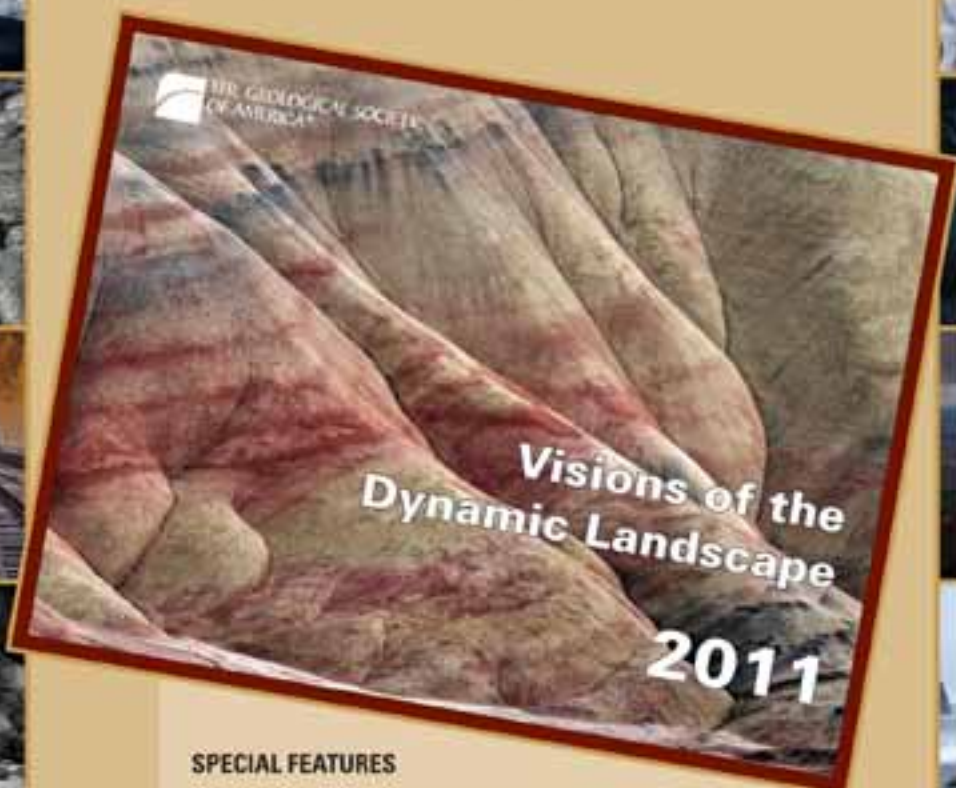
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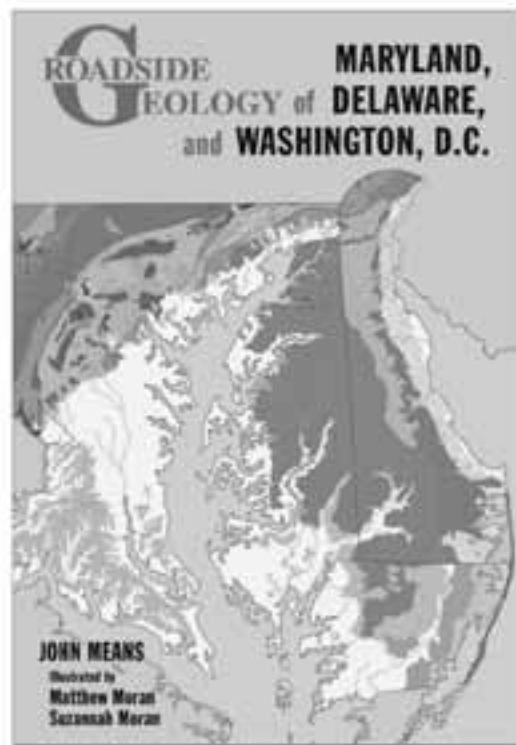
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To apply, please submit the following by 1 April 2011 to <http://rock.geosociety.org/ExxonMobilAward/>

- ❖ A résumé or curriculum vitae;
- ❖ Academic transcripts;
- ❖ Two letters of recommendation; and
- ❖ A cover letter indicating your background, your plans for the future, and how you feel this trip will help you accomplish these plans.



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Questions? Please contact Jennifer Nocerino, jnocerino@geosociety.org, or +1-303-357-1036.

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Positions Open

TWO TENURE TRACK GEOLOGY POSITIONS COLLEGE OF CHARLESTON

The Dept. of Geology and Environmental Geosciences at the College of Charleston (www.cofc.edu/~geology) is accepting applications for two (2) tenure-track Assistant Professor positions to begin in Aug. 2011. Our ideal candidate for each position is a Geologist who is an excellent teacher, is committed to undergraduate education and research, and is able to teach either (1) GIS or (2) remote sensing. Geologists who conduct research in geologic hazards, petrology, soil science, and/or surficial processes, and who are able to develop a sustainable research program involving undergraduate and graduate students are encouraged to apply. Successful candidates will be expected to teach introductory geology classes, develop one or more courses in their field of specialty, and possess the necessary skills to teach either GIS or remote sensing classes. A Ph.D. is required at the time of employment, and salary is dependent on experience.

To apply, email a letter of interest stating whether you are able to teach GIS and are interested in Position 1 (GIS), or you are able to teach remote sensing and are interested in Position 2 (Remote Sensing). Also include a current curriculum vitae, statement of research goals and teaching philosophy, and arrange for at least three letters of reference to be sent (if requested) to Dr. Cassandra Runyon (843-953-8279), Chair, Geospatial Search Committee, Dept. of Geology and Environmental Geosciences, College of Charleston, 66 George Street, Charleston, SC 29424. runyonc@cofc.edu. Applications will be accepted through Jan. 2011.

ASSISTANT PROFESSOR, BIOGEOSCIENCES WITTENBERG UNIVERSITY

The Dept. of Geology invites applications for a tenure-track appointment at the assistant professor rank beginning 22 Aug. 2011. Applicants should be broadly trained in the geosciences with expertise in the biogeosciences, specifically in the areas of geobiology, geochemistry, geomicrobiology, or paleoclimatology. Candidates must have interest and experience in environmental applications. The primary teaching responsibilities will include introductory geology and environmental science courses and advanced courses in the candidate's area of expertise. Advanced courses will be designed to attract students from the interdisciplinary areas of the candidate's expertise. The candidate will contribute to interdepartmental programs, including environmental science and the University's first-year seminar, advise undergraduate majors and new students, and participate in university service. The successful candidate will demonstrate excellence in teaching and the potential to supervise student research in her/his area of expertise. Current faculty expertise in the department includes mineralogy, igneous and metamorphic petrology, economic geology, process geomorphology, and physical sedimentology.

Wittenberg University is a small, private, residential undergraduate institution firmly committed to the liberal arts and sciences. Interested applicants are encouraged to visit our website (www.wittenberg.edu) for details about the University and the department. Wittenberg participates in AA/EEO/ADA. We encourage women and minority applicants to apply as we are committed to

creating an ethnically and culturally diverse community. Review of applications will begin 1 Feb. 2011 and continue until the position is filled.

Please submit a curriculum vitae, a statement about teaching and research in a liberal arts and sciences setting, and a list of at least three references (with phone numbers and e-mail addresses) to hwittenberg@wittenberg.edu or <http://www.wittenberg.edu/~hwittenberg>. Please use the following URL for job posting details: <http://www.wittenberg.edu/~hwittenberg>. Job posting ID: 22465.

ASSISTANT PROFESSOR, GEOGRAPHY WESTERN KENTUCKY UNIVERSITY

Western Kentucky University, Dept. of Geography and Geology, is seeking applicants for an Assistant Professor of Geography. This is a tenure-track assistant professor position beginning Aug. 2011. The successful candidate is expected to contribute to research and education programs of the University's Hoffman Environmental Research Institute, which may include affiliation with major Institute programs including the China Environmental Health Project, Crawford Hydrology Laboratory and Center for Cave and Karst Studies.

Qualifications:

Earned Ph.D. in Geography or a related environmental field is required; Must demonstrate a commitment to excellence in teaching and research at the undergraduate, master's, and post-doctoral levels; is expected to develop a strong externally funded research program in one or more environmental areas related to the mission of the Institute, including but not limited to environmental education, water resources, and water policy. Research experience in karst aquifer/landscape systems and familiarity with GIS are desirable but not required. The Hoffman Institute's mission statement can be found at <http://hoffman.wku.edu/mission.html>.

Collaborative and interdisciplinary research is highly desirable.

TENURE-TRACK POSITION ASSOCIATE OR ASSISTANT PROFESSOR ILLINOIS STATE UNIVERSITY

The Dept. of Geography-Geology at Illinois State University seeks applications for a tenure-track position at the rank of Associate or Assistant Professor with expertise in Hydrogeology. The preferred starting date is 16 Aug. 2011. A Ph.D. in Geology or closely related field is preferred, but ABD candidates who will finish before the time of appointment will be considered.

The department seeks a candidate that possess research and teaching interests that emphasize practical applications of field, laboratory and/or computational skills in one or more of the following areas (but not limited to): aqueous geochemistry, groundwater and surface water interaction, environmental geophysics, ecohydrology, and transport, fate, and remediation of contaminants. The successful candidate will be an integrated scholar with a strong commitment to teaching and mentoring at all levels, including participation in our Hydrogeology Graduate (M.S.) program. Primary teaching responsibilities will include a graduate, advanced undergraduate, and general education courses.

The evaluation of candidates will focus on the potential for innovative scientific research and commitment teaching. The successful candidate will be expected to mentor and advise graduate student research, and maintain an externally funded, internationally visible research program. Potential collaborative interactions exist within the department, with other departments and programs on campus (biological sciences, chemistry), with state agency researchers (Illinois State Geological Survey, Illinois State Water Survey, Illinois EPA). The potential for a significant startup package exists.

Illinois State University is a research-intensive university with an annual enrollment of approximately 20,000 students. The university is located in the Bloomington-Normal metropolitan area of central Illinois with a population of approximately 150,000. The Dept. of Geography-Geology offers B.S./B.A. degrees in geography, a B.S. degree in geology, and an M.S. degree in hydrogeology.

Please send applications to Chair, Hydrogeology Search Committee, Dept. of Geography-Geology, Illinois State University, Normal, Illinois, 61790-4400, USA. Applications should include a cover letter, curriculum vitae, statements outlining current and future research interests and teaching philosophy, three letters of recommendation, and all college and university transcripts. All materials must be received on or before 1 Feb. 2011. No e-mail applications will be accepted. Inquiries about the application process should be directed to Dr. Eric Peterson (ewpeter@ilstu.edu, +1-309-438-7865). Additional information about the department and the community can be found at www.geo.ilstu.edu. Filling this position is contingent upon budgetary approval.

FACULTY POSITIONS, ENVIRONMENTAL CHANGE UNIVERSITY OF NOTRE DAME

The University of Notre Dame invites applications for two new open-rank faculty positions that will enhance existing foundations of excellence in hydrology and aquatic chemistry in the College of Engineering and in environmental change biology in the College of Science. We seek applicants who employ quantitative modeling methods, or a combination of empirical and modeling tools, to address environmental change at broad geographic scales. Applicants should demonstrate experience or a research trajectory including cutting-edge simulations, scenarios, or predictions that are relevant to natural resource management or policy. It is expected that successful candidates would participate in the new Environmental Change Initiative (<http://sri.nd.edu/>; www.youtube.com/watch?v=SS_BORH4yayw) and be jointly appointed in the Dept. of Biological Sciences and the Dept. of Civil Engineering and Geological Sciences.

Watershed modeler (open rank) who will link the physical disciplines of hydrological science with the large-scale patterns of anthropogenic drivers (e.g., invasive species, nutrient run-off, climate change, land use/land cover) and environmental responses. Applicants should have a primary interest in projecting how changes in flows of freshwater affect freshwater, marine, and terrestrial ecosystems. Send applications to watmod10@nd.edu.

Ecosystem scientist (open rank) who will link climate science and biology with a primary interest in projecting how changes in climate affect biological systems. Example areas of interest include empirical and modeling aspects of transport processes related to chemical or organism dispersal, land use/land cover, ecosystem-climate feedbacks, assimilation of ecosystem or climate data into models, and mechanistic ecosystem modeling. Send applications to ecosci10@nd.edu.

The successful candidates are expected to contribute to our teaching program at the undergraduate and graduate levels. Positions include an attractive salary, competitive start-up package, and laboratory space tailored to the applicant's research needs. For additional information on departmental and other college faculty and facilities see <http://biology.nd.edu> and <http://www.nd.edu/~cegeos/>. Opportunities also exist for collaboration with faculty in other University departments, especially chemistry and biochemistry, physics, and applied and computational mathematics and statistics. Review of applications will continue until suitable candidates are identified. Qualified individuals should send to the email addresses above in PDF format a cover letter, curriculum vitae, separate statements of research and teaching interests, and have three letters of reference sent. To be considered for both positions, apply to one and indicate your interest in the other in your cover letter. The search committee is listed here: <http://aquacon.nd.edu/funding-opportunities/OpenFacultySearch.shtml>.

The University of Notre Dame, an international Catholic research university, is an equal opportunity employer.

POST DOCTORAL POSITION, ENERGY SCIENCE SCHOOL OF EARTH SCIENCES THE COLLEGE OF ARTS AND SCIENCES THE OHIO STATE UNIVERSITY

The School of Earth Sciences at The Ohio State University (OSU) invites applications from outstanding individuals for a post doctoral position with the principal emphasis on gaining a fundamental understanding of subsurface processes relevant to various Energy Science applications, including but not limited to CO₂ sequestration, oil and gas formation and migration, gas shales and Enhanced Geothermal Systems. The research will involve field based studies coupled with analytical characterization, bench-scale experiments and modeling. Candidates preferably will have experience in one or more of the following: physical and chemical characterization of rock materials, experimental water-rock interaction, and analytical elemental and isotope geochemistry. Experience with modeling flow, transport and geochemical/ geomechanical processes will be a plus. Candidates must have a Ph.D. in geology, chemistry, geochemistry or a related field at the time of the appointment. This will be a one-year appointment with possibility of renewal. Applicants should send curriculum vitae, description of research interests, and contact information for at least three references to Prof. David R. Cole, 275 Mendenhall Laboratory, 125 South Oval Mall, School of Earth Sciences, The Ohio State University, Columbus, OH 43210-1398 (cole.618@osu.edu). We will begin reviewing submissions immediately and will continue to do so until the position is filled. Information about the School of Earth Sciences can be found at www.earthsciences.osu.edu.

To build a diverse workforce Ohio State encourages applications from individuals with disabilities, minorities, veterans and women. EEO/AA employer. Flexible work options are available. Ohio State is an NSF Advance institution.

**ENDOWED CHAIR
ENVIRONMENTAL SCIENCE DISCIPLINE
COLLEGE OF SCIENCES AND HUMANITIES
BALL STATE UNIVERSITY, MUNCIE, INDIANA**

Tenured, full-professor position as Endowed Chair available 19 Aug. 2011, for a five-year renewable term. Responsibilities: implement and direct an incipient Environmental Science Ph.D. program within the college; conduct an active and extensive externally funded research program in environmental science or related field applicable to the Midwestern U.S.; promote and expand current interdisciplinary research and grant procurement activity among existing environmental science faculty; teach two courses per year in the successful candidate's discipline or as required by the Ph.D. program; advise graduate students. Minimum qualifications: earned doctorate in environmental science, biology, chemistry, geology, natural resources, or closely related field; demonstrated record of interdisciplinary scholarly activity in environmental science; possess at least ten years of professional experience related to the science discipline of which five must be academic; demonstrated record of successful extramural funding in support of research; strong record of research refereed publications; demonstrated record of interdisciplinary scholarly activity in environmental science; demonstrated ability to teach graduate and undergraduate students. Preferred qualifications: demonstrated record of leadership in interdisciplinary environmental science academic or professional programs; extensive and ongoing record of external grant submission and procurement; extensive and ongoing record of scientific publication; demonstrated high quality teaching.

Send cover letter, curriculum vitae, undergraduate and graduate transcripts, names and contact information for three individuals who can provide recommendations, and copies of pertinent publications and teaching evaluations to Dr. Thomas Lauer, Search Committee Chair, Dept. of Biology, Ball State University, Muncie, IN 47306. Review of applications will begin immediately and will continue until the position is filled (www.bsu.edu).

The College of Sciences and Humanities seeks to attract an active, culturally and academically diverse faculty of the highest caliber. Ball State University is an equal opportunity, affirmative action employer and is strongly and actively committed to diversity within its community.

**ASSISTANT PROFESSOR
ENVIRONMENTAL SCIENCE DISCIPLINE
COLLEGE OF SCIENCES AND HUMANITIES
BALL STATE UNIVERSITY, MUNCIE, INDIANA**

Tenure-track faculty position available 19 Aug. 2011. Responsibilities: teach two courses/semester in discipline or as required by the Ph.D. program in Environmental Science; have and maintain an active research program in environmental science or related fields applicable to the Midwestern U.S.; collaborate and participate with existing environmental science faculty to expand research activities within the college; actively procure external funding; produce refereed research publications; participate in service functions. Successful applicant will be appointed in one of the departments of biology, chemistry, or geological sciences within the college. Minimum qualifications: earned doctorate in biology, chemistry, geological science or closely related environmental science fields; more than one year of post-doctoral experience related to the science discipline. Areas of expertise may include some combination of geological science, biology, chemistry, environmental science, or related field. Preferred qualifications: a record of extramural proposal submissions; evidence of extramural grant acquisition; strong record of refereed research publications; demonstrated ability to teach graduate and undergraduate students; research interests that complement existing environmental science faculty.

Send electronically in PDF format: cover letter, curriculum vitae, statement of teaching and research interests and goals, transcript of highest degree earned, contact information for at least three professional references, and copies of representative publications and teaching evaluations related to environmental science to Dr. Jeffrey D. Grigsby, Search Committee Chairperson, at jgrigsby@bsu.edu. Review of applications will begin immediately and will continue until the position is filled (www.bsu.edu).

The College of Sciences and Humanities seeks to attract an active, culturally and academically diverse faculty of the highest caliber. Ball State University is an equal opportunity, affirmative action employer and is strongly and actively committed to diversity within its community.

**ASSISTANT PROFESSOR, GEOMICROBIOLOGY
STATE UNIVERSITY OF NEW YORK-BINGHAMTON**

Binghamton University seeks applications for a tenure-track assistant professor in the area of geomicrobiology. We seek exceptional candidates whose research is focused on microbial influences on the Earth's biosphere, atmosphere, hydrosphere and solid Earth, past and present. Areas of interest include but are not limited to microbial processes affecting cycling of elements (carbon, sulfur); long-term preservation of biomaterials and biomarkers; origin and evolution of microbial life on Earth, and extreme environments on Earth and beyond.

The successful candidate must develop and sustain an internationally recognized, externally funded research program in geomicrobiology. We also expect the candidate to develop a strong record of teaching and mentoring students and teach undergraduate and graduate courses in geobiology and other topics in his/her area of expertise. We are seeking candidates who will strengthen existing research programs in geochemistry and Earth surface processes with the potential to interact with geologists, biologists and environmental scientists on the Binghamton University campus.

Candidates must have a Ph.D. with a focus in geomicrobiology, or a related field, at the time of appointment, and should send a letter of application, curriculum vitae, statements of research and teaching interests, and names and contact information of at least three references by email to cslavets@binghamton.edu, or by mail to Search Committee, Dept. of Geological Sciences and Environmental Studies, State University of New York at Binghamton, Binghamton New York 13902. For further information about the position, visit the Geological Sciences and Environmental Studies website (www.geology.binghamton.edu) or contact Professor Tim Lowenstein by e-mail: lowenst@binghamton.edu.

Women and minorities are encouraged to apply. Binghamton University is an equal opportunity/affirmative action employer. Applications will be considered until the position is filled, but priority will be given to those received by 15 Jan. 2011.

**ENERGY SCIENCE, SCHOOL OF EARTH SCIENCES
COLLEGE OF THE ARTS AND SCIENCES
THE OHIO STATE UNIVERSITY**

The School of Earth Sciences at The Ohio State University (OSU) invites applications for a newly established tenure-track position in Energy Science—broadly defined. We are seeking applicants with a doctoral degree and research interests who will address fundamental problems directly relating to energy in the drillable subsurface. Potential applicants will have interests in one, or several topical areas such as unconventional hydrocarbon resources, carbon chemistry, energy recovery and storage or geomechanical impacts on energy extraction processes. The candidate will have advanced capabilities in at least some of the following areas: (1) mathematical modeling of physical, chemical and biochemical transformations of carbon in the subsurface; (2) oil and gas formation/migration; (3) carbon migration; (4) mechanical properties of rocks (fracture modeling) in relation to reservoir development; (5) thermodynamics; (6) reflection seismology; or (7) energy systems in basin analysis. We expect that this individual will develop strong collaborative links and funding opportunities with industries concerned with problems of the subsurface in addition to federal agencies.

The successful applicant is expected to have a developing record of research achievement through publications and external funding. Applicants from industry with such a track record of excellence are encouraged to apply. The new faculty member will be expected to contribute to the development, teaching, and enhancement of our education program in energy at the graduate and undergraduate levels. The new hire is expected to develop an independent research program in the area of energy science, and to generate external funds at a level that is appropriate for maintaining a research program at a major academic institution. We expect a strong effort to foster interactions with energy-related companies and to develop student opportunities in the energy area.

Applicants should submit a letter of application, curriculum vitae, and a statement of research interests and teaching philosophy. Candidates should arrange for three letters of recommendation to be sent under separate cover by the candidate's referees. Applications and letters should be sent to Professor Frank W. Schwartz,

275 Mendenhall Laboratory, 125 South Oval Mall, School of Earth Sciences, The Ohio State University, Columbus, OH, 43210. The anticipated start date for the position is 1 Oct. 2011. The position is open until filled. Information about the School of Earth Sciences can be found at www.earthsciences.osu.edu.

To build a diverse workforce Ohio State encourages applications from individuals with disabilities, minorities, veterans and women. EEO/AA employer. Ohio State is an NSF Advance institution.

**STRUCTURAL GEOLOGY
ASSISTANT PROFESSOR, STRUCTURAL GEOLOGY
WAYNE STATE UNIVERSITY**

The Dept. of Geology at Wayne State University invites applications for a tenure-track opening for a Structural Geologist/Geophysicist at the rank of assistant professor beginning in Aug. 2011. The successful candidate must demonstrate effective communication and teaching skills, and will be expected to develop a strong externally funded research program. Experience teaching structural geology with a solid field component, introductory geology courses and/or geophysics is highly desirable. We are interested in candidates with a solid background in structural geology or geophysics who are well acquainted with field methods. Preference will be given to candidates who are also able to integrate environmental issues into their research and teaching, and mentor graduate and undergraduate students in geology and environmental science.

Wayne State University is a large, nationally ranked research institution that offers state-of-the-art research facilities and highly competitive start-up packages. WSU is located in midtown Detroit, which enjoys vibrant cultural and educational amenities amidst the rich natural environment of the Great Lakes. Wayne State is also ideally situated to explore the multifaceted legacy of environmental concerns common to post-industrial urban regions.

Applicants must have a Ph.D. degree in geology or a closely related field and an outstanding record of research achievement. Post-doctoral experience is highly desired. All positions are posted online at jobs.wayne.edu. In addition to submitting an online application that includes cover letter and curriculum vitae, applicants must include a 2-page statement of their research interests and have three letters of reference e-mailed to ad5348@wayne.edu or mailed to Faculty Search Committee (Attn.: Louise Dezur), c/o Dept. of Geology, 4841 Cass Avenue, Wayne State University, Detroit, MI 48201. Review of complete application packages will begin 17 Jan. 2011.

Wayne State University is an affirmative action/equal opportunity employer.

Women and members of minority groups are especially encouraged to apply.

**POSTDOC
STABLE ISOTOPE/ORGANIC GEOCHEMISTRY
INDIANA UNIVERSITY-PURDUE UNIVERSITY
AT INDIANAPOLIS**

As part of a DOE funded study of the bacterial deep biosphere, including CO₂ injection sites, we seek a person with experience in stable isotope geochemistry and, preferably, compound-specific analysis of biomarkers via GC-MS. Interested individuals should submit a cover letter, c.v. and contact information for three references by e-mail to Kevin Mandernack (kevinman@iupui.edu), Chair of Earth Sciences, Indiana University-Purdue University at Indianapolis.

**VISITING ASSISTANT PROFESSOR
PALEONTOLOGY, OBERLIN COLLEGE**

The Dept. of Geology at Oberlin College seeks to fill a full-time, non-continuing opening in paleontology for a one-year term beginning 1 July 2011. Candidates must have the Ph.D. degree (in hand or expected by Sept. 2011) and interest in undergraduate teaching. Send letter of application, curriculum vitae, graduate academic transcripts, and three letters of recommendation to Karla Hubbard, Chair, Dept. of Geology, Oberlin College, Oberlin, Ohio 44074, Fax: 440 775 8038 (karla.hubbard@oberlin.edu) by 11 Feb. 2011. Materials received after the deadline will be considered until the position is filled. Salary will depend on qualifications and experience. For additional information please see http://new.oberlin.edu/home/jobs/jobs_detail.dot?id=2642668.

**NON-TENURE TRACK ASSISTANT OR ASSOCIATE
SPECIALIST (COLLECTION MANAGER)
KU BIODIVERSITY INSTITUTE**

The KU Biodiversity Institute seeks a full time, non-tenure track, assistant or associate specialist (collection manager) to oversee its world-class collections

of invertebrate fossils. Required qualifications include master's degree in museum studies, geology, systematics, or paleontology, five years experience in museum collections, knowledge of invertebrate fossil taxonomy and identification, knowledge of care and management of natural history collections, and familiarity with biodiversity informatics. Those with a bachelor's in museum studies, who can demonstrate thorough training in invertebrate paleontology collection management, may waive the required five years of experience. For additional information and complete application instructions please visit <https://jobs.ku.edu>, position #00005310. Review begins 1 Feb. 2011. EO/AA.

STRUCTURAL GEOLOGY, MARSHALL UNIVERSITY

The Geology Dept. at Marshall University is seeking to fill a tenure-track position at the Assistant Professor level for the 2011–2012 academic year. A Ph.D. is required at the time of appointment. Primary responsibility is teaching undergraduate courses in structural geology, geologic mapping, and computer methods as well as introductory labs and lectures in physical geology. Additionally, ability to develop and teach an upper-level undergraduate class in geophysics is desirable. Normal teaching load is 12 hours per semester; however, release time equivalent to 3 contact hours per semester will be given in the first three years to establish an independently supported research program of high quality in the person's area of expertise. A field-oriented approach to teaching and research is desirable and commitment to undergraduate research is a must. The department also seeks candidates who will contribute to the University's general education curriculum with its emphasis on a common First-Year Seminar and core curriculum courses that enhance students' critical thinking, and the College's support of interdisciplinary programs of study. For more information, please visit www.marshall.edu/geology

All candidates must send: (1) a current curriculum vitae; (2) statement of research plan; (3) statement of teaching philosophy; and (4) contact information for three references. Candidates must have official transcripts submitted (undergraduate and graduate) prior to interviewing on campus. Preferably, applications should be submitted electronically to niemann@marshall.edu as single PDF file, but may also be mailed to Geology Search Committee, Dept. of Geology, One John Marshall Drive, Marshall University, and Huntington, WV 25755.

Review of applications will begin on 7 Jan. 2011 and continue until the position is filled. Marshall University is the recipient of an NSF ADVANCE grant and the U. S. Labor department's EVE Award for its Affirmative Action Employment Opportunity Programs. Potential applicants may visit www.marshall.edu/mu-advance/candidates.asp for additional information about Marshall University and Huntington.

ASSISTANT PROFESSOR TENURE TRACK AND POST-DOCTORAL POSITIONS INSTITUTE OF GEOLOGY NATIONAL AUTONOMOUS UNIVERSITY OF MEXICO

The Institute of Geology UNAM offers two tenure-track Assistant Professor positions 05/11, and two post-doctoral positions 09/11. We seek earth scientists in metamorphic petrology, urban geology/landscape research, fluvial geomorphology, basin analysis and petroleum geology, or soil sciences/organic geochemistry. Expectations include research, teaching, student advisement, and continuing professional development.

With the highest admission standards of any university in Mexico, UNAM offers quality education, a diverse international faculty community, and high standards in research facilities. Applicants must submit a copy of Ph.D. degree, CV, two page letter describing research interest, name and e-mails of three referees. Application or more information to dirigl@unam.mx, academicai@geologia.unam.mx.

Websites: www.geologia.unam.mx, www.unam.mx.

FACULTY OPENING, GEOSCIENCES RESEARCH ASSISTANT PROFESSOR UNIVERSITY OF NEVADA-RENO

The Nevada Bureau of Mines and Geology (NBMG), University of Nevada-Reno (UNR), seeks applicants for a tenure-track, Research Assistant Professor faculty position beginning on or after 1 July 2011, with skills in state-of-the-art techniques in any one of the following areas:

- Quaternary geology, geomorphology, and neotectonics (incorporating geologic mapping in applications related to hazards, engineering geology, or environmental geology);
- Hydrogeology, particularly involving modeling of fluid flow in fractured rocks utilizing information from

detailed geologic mapping, geophysical observations, and drill-hole data; and

- 3D modeling that integrates geophysical and geological observations and interpretations (from a background in either structural geology or geophysics, but with a clear understanding of both).

Doctoral research must be in geology or a related geoscience field. Nevada is one of the most exciting regions in the world to do research in the geosciences. Opportunities abound for research on earthquake, flood, and ground-stability hazards; water flow in fractured rocks related to potable groundwater, geothermal systems, and mineral deposits; and detailed geologic mapping in support of fundamental understanding of Nevada's geological history and 3D framework. An additional tenure-track faculty position is open in the areas of economic geology and geothermal systems. For complete position descriptions and requirements, view the position announcements at www.nbm.unr.edu and <http://jobs.unr.edu/> or contact Geoscience Search, NBMG, Mail Stop 0178, UNR, Reno, NV 89557-0178. Applications received through <http://jobs.unr.edu/> by 31 Jan. 2011 will receive full consideration. EEO/AA. Women and members of underrepresented groups are encouraged to apply.

STABLE ISOTOPE GEOCHEMISTRY AND MASS SPECTROMETRY, UNIVERSITY OF PITTSBURGH

FY2011; Position number: 0003114.

Academic rank: Assistant/Associate Professor Level – Tenure Stream.

Specialization: Stable Isotopic geochemistry and mass spectrometry.

The Dept. of Geology and Planetary Science at the University of Pittsburgh (www.geology.pitt.edu) invites applications for a tenure-track faculty position in stable isotope geochemistry at the advanced assistant or associate professor level. The position would begin with the fall term 2011, subject to budgetary approval. We seek an outstanding individual whose research program includes a strong field component, and who has expertise in light stable isotope mass spectrometry. A Ph.D. is required at the time of appointment.

The successful candidate will be expected to develop an active, externally funded research program, including supervision of M.S. and Ph.D. students and undergraduate research projects. Teaching duties will include undergraduate and graduate courses in isotope geochemistry and related fields. We seek someone who would complement one or more of our existing programs in environmental geology, geophysics and geochemistry, hydrology, paleoclimatology, soil science, and volcanology.

Applicants should submit to the Stable Isotope Geochemistry Mass Spectrometry Search Committee, Dept. of Geology and Planetary Science, 200 SRCC, University of Pittsburgh, Pittsburgh, PA, 15260, USA the following materials: CV (including past and current grant support); statements of research and teaching interests; copies of relevant publications; names and addresses of at least four references.

Application deadline: 15 Jan. 2011.

The University of Pittsburgh is an equal opportunity/affirmative action employer. Applications from women and members of minority groups are especially encouraged.

STRUCTURAL GEOLOGIST UNIVERSITY OF PITTSBURGH

FY2011; Position No. 0002036.

Academic rank: Assistant Professor level – Tenure Stream.

Specialization: Structural Geology/Tectonics.

The Dept. of Geology and Planetary Science (www.geology.pitt.edu) at the University of Pittsburgh invites applications for a tenure-track faculty position in structural geology/tectonics at the assistant professor level. The position would begin with the fall term 2011, subject to budgetary approval. We seek an outstanding individual whose research program includes strong field, laboratory component, and/or modeling components, with a particular emphasis in one or more of the following areas: structural analysis, plate tectonic interactions, planetary geodynamics, and/or volcano-tectonics. A Ph.D. is required at the time of appointment.

The successful candidate will be expected to have and/or develop an active, externally funded research program, including the supervision of M.S. and Ph.D. students and undergraduate research projects. Teaching duties will include undergraduate and graduate courses in structural geology and topics related to the individual's expertise. We seek dynamic individual who would complement one or more of our existing programs in geophysics/paleomagnetism, tectonics, planetary science, regional tectonics, volcanology, and

remote sensing. Further information can be found on the department's website at www.geology.pitt.edu.

Applicants should submit to the Structural Geology Search Committee, Dept. of Geology and Planetary Science, 200 SRCC, University of Pittsburgh, Pittsburgh, PA, 15260, USA the following materials: CV (including past and current grant support); Statements of research and teaching interests; Copies of relevant publications; Names and addresses of at least four references.

Application deadline: 15 Jan. 2011.

The University of Pittsburgh is an equal opportunity/affirmative action employer. Applications from women and members of minority groups are especially encouraged.

Opportunities for Students

Graduate Student Fellowships. The Dept. of Earth Sciences at Indiana University–Purdue University at Indianapolis (IUPUI) is offering competitive fellowships to graduate students as part of our new Ph.D. program in Applied Earth Sciences. This novel and multidisciplinary program embraces an Earth Systems approach with particular emphasis in environmental, hydrological and human health issues broadly related to the Earth Sciences. Students can find more information and application instructions, respectively, at www.earthsciences.iupui.edu AND www.iupui.edu/~gradoff/admissions.

The Environmental Science Graduate Program at Iowa State University (www.ensci.iastate.edu/grad/homepage.html) is a dynamic, nationally ranked, multi-disciplinary program that emphasizes but is not limited to research at the interface of agriculture and the global environment. The faculty includes nationally recognized researchers working in the fields of agricultural engineering, agronomic sciences, biogeochemistry, climate studies, ecology, geology, limnology, marine science, and natural resource management. Program graduates, both MS and Ph.D., enjoy a >95% placement rate in careers as research scientists, university faculty, government advisors and technicians, and private consultants.

Several faculty are seeking M.S. and Ph.D. applicants for the Fall 2011 admissions cycle. Among others, research areas and recruiting faculty include:

- Environmental and biogeochemical control of cyanobacteria dominance (Ph.D., Dr. John Downing);
- Rhizosphere C and N cycling in maize agroecosystems using stable isotope approaches; position requires extensive lab and some field work (M.S., Drs. Kirsten Hofmocker & Michael Castellano);
- Re-suspension of *E. coli* from a sediment bed, development of equations to predict the process, and field experiments to test lab-derived re-suspension relationships (Ph.D., Dr. Michelle Soupir);
- Observing and modeling the land surface energy, water, and carbon balance in agroecosystems with applications to satellite remote sensing (Ph.D., Dr. Brian Hornbuckle);
- Groundwater hydrogeology, including modeling, geochemistry, water quality, and sustainability issues (M.S. & Ph.D., Dr. William Simpkins);
- Air quality and greenhouse gas emissions related to livestock production, novel chemical analysis of bio-renewable fuels, and analytical chemistry of grapes and/or wine (Ph.D., Dr. Jacek Koziel);
- Marine climate change, paleoclimate, and stable isotope geochemistry in biogenic archives (Ph.D., Dr. Alan Wanamaker);

Follow application instructions at www.ensci.iastate.edu/grad/homepage.html. For more information, please contact Charles R. Sauer, Program Coordinator, voice: +1-515-294-6518, fax: +1-515-294-1337, e-mail: ensci-gradoffice@iastate.edu; website: www.ensci.iastate.edu/grad/homepage.html.

Graduate Assistantships and Fellowships, University of Kentucky. The Dept. of Earth and Environmental Sciences at the University of Kentucky has assistantships and fellowships available for the 2011–12 academic year for M.S. and Ph.D. students. All awards include tuition and health insurance. The department has 7 regular faculty, 3 lecturers, and 12 adjunct faculty, including staff at the Kentucky Geological Survey and the Center for Applied Energy Research. Two new faculty members will join the department in Aug. 2011. Research specializations include geochemistry, geophysics, hydrogeology, igneous/metamorphic petrology, sedimentary geology, and tectonics. Facilities

include a newly expanded stable isotope laboratory, the Kentucky Seismic and Strong-Motion Network, instruments for potential field geophysics, electron microprobe and X-ray diffraction laboratories, and extensive library holdings. UK is located in Lexington, a vibrant community of 270,000. The surrounding area offers a wealth of outdoor and cultural opportunities. For more information, visit www.as.uky.edu/EES or contact Dr. Alan Fryar, Director of Graduate Studies (+1-859-257-4392 or alan.fryar@uky.edu).

Ph.D. Assistantship in Energy Science. The School of Earth Sciences of The Ohio State University invites applications from qualified students interested in pursuing graduate research in one of several possible Energy Science focus areas: geophysical and/or geochemical consequences of carbon sequestration in the subsurface; oil and gas formation and migration; unconventional hydrocarbons; thermodynamics and kinetics of water-rock interaction at diagenetic and hydrothermal conditions; physical and chemical rock properties at reservoir conditions; and application of isotopic and chemical tracers in monitoring subsurface processes. The research may involve field based studies coupled with bench-scale experiments and modeling. Interested students are encouraged to contact Prof. David R. Cole, School of Earth Sciences, The Ohio State University, Columbus, OH 43210-1398 (cole.618@osu.edu). For more information about the School of Earth Sciences, visit our website at www.earthsciences.osu.edu. Application forms can be obtained from <http://gradadmissions.osu.edu/>.

Geothermal Graduate Fellowship, Great Basin Center for Geothermal Energy, University of Nevada-Reno. Two Fellowships are available. The Fellowship award provides tuition support, health insurance, and an annual stipend of \$26,000 for living expenses for pursuit of full-time graduate study and thesis/dissertation research. The award is renewable for additional years, pending satisfactory progress. Support is limited to two years for MS students and four years for Ph.D. students. These awards will be highly competitive as we expect to fund only two students to begin studies in Fall 2011.

Criteria: The graduate fellowship stipend will be competitively awarded based on undergraduate preparation and GPA, GRE scores, and letters of recommendation provided with the application to graduate school at UNR. Applicants must be US citizens. The student

must be accepted into a graduate M.S. or Ph.D. degree program at UNR in the Dept. of Geological Sciences and Engineering, Graduate Program in Hydrological Sciences or one of the departments in the College of Engineering. In addition to all application materials required by the home department submitted directly to the department or the graduate school, the candidate will need to provide a personal essay describing career goals and a letter of recommendation from a UNR faculty member willing to supervise the candidate. The essay and faculty letter should outline a proposed thesis/dissertation project relevant to the discovery, production, or use of geothermal energy resources and should be forwarded directly to the Center for Geothermal Energy (geothermal@mines.unr.edu).

IMPORTANT NOTE: Departmental deadlines must be adhered to and typically occur prior to the deadline for this Fellowship. Make certain that departmental materials are submitted to your preferred graduate program prior to completing your geothermal fellowship application. Applications can be found at www.unr.edu/geothermal/GeothermalFellowship.htm

Graduate Fellowship materials are due to GBCGE on 1 March 2011.

The Jonathan O. Davis Scholarship supports graduate students working on the Quaternary geology of the Great Basin. The national scholarship is \$4,000 and the University of Nevada-Reno stipend is \$1,500. The national scholarship is open to graduate students enrolled in an M.S. or Ph.D. program at any university in the United States. The stipend is open to graduate students enrolled in an M.S. or Ph.D. program at the University of Nevada-Reno. Details on application requirements can be found at www.dri.edu/GradPrograms/Opportunities/JonathanDavis. Applications must be post-marked by 2 Feb. 2011. Proposal reviews will not be returned. Applications should be addressed to Executive Director, Division of Earth and Ecosystem Sciences, Desert Research Institute, 2215 Raggio Parkway, Reno NV, 89512.

Graduate Assistantships, Indiana State University. The Dept. of Earth & Environmental Systems at Indiana State University has graduate assistantships available for students wishing to pursue an MS degree in Earth and Quaternary Sciences or a Ph.D. in our new Spatial & Earth Sciences Program. The department offers a new and exciting field- and laboratory-intensive curriculum emphasizing environmental geology and geochemistry,

medical geology, geoarchaeology, surface processes, paleoecology, geobiology, dendrochronology, GIS/remote sensing, paleoceanography, marine geology, biogeochemistry, climatology, and paleoclimatology. The department supports a number of state-of-the-art laboratory facilities, and our faculty are committed to providing students with hands-on learning experiences. Application review begins immediately and preference is given to applications received before 1 Feb. 2011. Application forms can be obtained by visiting www.indstate.edu/ees. For more information contact Dr. Anthony Rathburn, Dept. of Earth & Environmental Systems, Indiana State University, Terre Haute, Indiana 47809, Tony.Rathburn@indstate.edu

Graduate Studies in Geological Sciences, The University of Delaware. The Dept. of Geological Sciences invites applications for M.S. and Ph.D. degree programs in Geology. Students have access to state-of-the-art field equipment and advanced laboratories. Fellowships, research assistantships, and teaching assistantships are available for qualified applicants. Student opportunities exist in research areas including hydrogeology, geomicrobiology, earth surface processes, coastal geology, sediment dynamics, quaternary geochronology, and subsurface geologic methods. Visit us on the Web at www.geosci.udel.edu/.

For additional information contact the Chair of Graduate Admissions, Dr. Art Trembanis, at art@gudel.edu. Applications for the Fall 2011 are due 15 Feb. 2011 and may be completed online at www.udel.edu/gradoffice/applicants.

Graduate Opportunities in the Earth Sciences: The Dept. of Marine, Earth and Atmospheric Sciences at NC State University invites applications from prospective MS and Ph.D. students in the Earth Sciences. The department provides a multi-disciplinary learning environment with core research programs in coastal margin evolution, geomorphology, geophysics, geoscience education, GIS modeling, chemical and physical hydrology, marine sediment transport, marine geochemistry, mid-ocean ridge processes, igneous petrology, structural geology, tectonics, and vertebrate paleontology. Financial support is available through a combination of research and teaching assistantships. Applications are invited from students with backgrounds in the physical and biological sciences, mathematics or engineering. The deadline for fall admissions is 15 Feb. 2011. For more information, please visit www.meas.ncsu.edu.

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CALL FOR SHORT COURSE PROPOSALS

Deadline: 1 February 2011

Share your unique knowledge and experience in our dynamic annual meeting setting.
Your peers, students, and earth science teachers will thank you.

Proposals can be submitted online at www.geosociety.org/meetings/2011/scProposals/.

Questions? Contact Jennifer Nocerino, +1-303-357-1036, jnocerino@geosociety.org.



Technical Session proposals accepted
through 11 January at
www.geosociety.org/meetings/2011/.



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Putting Partnership First: A Dialogue Model for Science and Risk Communication

Jen Schneider, *Div. of Liberal Arts and International Studies, Colorado School of Mines, Golden, Colorado 80401, USA, jjschnei@mines.edu*; **Roel Snieder**, *Dept. of Geophysics, Colorado School of Mines, Golden, Colorado 80401, USA, rsnieder@mines.edu*

In April 2010, the *New York Times* reported that Vattenfall AB, an energy company owned by the Swedish government, had built one of the first coal-fired power plants designed to capture ~90% of the CO₂ it produced, with plans to sequester that CO₂ underground in geologic repositories near its plant in Brandenburg, Germany (Voosen, 2010). By most measures, if the plant's operations were proven to be successful, it could have served as a model for other carbon capture and sequestration plants worldwide.

But we don't yet know if the Vattenfall experiment will work. Though the plant continues to capture almost all of its CO₂ emissions, it has not had an opportunity to sequester them underground—emissions are, instead, released into the atmosphere. The *New York Times* reports that this is because of “frightened, furious neighbors” who do not believe Vattenfall AB's claims that the CO₂ sequestration will be safe (Voosen, 2010). Citizens are primarily concerned about the risks of “induced seismicity”—the possibility of earthquakes or other seismic events created when the CO₂ is pumped into and stored in rock formations deep underground. Similar processes are used in the extraction of petroleum, natural gas, and geothermal energy.

What is most interesting in the Brandenburg case—and in others like it occurring throughout Europe (Deichmann and Giardini, 2009; Glanz, 2009a) and the U.S. states of Pennsylvania (Falchek, 2010; Zeller, 2010) and California (Glanz, 2009b; Harmon, 2009)—is not so much the possible occurrence of induced seismicity and related risks, but the interplay between concerned citizens, energy corporations, and the scientists and engineers who work for them. In a number of these cases, the “frightened, furious” public is skeptical of energy companies, and projects face increasing resistance. A familiar pattern of events typifies such cases: The scientific experts inform the public about the risks of the project, which the experts understand to be low. The public instead perceives such risks to be high, or is concerned with a separate set of risks, and thus opposes the project. The experts in turn shake their heads at the public's ignorance of technical and scientific matters. The

project proceeds. The public is outraged. The project is stalled and sometimes abandoned.

As a palliative to this “deficit model” of communication, risk communication scholars, along with those in environmental communication, science and technology studies, and other fields, now frequently argue that the best and most effective forms of risk communication involve meaningful partnerships and engagement with the public (Daniels and Walker, 2001; Guston and Sarewitz, 2006; Groffman et al., 2010). There may be lessons from this research for corporations like Vattenfall AB, and others, stemming from “best practices” in risk communication and public deliberation. These include (1) establishing real, long-term partnerships with communities and the affected public, either by involving them in deliberation or as stakeholders; (2) planning these partnerships carefully and with help from those experienced in partnership and deliberation, with a special emphasis on listening processes; (3) providing ample opportunities for feedback on the process itself; (4) maintaining flexibility in the process and outcomes; and (5) having a plan for evaluating the process so that it can be continually improved. These steps encourage scientists, engineers, and others to establish trusting relationships with the public, which takes time and coordination.

This is a very different model of expertise than the one scientists and engineers might be used to—which often falls back on calling for improved science education for the public—and it may require the acquisition of new skills, such as that of contextual listening (Leydens and Lucena, 2009; Lucena et al., 2010). What we are advocating is definitely not just a public-relations model, which we see put into operation in crisis situations, such as that in the recent oil spill in the Gulf of Mexico, and that, from the perspective of establishing open communication among government, industry, and the public, has not been effective. The emphasis must be on establishing real and significant relationships with those affected, not merely maintaining the perception of doing so.

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Manuscript received 16 Sept. 2010; accepted 22 Oct. 2010.

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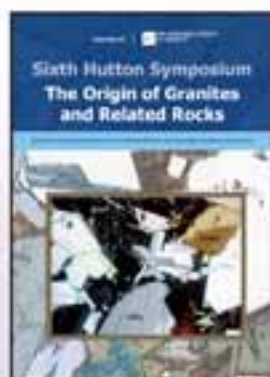
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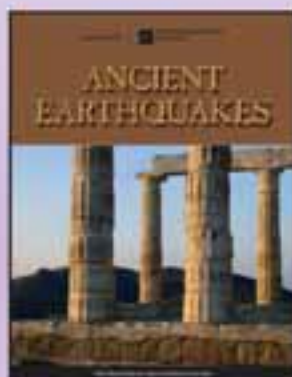
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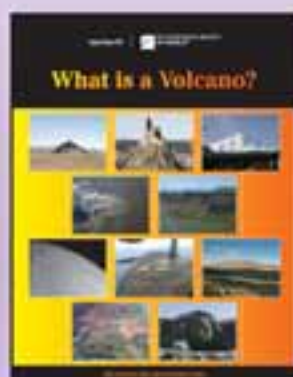
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