GSA TODAY

VOL. 15, No. 8 A PUBLICATION OF THE GEOLOGICAL SOCIETY OF AMERICA AUGUST 2005

Red rock and red planet diagenesis: Comparisons of Earth and Mars concretions

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VOLUME 15, NUMBER 8

AUGUST 2005

Cover: Accumulations of iron oxide concretions (~2–4 cm diameter) from the colorful Jurassic Navajo Sandstone near St. George, southwestern Utah. See "Red rock and red planet diagenesis: Comparisons of Earth and Mars concretions," by Chan et al., p. 4–10.

GSA TODAY

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GSA TODAY (ISSN 1052-5173 USPS 0456-530) is published 11 times per year, monthly, with a combined April/May issue, by The Geological Society of America, Inc., with offices at 3300 Penrose Place, Boulder, Colorado. Mailing address: P.O. Box 9140, Boulder, CO 80301-9140, USA. Periodicals postage paid at Boulder, Colorado, and at additional mailing offices. Postmaster: Send address changes to *GSA Today*, GSA Sales and Service, P.O. Box 9140, Boulder, CO 80301-9140.

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SCIENCE ARTICLE

Red rock and red planet diagenesis: Comparisons of Earth and Mars concretions

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ABSTRACT

Compelling similarities between concretions on Earth and "blueberries" on Mars are used to suggest the blueberries are concretions that formed from a history of watery diagenesis. In the terrestrial examples, groundwater flow produces variations in sandstone color and iron oxide concretions in the Jurassic Navajo Sandstone of Utah. Variations in concretion mineralogy, form, and structure reflect different conditions at chemical reaction fronts, the influence of preferential fluid flow paths, the relative roles of advection and diffusion during precipitation, the presence of multiple events, fluid geochemistry, and time. The terrestrial concretions are analogs that can be used to understand the water-saturated conditions that formed spherical hematite concretions on Mars.

Keywords: diagenesis, concretions, hematite, goethite, Mars, Navajo Sandstone.

INTRODUCTION

The dramatic red Mesozoic sandstones in the southwestern desert of the United States often evoke images of the red planet, Mars. Understanding the evolution of red rock diagenesis on Earth could provide insights on the geologic history of Mars. Some of the most intriguing discoveries from the 2004 National Aeronautics and Space Administration (NASA) Mars Exploration Rover (MER) *Opportunity* images were the abundant accumulations of spherical balls (<0.5 cm diameter) of hematite. These spherical forms were dubbed "blueberries" because their distribution in the host rock was similar to blueberries in a muffin (Squyres et al., 2004).

Similar spherical balls are common on Earth as concretions, and many resemble marbles in size and shape. Concretions are concentrated mineral masses of a minor component precipitated in pores of sediments and sedimentary rocks (e.g., Mozley, 2003). Although there is no perfect Earth analog for the unique sedimentary system discovered at Meridiani Planum (e.g., basaltic host rock, evaporite cements, pure hematite concretions; Squyres et al., 2004), the Navajo Sandstone in southern Utah contains some of the world's most abundant and diverse examples of spheroidal iron oxide concretions and can be used to evaluate complex diagenetic concretion-forming processes.

This paper builds on previous work (Chan et al., 2004; Ormö et al., 2004) to highlight how interpretation of the new detailed Mars data requires a solid knowledge of Earth analogs and processes. Interdisciplinary studies of sedimentology and diagenesis from the terrestrial realm can yield valuable insights for understanding planetary geology. Despite differences in host rock, water types, sources of iron, burial history, and fluid flow timing, diagenesis on both Mars and Earth led to the formation of spherical hematite concretions. We present our model of red rock diagenesis from Utah examples, compare remarkable forms between Earth and Mars, and discuss the implications of the terrestrial analog for understanding Mars.

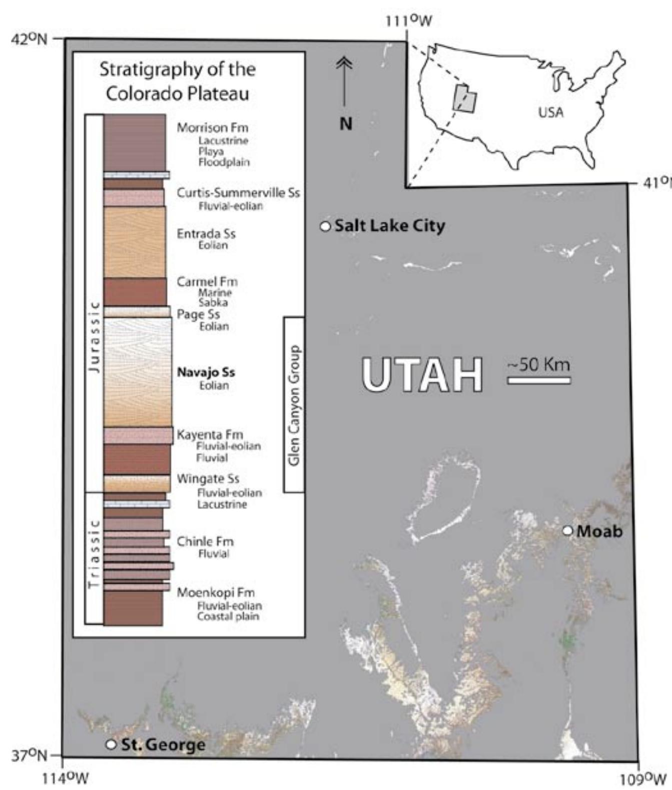

Figure 1. Locality map and stratigraphic section of southern Utah. Early Jurassic Glen Canyon Group (including the Navajo Sandstone) outcrops primarily exposed along Laramide uplifts. Outcrop color patterns from Landsat 7 ETM+ (bands 7, 4, 2) satellite imagery. Green indicates vegetation. Stratigraphic section shows typical outcrop colors.

GSA Today: v. 15, no. 8, doi: 10:1130/1052-5173(2005)015<4:RRARPD>2.0.CO;2

RED ROCK DIAGENESIS

The Lower Jurassic Navajo Sandstone is a well-exposed and widespread eolian unit in southern Utah (Fig. 1) with conspicuous color variations and a variety of iron oxide concretions. It is well known that sandstone color variations are due to different amounts of iron oxide (Cornell and Schwertmann, 2003), but the mechanisms of diagenesis and relationships to fluid flow and concretions have only recently been recognized (Chan et al., 2000; Chan and Parry, 2002; Beitler et al., 2003, 2005; Parry et al., 2004). Our studies of field relationships, petrography, geochemistry, mineralogy, and geochemical modeling provide the basis for analyzing fluid flow history within this system.

The Navajo Sandstone is one of the most porous and permeable units of the Colorado Plateau and therefore is a conduit for fluid movement, creating favorable conditions for the formation of concretions. The well-sorted, fine- to medium-grained eolian quartz arenite is composed of framework grains that are typically ~90% quartz, ~5% potassium feldspar, and ~5% clays and other accessory minerals (Beitler et al., 2005). Effective porosity averages ~17% (Cordova, 1978), and permeability can be up to 1 Darcy (Lindquist, 1988) with the coarser-grained grain flow laminae having higher permeabilities than the finer-grained and more clay-rich wind ripple laminae. Cement volumes typically comprise a few percent in unaltered Navajo Sandstone to as much as 35% in the concretions (Beitler et al., 2005). The conditions for formation of Utah concretions are interpreted to be diagenetic based on Navajo Sandstone burial estimates (Chan et al., 2004) and lack of high-temperature evidence or mineral assemblages.

Navajo Sandstone color variation and iron mineralization can be summarized as a three-step process of diagenetic stages involving groundwater flow, based on synthesis of material previously presented in several papers (e.g., Chan et al., 2000, 2004; Chan and Parry, 2002; Beitler et al., 2003; Parry et al., 2004).

1. *Iron source.* The source of iron is the initial breakdown of detrital Fe-bearing silicate minerals within the sandstone during interaction with meteoric waters. Thin iron oxide films coat individual sand grains shortly after deposition or during early burial (Berner, 1969). The thin hematite films typically comprise 0.18–1.25 wt% (Beitler et al., 2005) of the whole rock and impart a pink to orange-red color to the sandstone (Fig. 2A).
2. *Iron mobilization.* After burial and early cementation (e.g., calcite, quartz overgrowths), reducing fluids derived from underlying units move through the porous sandstone and remove the iron oxide films (Fig. 2B–C). The

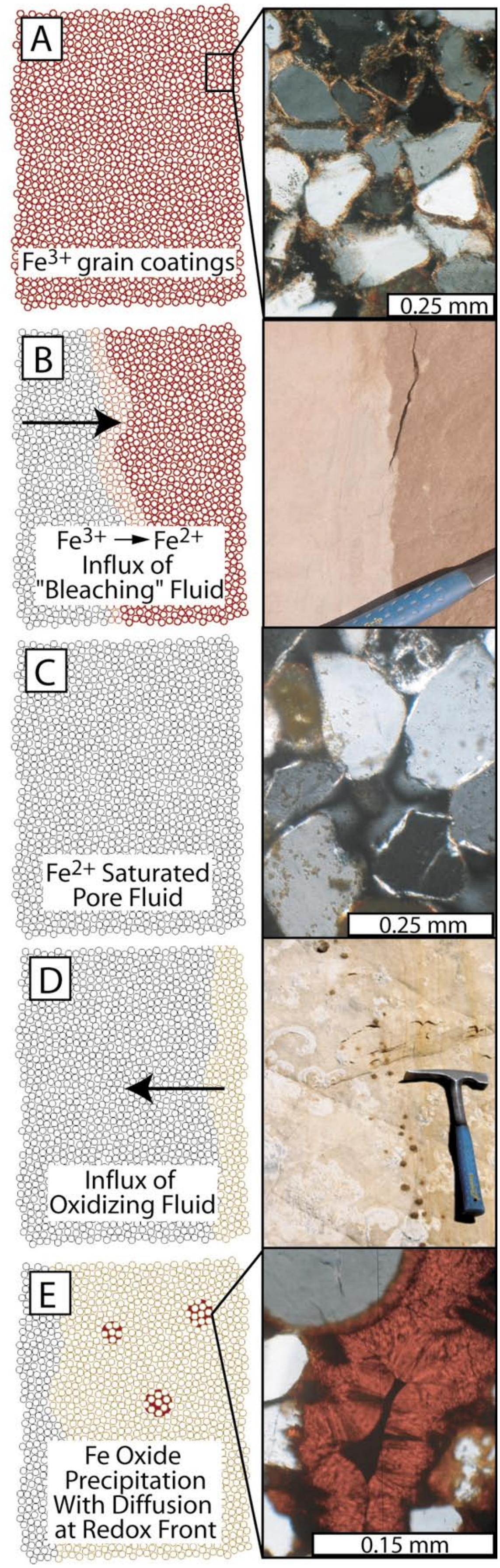

Figure 2. Grain scale model for terrestrial examples of Navajo Sandstone concretion formation. (A) Early hematite (Fe^{3+}) grain coatings; photomicrograph of hematite films around grains. (B) Influx of reducing fluids effectively "bleach" the buried sandstone. (C) Bleached sandstone pores are saturated with waters containing reduced iron (Fe^{2+}); photomicrograph of bleached sandstone lacking hematite grain coatings. (D) Influx of oxidizing groundwater creates redox front where concretions precipitate. (E) Concretions form along front with organized distribution and spherical shape; photomicrograph of cementing fibrous goethite crystals filling pore space to make the concretion.

reducing fluids effectively bleach the sandstone white, leaving <0.5 wt% iron oxide (Beitler et al., 2005). The reducing fluids may also reduce sulfate to sulfide and precipitate some of the iron as pyrite. Previous work on the Navajo Sandstone suggested that the reducing fluids are likely hydrocarbons (petroleum or methane) (Chan et al., 2000). Bleaching occurs on millimeter (Parry et al., 2004) to regional (Beitler et al., 2003) scales, reflecting the broad range of heterogeneities that can control fluid flow.

3. *Concretion precipitation.* Reducing fluids that carry the iron eventually mix with oxidizing groundwater (Fig. 2D–E). Under phreatic conditions where all the pores are saturated with the reducing fluid, diffusion at the interface between the oxidizing and reduced solution causes oxidation of iron and precipitation of concentrated hematite and/or goethite cements (von Gunten and Schneider, 1991). If pyrite is present, it would also oxidize to goethite at this stage. Many different shapes, such as bulbous nodules, pipes, sheets, and banding occur (Fig. 3), but the most common form along a reaction front is spheroidal. Dating of related mineralization (Chan et al., 2001) suggests that some precipitation occurred ca. 25 Ma, but mineralization commonly appears episodic, and some mineralization may be younger.

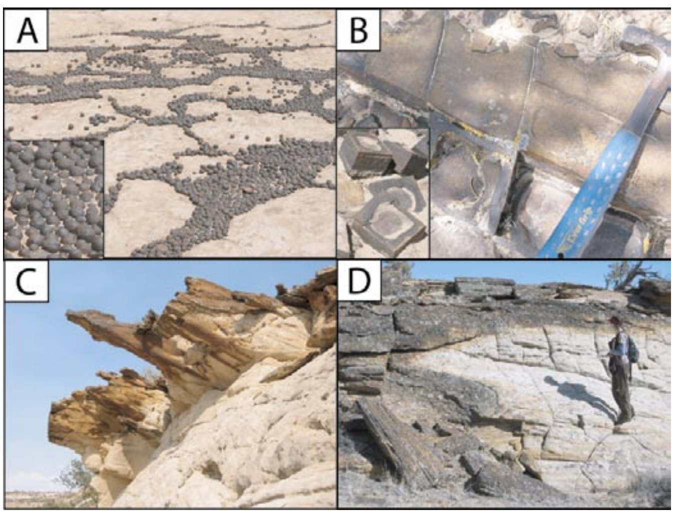

Figure 3. Diverse Utah concretionary forms due to different inherent host rock properties, anisotropies, and fluid flow characteristics. Concretion accumulations can act as geomorphic armor, protecting the underlying sandstone from erosion. (A) Spherical concretions (~3–5 cm diameter). (B) "Cinderblocks" from oxidizing fluids preferentially following horizontal stratification and vertical joint sets. (C) Subhorizontal pipes along bedding surface (pipes ~5 cm in diameter). (D) "Roll-front" type deposit.

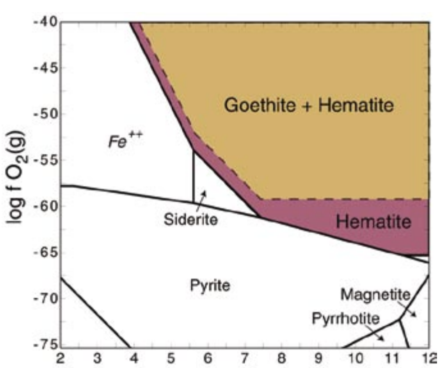

Figure 4. Phase diagram showing stability fields of iron oxides hematite and goethite at varying pH and fugacity of oxygen typical of Utah conditions where they form. Note that hematite and goethite occupy nearly identical areas due to similarity in free energy. Calculated at 50 °C, pressure = 1 atm, a[Fe^{2+}] = 10^{-5}, a[H_20] = 1, a[SO_4^{-2}] = $10^{-2.57}$, a[HCO_3^-] = $10^{-1.29}$, a[Ca^{+2}] = $10^{-2.04}$, a[Mg^{+2}] = $10^{-2.42}$, a[Na^+] = $10^{-1.18}$. Activity scale in units of molality (mol/Kg). Compiled with the Geochemist's Workbench (Bethke, 1998).

This diagenetic model of mixing fluids to precipitate concretions is similar to uranium roll-front models (e.g., Adler, 1974; discussion in Beitler et al., 2005) where uranium precipitates at chemical reaction mixing fronts. However, uranium precipitates under reducing conditions and is mobile under oxidizing conditions, the reverse of iron (Fig. 4). In the iron oxide model presented here, it is important to recognize this is an open chemical system with many complexities, including kinetic barriers, nucleation, mass transport, heterogeneities, and lack of equilibrium.

Concretion growth is affected by two important components of mass transfer: advection and diffusion. Advective flow is necessary to supply the required amounts of reactant iron and is indicated by oriented concretionary flow forms (Fig. 5). Iron is transported to the sites of concretion formation in water as reduced (ferrous) iron. The iron is precipitated by oxidation at a mixing front where the oxidant is transported to the site in a separate solution. There are

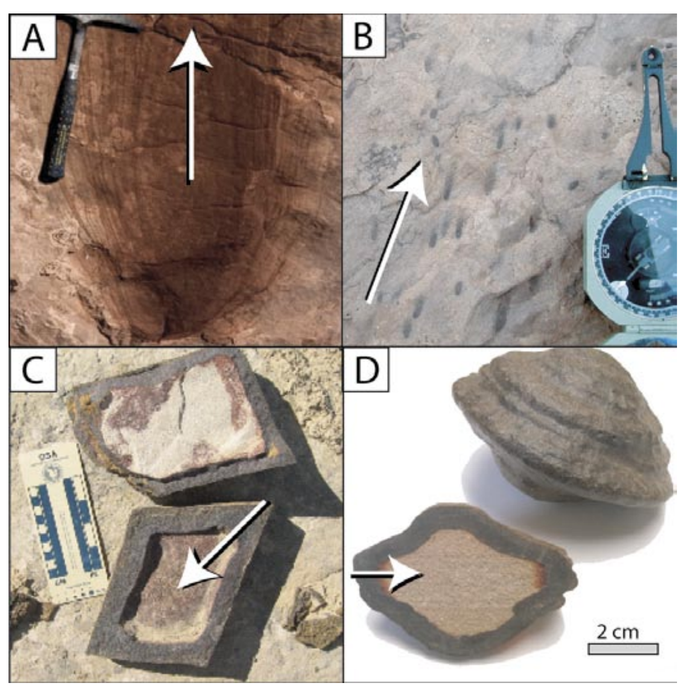

Figure 5. Flow patterns (arrows) indicated by preferential geometries in Navajo Sandstone concretions. (A–B) Advective flow indicated by strong asymmetric patterns. (C–D) Diffusive mass transfer indicated by inward directed patterns (left, along conjugate joints becoming less angular inward; right, "bleeding" along more permeable laminae).

insufficient amounts of iron and oxidant in a local volume of just the host rock alone to form an iron oxide concretion. Advection of reactants in two solutions is necessary.

Consider a spherical volume of porous rock 10 cm in diameter. If the water saturating the rock at 20% porosity contained 20 mg/kg Fe^{2+} (Parry et al., 2004) or 10 mg/kg O_2 (reasonable for air-saturated meteoric recharge water), the iron precipitate could amount to 3 mg of hematite or the O_2 could precipitate 10 mg of hematite. The amount of iron oxide in the Utah concretions exceeds this amount considerably. Therefore, both iron and oxygen must be supplied to the precipitation site advectively or by diffusion over large distances (several meters). Although advective mass transfer may be necessary for conditions that would support concretion growth, the spherical shapes and organized distribution suggests that diffusion of reactants from one solution to the other actually causes concretion precipitation (Berner, 1968, 1980).

UTAH-MARS SIMILARITIES

Hematite (Fe_2O_3) and iron oxide–hydroxide (e.g., goethite, FeOOH) nodules occur in a variety of geological settings and have a wide range of expressions, including pedogenic (Cescas et al., 1970; Schwertmann and Taylor, 1989; Stiles et al., 2001), oolitic (Van Houten and Bhattacharyya, 1982), and lakebed or seafloor nodules (Burns and Burns, 1975). Although a number of mechanisms can generate spherical shapes and iron oxide–rich nodules, the Utah concretions are consistent with more of the Mars blueberry characteristics and currently comprise a good analog for Mars blueberries for six reasons:

1. *Comparable hematite mineralogy.* X-ray diffraction and spectral analyses of Utah concretions show that different chemical reaction fronts from spatially distinct areas can have a range of compositional variations, including hematite and goethite (Chan et al., 2000; Beitler et al., 2005). The free energies of hematite and goethite are so close that either or both can precipitate (Majzlan et al., 2003) (Fig. 4). Iron solids typically precipitate at an oxic-anoxic boundary as polynuclear aggregates of Fe^{+3}

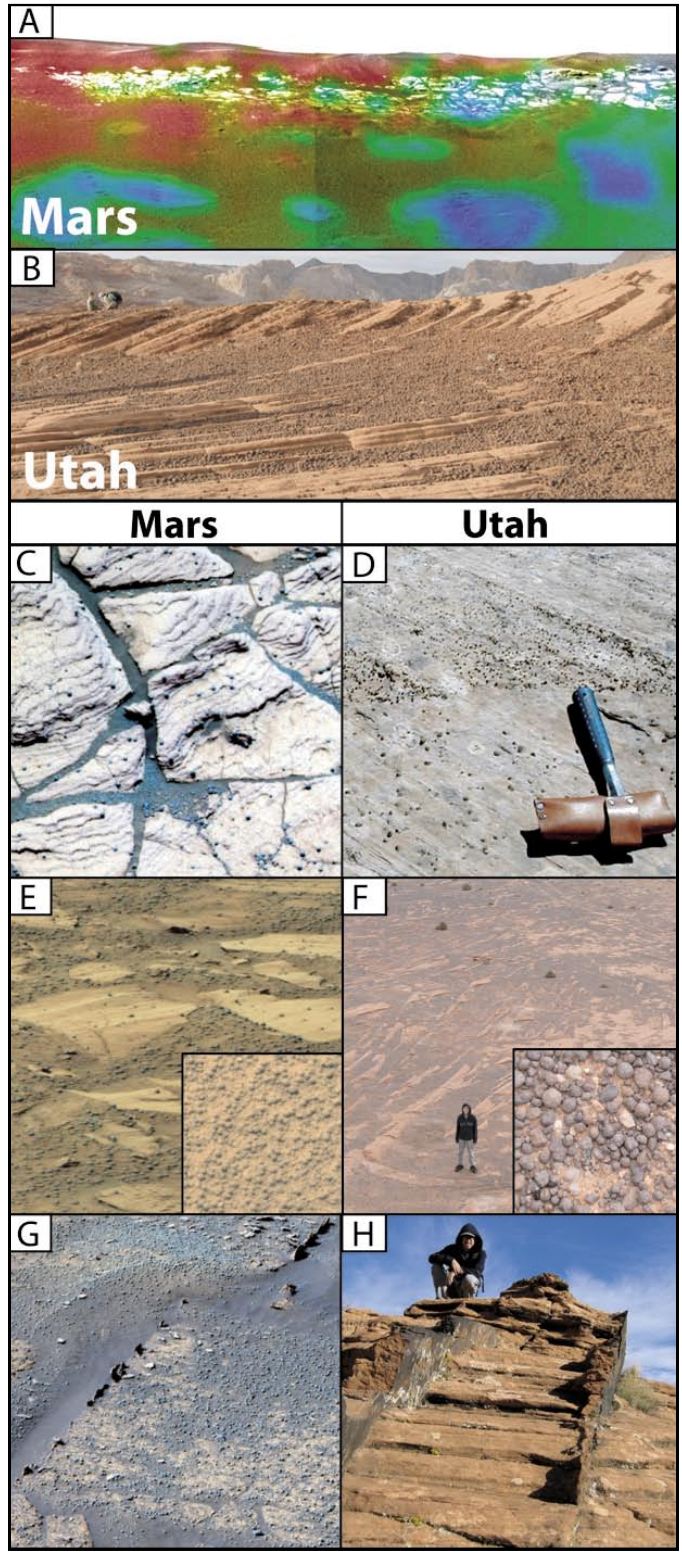

Figure 6. Comparisons of Mars and Utah examples. (A–B) Landscape scale. (C–D) In situ spherical concretions. (E–F) Weathered accumulations of spherical concretions. (G–H) Fracture-fill features. Mars examples (left) are compared with terrestrial images (right). (A) Mars Exploration Rover (MER) *Opportunity* panoramic view of Eagle Crater in Meridiani Planum region of Mars. Data from miniature thermal emission spectrometer superimposed on panoramic camera image. Superimposed colors indicate relative iron abundance: red and orange represent higher abundances than green and blue. Outcrop ledge (~1 m high) is relatively iron-poor, whereas accumulations of spherical objects ("blueberries") are iron-rich. Blue circular features in foreground show where the landing MER airbag bounced and buried the iron-rich spherical objects. Image credit: National Aeronautics and Space Administration (NASA)–Jet Propulsion Laboratory (JPL)–Arizona State University–Cornell. (B) Comparable Navajo Sandstone scene near St. George, Utah. Extensive bleached outcrop on the horizon, with weathered accumulation of iron oxide cemented spherical concretions (~2–4 cm diameter sizes) in the foreground. (C) False-color composite image of bedded "Shoemaker" outcrop in Eagle Crater, Mars. In situ spherical, iron-rich "blueberries" (~4 mm diameter) are embedded and regularly spaced within the sedimentary rock. Image credit: NASA–JPL–Cornell. (D) In situ Navajo Sandstone iron oxide concretions embedded within the sandstone at a similar spacing. Changes in permeability related to different types of eolian lamination commonly affect concretion spacing. (E) False color panoramic camera image in Endurance Crater, Mars. Inset shows weathered accumulation of spherical forms. Image credit: NASA–JPL–Cornell. (F) Navajo Sandstone plains covered by "blueberry"-sized iron oxide concretions, southwestern Utah. Inset shows weathered concretion accumulation (up to 1 cm diameter; most 3–6 mm diameter). (G) "Razorback" ridge that could be from diagenetic fracture fill in Endurance Crater, Mars. Feature is a few cm tall and <1 cm wide. Image credit: NASA–JPL–Cornell. (H) Iron oxide–cemented ridges from fluid flow along joint fractures in southwestern Utah.

hydroxides and ferrihydrite (Schwertmann and Fischer, 1973; von Gunten and Schneider, 1991). The original precipitate can convert to goethite, lepidocrocite, akaganeite, and finally to hematite (Berner, 1969). New studies suggest the Mars concretions were likely precipitated initially as goethite and dehydrated to hematite (Glotch et al., 2004; Tosca et al., 2005), similar to the Utah system. Mars hematite was suspected to be pure and crystalline based on spectral signatures (Christensen et al., 2001; Catling and Moore, 2003), which was confirmed by the distinctive six-peak hematite signature from in situ Mössbauer analysis at the *Opportunity* site (Klingelhöfer et al., 2004). Hematite concretions within the Navajo examples are typically fine-grained and red, in contrast to the pure, coarse-grained (gray) and crystalline concretions on Mars (Christensen et al., 2004; McLennan et al., 2005). The Utah concretions contain up to 35% iron oxide (Chan et al., 2000; Beitler et al., 2005), where nearly every mineral component is replaced by the hematite except for the very resistant quartz host grains. Similarly, the spherules in the "Berry Bowl" at the Eagle Crater, Meridiani, are reported to be replacive with up to 50% hematite and some remaining host rock component of basaltic mud and evaporite in the spherules (McLennan et al., 2005).

2. *Comparable size and self-organized in situ distribution.* The spherical forms in Utah and Meridiani have consistent and constrained size populations (Chan et al., 2004; McLennan et al., 2005). The distribution within the host rock is one of the key factors indicating that the Mars blueberries are concretions (Fig. 6). In nearly every other way that spherical terrestrial iron oxide nodules are generated (such as seafloor nodules, oolitic, or other), nodules would be clustered and touching, typically in a single bed. Instead, the concretion distribution suggests self-organization (Ortoleva, 1984, 1994) with a self-propagating, nearest-neighbor spacing. The Mars concretions appear to be contained within a specific geologic unit with consistent physical properties (Hynek et al., 2002). Although overall Navajo Sandstone spheroidal concretions range from mm-sized "blueberries" to >10 cm-sized "grapefruits," within any one reaction front population there is generally a consistent size. In general, small concretions are more closely spaced, and larger concretions are more widely spaced (Chan et al., 2004). The distribution of concretion sizes and their spacing is related to diffusion and density of nucleation sites. Thus, sparse large concretions form from a low number of nucleation sites, similar to textures in materials science and metamorphic porphyroblasts (e.g., Carlson et al., 1995).
3. *Comparable loose spherical forms in weathered accumulations.* Concretions are hard masses that are better cemented than the more easily weathered host rock and are collected in topographic lows because the round, loose marbles and blueberries can easily roll downhill (Fig. 6). The MER rock abrasion tool indicates the Mars blueberries are much more cemented than the surrounding host rock (Herkenhoff et al., 2004). Thus, the resistant balls collect on flat or topographically low places as a function of the weathering processes (e.g., eolian deflation lags) and inherent properties of the cementation (Soderblom et al., 2004). At the outcrop scale, iron oxides occur in relatively low amounts because the disseminated concretions are spread out within the host rock. Areas with higher iron oxide values occur where there are greater accumulations of concretions.

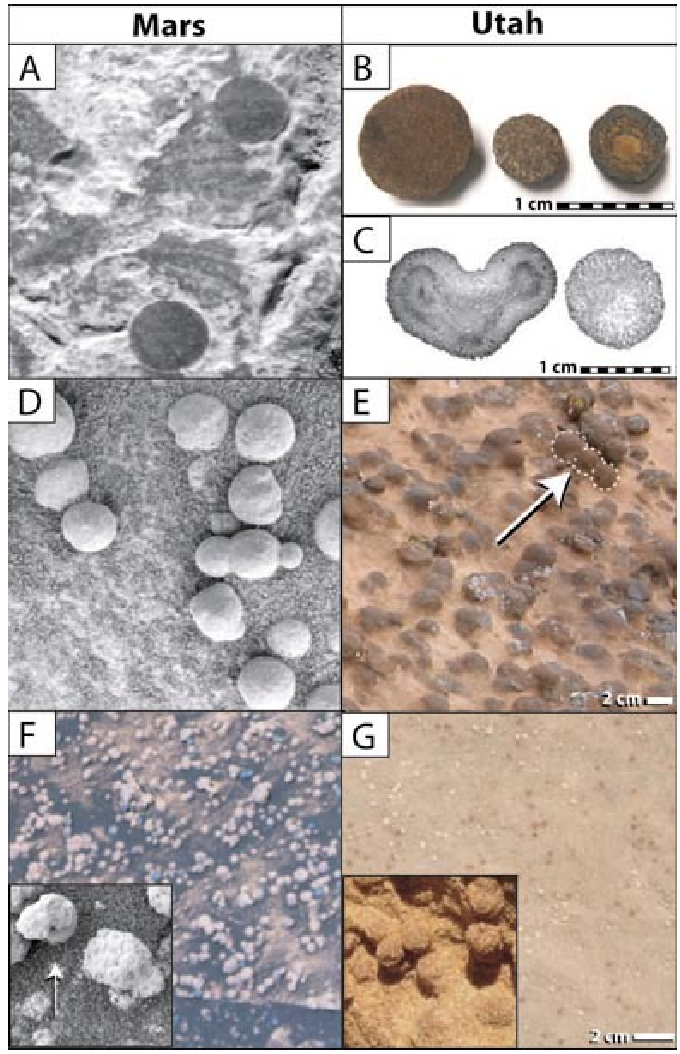

Figure 7. Comparison between internal structure and texture of Utah concretions and Mars "blueberries" (largest ones ~5 mm diameter). (A) Sliced Mars spherical forms showing relatively homogeneous internal structure. Image credit: National Aeronautics and Space Administration (NASA)–Jet Propulsion Laboratory (JPL)–Arizona State University–Cornell–U.S. Geological Survey (USGS). (B) Sliced (cross sectional) "blueberry"-sized Utah concretions showing relative homogeneous internal texture as well as concentric layered texture. (C) Microtomography displaying internal structure of Utah concretions. (D) Triplet of spherical forms from "Berry Bowl" in Eagle Crater, Mars. Image credit: NASA–JPL–Cornell–USGS. (E) Example of in situ concretion twins and triplets, Navajo Sandstone. (F) "Popcorn" texture coating associated with hematite-rich spherical forms in Endurance Crater, Mars. Image credit: NASA–JPL–Cornell. Inset: Detailed close-up showing hematite-rich spherical form embedded beneath the "popcorn" coating. Image credit: NASA–JPL–Cornell–USGS. (G) Weakly cemented Navajo concretions of both hematite (red) and carbonate (white) mineralogy. Inset: Weakly cemented terrestrial concretions with texture similar to Mars "popcorn."

4. *Comparable internal structure*. Although internal structures of other common concretions (e.g., carbonate) can show nuclei (Burns and Burns, 1975), the Utah Navajo Sandstone concretions and the Mars blueberries (Squyres et al., 2004) both lack an obvious macro nucleus (Fig. 7). An initial nucleus (such as a potassium feldspar or calcite grain in Utah sandstone) could be consumed in chemical reactions over time [e.g., H^+ consumption driving up pH to precipitate FeO(OH)] (Fig. 4). Many of the small, mm-sized terrestrial concretions typically show solid interiors, lacking obvious internal structure (Fig. 7B). The massive, solid interiors suggest fluid saturation and sufficient supply of the chemical reactants, balanced with the space for their growth (as opposed to outer rind types or "onion skin" types). With more time and perhaps multiple fluid-flow events, larger forms may grow. Within a given area and redox front, there can be thousands of small concretions. Some of the larger concretions typically exhibit layered internal structure, and some might have just one outer layer (from very thin, like an eggshell, to a thick rind) (Fig. 7B and 7C). Internal structure of the Utah concretions varies formation-wide, but is typically consistent within a specific reaction front population.
5. *Comparable geometric forms*. Both the Utah and Mars systems contain abundant spherical forms as well as some joined doublet and triplet forms (Fig. 7D and 7E). Where concretions nucleate in a homogeneous host rock by diffusive influx of solvents, the sphere is the most efficient (minimum free energy) form. In the Utah system, concretion size is at least partially a function of host rock properties. The spherical geometry and consistent size of the Mars concretions suggest the host rock is relatively homogeneous. The persistent occurrence of joined forms (e.g., doublets and triplets) can be attributed to nucleation phenomena, merging growth of adjacent spheres, or clustering as the diagenetic fluids move through the host rock. Navajo concretion triplets can form in a line or at angles (Fig. 7C and 7E). It is clear that variations in porosity and permeability have a strong influence on the formation of concretions (Seilacher, 2001). If anisotropies are present, mineralizing fluids tend to move preferentially along the paths with highest permeability (e.g., Mozley and Davis, 1996). Anisotropy of individual lamina can affect the fluid flow, and thus the spherical concretions may have a ridge-like feature around the periphery (Fig. 5D). Preferential cementation can occur as joint or fracture-fill as these provide conduits for migrating fluids. Cements precipitated along these pathways (whether iron oxide or other mineralogy) weather out as resistant "fins," akin to the dubbed "Razorback" recognized on Mars (Fig. 6G and 6H).
6. *Comparable variations in cementation.* Variations in cementation within the Mars system have created rough-texture forms dubbed "popcorn" by the MER team (McLennan et al., 2005). "Popcorn" concretions with a rough outer surface occur in the Utah analog where the concretion has a relatively low amount of cement and sometimes can show multiple diagenetic stages. In other words, "popcorn" may be a concretion form in which the iron oxide cement is only a few wt% versus more densely cemented concretions (Fig. 7F and 7G). "Popcorn" forms may have a hematite core, with more roughly textured portions of the concretions on the outside that can be interpreted as multiple cement generations (McLennan et al., 2005) and similarly can form in terrestrial examples.

COMPLEXITIES OF CONCRETION SYSTEM

There are clearly differences between Utah and Mars concretions. The Navajo concretions precipitate in a relatively chemically inert quartz arenite, where it is fairly straightforward to identify diagenetic mineralogy within the host rock pores. In the Meridiani environment, the host rock is more labile and potentially more involved in supplying the reactants for concretion formation (e.g., Catling, 2004; Clark et al., 2005; McLennan et al., 2005; Tosca et al., 2005). We infer that the Mars spherical forms are concretions that may have formed from mixing of an aqueous fluid that contained iron in solution and a separate oxidizing groundwater that precipitated hematite.

Occurrences of concretions in the Navajo Sandstone span many tens of kilometers, with variable conditions, expressions, and chemical reaction fronts, which all contribute to the diversity of forms. The Utah examples contain many shapes and sizes in comparison to Mars because (1) different tectonics, local porosity variations, and multiple fluid events have a notable effect; and (2) the *Opportunity* rover has traversed smaller areas and distances to date. The strength of the Utah examples in interpreting the Mars concretions is that the variability in the terrestrial system helps us to determine how different parameters affect the resulting concretions, and this in turn can help us isolate which parameters likely prevailed in concretion formation on Mars.

SUMMARY

Utah marble iron oxide concretions provide a valuable analog to help interpret spherical hematite blueberries on Mars. Although the singular aspect of the spherical geometry alone can be compared to a wide range of possible geologic Earth analogs where iron oxide occurs in nodular forms, the concretion model shows the most compelling comparisons to Mars. Both terrestrial marbles and Mars blueberries preserve a valuable stage of the diagenetic history that might not otherwise be present in the more extensive host rock. Variations on the terrestrial models help isolate potential controls on the processes, and these differences may be useful in distinguishing how and why the Mars blueberries are unique.

ACKNOWLEDGMENTS

We thank Gerry Ross, Laura Crossey, Scott McLennan, and Peter Mozley for their reviews and input on this manuscript. We thank Anthony Park of Sienna Geodynamics and Consulting Inc. for graphical contributions. We gratefully acknowledge donors to the American Chemical Society Petroleum Research Fund and the Bureau of Land Management Grand Staircase–Escalante National Monument for partial support of this research (to M.A.C. and W.T.P.). We acknowledge the successful efforts of the National Aeronautics and Space Administration Mars Exploration Rover

team; their images provide the basis for comparing the Martian results with the terrestrial analogs and will stimulate many future studies in understanding extraterrestrial processes.

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Manuscript received 2 March 2005; accepted 31 May 2005.

Call for Applications and Nominations for *GEOLOGY* Co-Editor

GSA is soliciting applications and nominations for the position of co-editor of *GEOLOGY*, an internationally recognized geoscience journal. The co-editor will serve a four-year term, beginning in January 2006 (exact start date to be negotiated), and will be one of a three-editor team. A co-editor with expertise and broad interests in tectonics and structural geology would best complement the continuing editors' strengths, but fields are flexible.

Desirable characteristics for the successful candidate include:

1. Broad interest and experience in geosciences;
2. International recognition;
3. Progressive attitude; willing to take risks and encourage innovation;
4. Familiar with many earth scientists and their work;
5. Sense of perspective and humor;
6. Organized and productive;
7. Willing to work closely with GSA headquarters staff;
8. Able to make decisions;
9. Familiar with new trends in geosciences; and
10. Willing to consider nontraditional research in geosciences.

GSA provides the editor with a small stipend as well as expenses for administrative assistance, mail, telephone, and Internet. The editor will work out of his or her current location at work or home—no move is necessary.

If you would like to be considered, please submit a curriculum vitae and a brief letter describing why you are suited for the position. If you would like to nominate someone for the position, submit a letter of nomination and the individual's written permission and CV. **Send nominations and applications to Jon Olsen, Director of Publications, GSA, P.O. Box 9140, Boulder, CO 80301, jolsen@geosociety.org, by 7 October 2005.**

2004–2005 Congressional Science Fellow Report

U.S. Space Policy: Where are we going, and why are we in this hand basket—I mean—space shuttle?

Sarah K. Noble, *2004–2005 GSA–U.S. Geological Survey Congressional Science Fellow*

When I signed up to work on the Hill this year, I knew that I wanted to work on space policy, and I knew that it was going to be an interesting year.

I remember hearing a Chinese curse that stated, "May you live in interesting times." Interesting times indeed: from the unique perspective of a staffer on the House Science Committee's space subcommittee, I am witnessing firsthand what I imagine (or at least, hope) will go down in history as a pivotal time for space exploration. From the winning of the Ansari X Prize® to the shuttle's return to flight and the president's vision for space exploration, the space program finally seems to be going somewhere again. It's all very exciting.

It is the president's vision for space exploration (the "VSE"—you know that the National Aeronautics and Space Administration [NASA] has an acronym for everything) that is occupying much of my time. The president announced this bold new space initiative more than a year ago, and although President Bush himself has been largely quiet on the subject, behind the scenes things have been happening quickly. NASA is now in the midst of a massive transformation. The White House has said that because Congress passed NASA's budget last year, even giving NASA a small increase in a year when most discretionary budgets were cut, it is tantamount to a congressional stamp of approval for the VSE. Most members of Congress would beg to differ. The budget was passed as part of a giant omnibus bill, which didn't give Congress the opportunity to scrutinize it the way they would have liked. That is the subcommittee's job this year—to take an in-depth, critical look at the VSE and decide if that is the right direction for the U.S. Space Program.

To that end, we have been quite busy holding hearings and having meetings with people throughout NASA's administration, keeping an eye on NASA's road mapping (strategic planning) exercise, and generally trying to figure out where NASA is heading and how it is going to get there. All of this scrutiny should result in a comprehensive "NASA authorization bill" this summer. In theory, the science committee is expected to produce such a bill every two years to provide NASA direction. The last NASA authorization bill was passed in 2000, so we are a little behind. Both the chair of the full science committee and the space subcommittee chair have said publicly that a NASA authorization bill is their number one priority this year. Perhaps I'm naive, but I am hopeful that we will manage to produce one.

In the meantime, allow me to share with you a few of my own thoughts on where NASA is headed. On the surface, the president's VSE (to return to the Moon and then go to Mars and beyond) is a great idea. NASA has been hanging out in Earth orbit for far too long, and it is past time for them to have a long-range goal. But I'm worried.

I'm worried about the role that science will play in this new vision. I have more than once heard supporters of the VSE state that exploration *is* science, and that is wrong; all science is exploration, but not all exploration is science. Already we have seen some troubling signs coming out of NASA. The president's budget proposal for next year shows significant cuts in many of NASA's science programs.

I'm not the only person on the Hill worried about the president's VSE and its effect on science programs at NASA. I have been pleasantly surprised to find that most of the representatives on the science committee, from both sides of the aisle, share this concern, so don't lose hope. The battle isn't over; in fact, it has barely begun.

I don't have room here to discuss all of my concerns about the VSE, but let me take a minute to cover one concern that I know many of you share. The earth sciences were particularly hard-hit in the president's budget. Several missions have been cut (like the Landsat Data Continuity mission and the Glory mission), others have been delayed, and future missions are likely to be fewer and farther between.

Much of the funds are being used to help with the constantly escalating costs of returning the space shuttle to flight. Hopefully, by the time you read this article, we will be successfully back in the spaceflight business, but the funding crunch is far from over. The space shuttle and space station will continue to eat up the lion's share of NASA's budget, and now preparations for returning to the Moon, particularly designing the CEV (crew exploration vehicle), will demand another chunk of the pie. With the federal budget stretched tight, someone has to lose.

Why was earth science targeted? Maybe because it has become an easy target. NASA's earth science program really has no coherent plan for the future, no "vision" of its own. One way to remedy this is through a decadal survey like those the astronomy and planetary science communities conduct. These surveys are produced by the National Academy of Science with significant input from scientists throughout the field. They provide NASA and Congress with a coherent strategy and prioritized agenda from which to make decisions. The good news is that there is a decadal survey currently under way for the earth sciences (go to http://qp.nas.edu/decadalsurvey to learn more). This is, understandably, a difficult task—the earth science community is much larger and arguably more diverse than the astronomy or planetary science communities—but just because it is difficult doesn't make it any less necessary. The bad news is that the survey won't be finished until next year, too late to influence this year's budget.

NASA's earth science program also doesn't sell itself as well as it should. Earth science missions may not be as sexy as Mars rovers or as awe inspiring as Hubble images. That just means that the earth science community needs to work harder at selling both the general public and Congress on the value of NASA's earth science program. That really shouldn't be so difficult. Earth science missions have many practical applications—from predicting the weather to predicting the path of a hurricane, from understanding land-use change to understanding global climate change. I have found, though, that there often seems to be a disconnect as to where this information comes from: I call it the "Why do we need weather satellites when we already have the weather channel?" mentality.

Okay, you knew that it was coming: we have now arrived at the point in the article where I encourage you to get involved. Yes, you. The science community needs to do a better job of communicating the importance of NASA's earth science missions, particularly those scientists who are directly involved in these missions, but the rest of us can help.

What can you do? Talk to your friends and family, write an op-ed letter to your favorite newspaper, and talk to school groups and scout troops about what these missions have and will accomplish. Imagine if the public were as riled about the threat of the Landsat program ending as they are about Hubble or Voyager ending. That would motivate Congress.

What else? Take the direct route. Write, call, or visit your members of Congress. Trust me, it's not as scary as it sounds. A few tips:

- If you write, keep it short and to the point. Focus either on a particular mission or NASA's earth science program in general, but be careful that it doesn't turn into a laundry list. Real letters are much more effective than e-mail, but if e-mail is all you have time for, it's better than nothing.
- If you call, ask to talk to the legislative assistant (LA) in charge of NASA issues. If your representative is on the science committee, his or her LA will probably be quite knowledgeable but will appreciate hearing from someone in the district. An office that is not on the science committee may have limited knowledge or background, so be ready with some basic information and concrete examples. In either case, be prepared to talk about how a particular mission impacts you as a constituent and the district in general. Does the mission pay your salary or your graduate student's salary? How will the research benefit the district (hurricane predictions, forest fire management, etc.)? Also—this is important—be sure to provide your contact information and let the LA know that you are happy to be a resource and that his or her office can contact you whenever questions arise. Calling once isn't necessarily enough. Turnover is high and memories are short in this town; the LA you talked to today may not be there in six months. Check in once or twice a year.
- If you visit in person, all of the above advice applies. Be prepared to talk to either the Congress member or his or her staff. Provide them with a one-page (never longer) summary of your main points, and don't forget your contact information. If you find this too intimidating to do on your own, consider joining in the annual Science and Technology Congressional Visits Day, when scientists and engineers from all across the country come to the Hill en masse to lobby for science. This two-day event usually happens in early May.

These tips apply even if you want to talk about something other than NASA's earth science program. One thing that I have learned over and over this year: on the Hill, knowledge is power. I know that the earth science community has plenty of knowledge to share. You can be a tremendous resource for Congress, if only they can get your phone number.

This manuscript is submitted for publication by Sarah Noble, 2004–2005 GSA–U.S. Geological Survey 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. 02HQGR0141. 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. Noble can be reached at sarah.noble@mail.house.gov.

Call for Applications

Apply for the GSA–USGS Congressional Science Fellowship for 2006–2007

Opportunities to serve as a Congressional Science Fellow are rare, unique experiences. This position may be a good fit for you. It will enable you to work directly with national leaders and put your expertise and experience to work helping shape science and technology policy on Capitol Hill.

The Congressional Science Fellow will be selected from top competitors early in 2006. Prospective candidates should be GSA members with a broad geoscience background and excellent written and oral communication skills. Minimum requirements are a Master's degree with at least five years professional experience or a Ph.D. at the time of appointment.

If you possess this professional background, have experience in applying scientific knowledge to societal challenges, and share a passion for helping shape the future of the geoscience profession, GSA invites your application. The fellowship is open to U.S. citizens or permanent U.S. residents.

Deadline to apply: 1 February 2006

For application information, visit www.geosociety.org/science/csf/, or contact Ginger Williams, GSA Headquarters +1-303-357-1040, gwilliams@geosociety.org.

2005–2006 Congressional Science Fellow Named: Nicole Gasparini

Nicole Gasparini has been chosen as the GSA–U.S. Geological Survey Congressional Science Fellow for 2005–2006. Gasparini's research focuses on the physics of fluvial processes and how rivers shape Earth's surface, and she has explored the effects of climate and tectonics on landscape evolution over many different time scales. Gasparini was drawn to this research because water and erosion are closely tied to many social and political issues. She is interested in the way that humans affect and are affected by riverine environments.

Gasparini earned a B.S. in applied mathematics and a B.A. in physical geography from the University at Buffalo, State University of New York, in 1995. As an undergraduate, she spent a summer at the National Aeronautics and Space Administration (NASA) Goddard Space Flight Center summer institute on atmospheric and hydrospheric sciences. She later attended Massachusetts Institute of Technology (MIT), where she completed an S.M. in 1998 and earned a Ph.D. in 2003 in hydrology from the Civil and Environmental Engineering department. While at MIT, she received the NASA Earth System Science Fellowship and a National Science Foundation Hydrology Fellowship. She comes to Washington, D.C., after spending two years at Yale University in the department of Geology and Geophysics as the Bateman Postdoctoral Fellow. The interdisciplinary nature of geomorphology is reflected in Gasparini's broad background in the earth sciences.

As a graduate student, Gasparini participated in a team project to design a numerical landscape evolution model (CHILD). One of the applications of this model was to understand gully erosion on U.S. Army bases in Colorado. Her team worked with land managers and other Army scientific personnel. "It wasn't always easy to share scientific findings with other scientists in similar fields and with similar goals. After this experience, I realized how challenging it must be to communicate scientific ideas with policymakers," said Gasparini. She believes that a critical but often overlooked part of the scientific process is proper dissemination of findings beyond the scientific community. She is excited to have the opportunity to work in the political arena and use her scientific knowledge outside of the laboratory.

Gasparini considers it to be a great privilege to participate in the fellowship program and to play a role in shaping environmental and scientific policy. "There are many pertinent political issues related to earth science, such as climate change and energy use, that need to be addressed now and in the coming years. I hope that after my experience as a congressional fellow, I will continue to be a strong voice for science in policy and that I can encourage my colleagues in the earth sciences to get involved as well."

SLC 2005

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GSA Annual Meeting & Exposition

ENRICH YOUR MEETING EXPERIENCE WITH A FIELD TRIP

Standard Registration Deadline: 12 September 2005
Cancellation Deadline: 19 September 2005
Register online at www.geosociety.org/meetings/2005/reg.htm.

Questions? Contact the field trip leader or Edna Collis, +1-303-357-1034, ecollis@geosociety.org. Complete trip descriptions, registration details, and information are in the June issue of *GSA Today* and are posted at www.geosociety.org/meetings/2005/fieldTrips.htm. All trips begin and end in Salt Lake City at the Salt Palace Convention Center, *unless otherwise indicated*. Meals and lodging are noted by the following symbols: B—breakfast, L—lunch, R—refreshments, D—Dinner, ON—overnight lodging.

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PREMEETING

1. **Neoproterozoic Uinta Mountain Group of Northeastern Utah: Pre-Sturtian Geographic, Tectonic, and Biologic Evolution [401]**

Thurs.–Fri., 13–14 Oct. Cosponsored by *GSA Sedimentary Geology Division*. Carol M. Dehler, Dept. of Geology, Utah State University, Logan, UT 84321, +1-435-797-0764, fax +1-435-797-1588, chuaria@cc.usu.edu; Susannah Porter; Doug Sprinkel. Max.: 27; min.: 12. Cost: US$185 (2L, R, 1ON, vans). *This field trip is in conjunction with the Pocatello Formation and Overlying Strata, Southeastern Idaho: Snowball Earth Diamictites, Cap Carbonates, and Neoproterozoic Isotopic Profiles field trip held Sat., 15 Oct.*

2. **Basaltic Volcanism of the Central and Western Snake River Plain and its Relation to the Yellowstone Plume [402]**

Thurs.–Sat., 13–15 Oct. John Shervais, Dept. of Geology, Utah State University, Logan, Utah 84322, +1-435-797-1274, fax +1-435-797-1588, shervais@cc.usu.edu; John Kauffman; Kurt Othberg; Virginia Gillerman. Max.: 22; min.: 12. Cost: US$325 (3L, R, 2ON, vans).

3. **From Cirques to Canyon Cutting: New Quaternary Research in the Uinta Mountains [403]**

Thurs.–Sat., 13–15 Oct. Cosponsored by *GSA Quaternary Geology and Geomorphology Division*. Jeffrey Munroe, Geology Dept., Middlebury College, Middlebury, VT 05753, +1-802-443-3446, fax +1-802-443-2072, jmunroe@middlebury.edu; Joel Pederson; Benjamin Laabs; Eric Carson. Max.: 30; min.: 14. Cost: US$255 (3L, 1D, R, 2ON, vans).

4. **Geomorphology and Rates of Landscape Change in the Fremont River Drainage, Northwestern Colorado Plateau [404]**

Thurs.–Sat., 13–15 Oct. Cosponsored by *GSA Quaternary Geology and Geomorphology Division*. David Marchetti, Dept. of Geology and Geophysics, University of Utah, Salt Lake City, UT 84112, +1-801-581-7062, fax +1-801-581-8219, dwmarche@mines.utah.edu; John Dohrenwend; Thure Cerling. Max.: 25; min.: 10. Cost: US$315 (2B, 3L, 2D, R, 2ON, vans).

ATTENTION STUDENTS

GSA's **Coal Geology Division** offers a US$50 scholarship to the first division-affiliated student member who registers for a division-sponsored field trip. Student must pay the full field trip fee when registering but will be reimbursed US$50 after the GSA meeting by the Coal Geology Division.

GSA's **Sedimentary Geology Division** is cosponsoring several field trips and will subsidize ten student members of their division (see individual trip descriptions for those sponsored). Students must pay the full field trip fee when registering, but will be reimbursed US$100 after the GSA meeting by the Sedimentary Geology Division. To be reimbursed, students must apply by e-mail, before the Annual Meeting, to Paul K. Link, secretary of the Sedimentary Geology Division, at linkpaul@isu.edu. In the application, students must provide their GSA member number, certify that they are members of the Sedimentary Geology Division, and provide their social security number and address.

GSA's **Structural Geology and Tectonics Division** offers up to five US$100 Scholarships to Division-affiliated student members for Division-sponsored field trips. Apply in writing, giving name, institution, class, specialty, poster or talk title, field trip title, and a one-paragraph rationale by e-mail only to David Lageson, lageson@montana.edu. The deadline to apply is 1 September. See the Structural Geology and Tectonics newsletter for more information.

5. Ice in Equatorial Pangea: The Unaweep-Cutler System [405]

Note: This field trip has been withdrawn at the request of the trip leader.

6. Lacustrine Records of Laramide Landscape Evolution, Green River Formation [406]

Thurs.–Sat., 13–15 Oct. Cosponsored by *GSA Limnogeology Division; GSA Sedimentary Geology Division.* Alan Carroll, Dept. of Geology and Geophysics, University of Wisconsin, Madison, WI 53706, +1-608-262-2368, fax +1-608-262-0693, carroll@geology.wisc.edu; Paul Buchheim; Arvid Aase. Max.: 33; min.: 10. Cost: US$340 (3B, 3L, 1D, R, 2ON, vans).

7. Late Cretaceous Stratigraphy, Depositional Environments, and Macrovertebrate Paleontology in Grand Staircase–Escalante National Monument, Utah [407]

Thurs.–Sat., 13–15 Oct. Cosponsored by *GSA Geobiology and Geomicrobiology Division; GSA Sedimentary Geology Division.* Alan L. Titus, Grand Staircase–Escalante National Monument, 190 E. Center Street, Kanab, UT 84741, +1-435-644-4332, fax +1-435-644-4350, Alan_Titus@blm.gov; John D. Powell; Eric Roberts; Stonnie Pollock; Jim Kirkland; L. Barry Albright. Max.: 36; min.: 12. Cost: US$220 (3L, R, 2ON vans).

8. Transect across the Northern Walker Lane, Northwest Nevada and Northeast California: An Incipient Transform Fault along the Pacific–North American Plate Boundary [408]

Thurs.–Sat., 13–15 Oct. Cosponsored by *GSA Structural Geology and Tectonics Division.* James E. Faulds, Nevada Bureau of Mines and Geology, MS 178, University of Nevada, Reno, NV 89557, +1-775-784-6691, ext. 159, fax +1-775-784-1709, jfaulds@unr.edu; Christopher D. Henry; Nicholas H. Hinz. Max.: 29; min.: 12. Cost: US$285 (3L, 1D, R, 3ON, vans). *Begins and ends in Reno.*

9. Brittle Deformation, Fluid Flow, and Diagenesis in Sandstone at Valley of Fire State Park, Nevada [409]

Fri.–Sat., 14–15 Oct. Cosponsored by *GSA Structural Geology and Tectonics Division.* Peter Eichhubl, Physical and Life Sciences Dept., Texas A&M University, Corpus Christi, TX 78412, +1-361-825-2309, fax +1-361-825-3345, peichhubl@falcon.tamucc.edu; Eric Flodin. Max.: 20; min.: 10. Cost: US$170 (2L, R, 1ON, vans). *Begins and ends in Las Vegas.*

10. Evolution of a Miocene-Pliocene Supradetachment Basin, Northeastern Great Basin [410]

Sat., 15 Oct. Cosponsored by *GSA Structural Geology and Tectonics Division.* Alexander Steely, Dept. of Geology, Utah State University, Logan, UT 84321, +1-435-797-1273, fax +1-435-797-1588, asteely@cc.usu.edu; Susanne Janecke; Stephanie Carney; Sean Long; Robert Oaks, Jr. Max.: 25; min.: 12. Cost: US$95 (1L, R, vans).

11. Geology and Natural Burning Coal Fires of the Ferron Sandstone Member of the Mancos Shale, Emery Coalfield, Utah [411]

Sat., 15 Oct. Cosponsored by *GSA Coal Geology Division.* Glenn B. Stracher, East Georgia College, Swainsboro, GA 30401, +1-478-289-2073, fax +1-478-289-2080, stracher@ega.edu; Paul B. Anderson; David E. Tabet; Janet L. Stracher. Max.: 36; min.: 12. Cost: US$90 (1L, 1D, R, vans).

12. Latest Pleistocene–Early Holocene Human Occupation in the Bonneville Basin [412]

Sat., 15 Oct. Cosponsored by *GSA Archaeological Geology Division.* David Rhode, Desert Research Institute, Reno, NV 89512, +1-775-673-7310, fax +1-775-673-7397, dave.rhode@dri.edu; Ted Goebel; Bryan Hockett; Kevin Jones; David Madsen. Max.: 48; min.: 12. Cost: US$75 (1L, R, vans).

13. Neotectonics and Paleoseismology of the Wasatch Fault, Utah [413]

Sat., 15 Oct. Cosponsored by *GSA Structural Geology and Tectonics Division.* Ronald L. Bruhn, Dept. of Geology and Geophysics, University of Utah, Salt Lake City, UT 84112, +1-801-581-6619, fax +1-801-581-8219, rlbruhn@mines.utah.edu; Ronald Harris; William R. Lund; Christopher DuRoss. Max.: 40; min.: 12. Cost: US$70 (1L, R, bus).

14. Pocatello Formation and Overlying Strata, Southeastern Idaho: Snowball Earth Diamictites, Cap Carbonates, and Neoproterozoic Isotopic Profiles [414]

Sat., 15 Oct. Cosponsored by *GSA Sedimentary Geology Division.* Paul Link, Dept. of Geosciences, Idaho State University, Pocatello, ID 83209, +1-208-282-3846, fax +1-208-282-4414, linkpaul@isu.edu; Frank Corsetti; Nathaniel Lorentz. Max.: 30; min.: 10. Cost: US$80 (1L, R, vans). *This field trip is in conjunction with the Neoproterozoic Uinta Mountain Group of Northeastern Utah: Pre-Sturtian Geographic, Tectonic, and Biologic Evolution field trip held Thurs.–Fri., 13–14 Oct.*

DURING THE MEETING

15. Geology of the Wasatch—A Two Billion Year Tour through the Upper Third of the Crust—A One-Day Trip [415]

Mon., 17 Oct. Cosponsored by *National Association of Geoscience Teachers.* Michael Bunds, Dept. of Earth Science, Utah Valley State College, Orem, UT 84058, +1-801-863-6306, fax +1-801-863-8064, bundsmi@uvsc.edu; William Dinklage; Daniel Horns. Max.: 36; min.: 12. Cost: US$60 (1L, R, vans).

16. Unique Geologic Features of Timpanogos Cave National Monument—A Half-Day Trip [416]

Tues., 18 Oct. Cosponsored by *National Park Service.* Jon Jasper, Timpanogos Cave National Monument, American Fork, UT 84003, +1-801-492-3647, fax +1-801-756-5661, jon_jasper@nps.gov; Dave Herron. Max.: 20; min.: 10. Cost: US$95 (1L, vans).

17. Biogeochemistry, Limnology, and Ecology of Great Salt Lake—A Half-Day Trip [417]

Wed., 19 Oct. David Naftz, U.S. Geological Survey, 2329 Orton Circle, Salt Lake City, UT 84119, +1-801-908-5053, fax +1-801-908-5001, dlnaftz@usgs.gov; Wayne Wurtsbaugh; Don Paul; Terry Kenney. Max.: 45; min.: 33. Cost: US$75 (1L, boat ride, bus).

POSTMEETING

18. Anatomy of Reservoir-Scale Normal Faults in Central Utah: Stratigraphic Controls and Implications for Fault Zone Evolution and Fluid Flow [418]
Wed.–Fri., 19–21 Oct. Cosponsored by *GSA Structural Geology and Tectonics Division.* Peter Vrolijk, ExxonMobil Upstream Research Company, Houston, TX 77252, +1-713-431-4151, fax +1-713-431-4114, mpeter.vrolijk@exxonmobil.com; Zoe K. Shipton; Rod Myers; James P. Evans; Mike Sweet. Max.: 24; min.: 10. Cost: US$220 (2L, 1D, R, 2ON, vans).

19. Sheet-like Emplacement of Satellite Laccoliths, Sills, and Bysmaliths of the Henry Mountains, Southern Utah [419]
Wed.–Fri., 19–21 Oct. Cosponsored by *GSA Structural Geology and Tectonics Division.* Sven Morgan, Dept. of Geology, Central Michigan University, Mount Pleasant, MI 48859, +1-989-774-1082, fax +1-989-774-2142, sven.morgan@cmich.edu; Eric Horsman; Basil Tikoff; Michel de Saint Blanquat. Max.: 36; min.: 12. Cost: US$195 (3L, R, 2ON, vans).

20. Folds, Fabrics, and Kinematic Criteria in Rheomorphic Ignimbrites of the Snake River Plain, Idaho: Insights into Emplacement and Flow [420]
Wed.–Sat., 19–22 Oct. Cosponsored by *GSA Structural Geology and Tectonics Division.* Graham D.M. Andrews, Dept. of Geology, University of Leicester, Leicester, UK, (+44)1162523930, gdma1@le.ac.uk; Steve Temperley; Mike J. Branney. Max.: 24; min.: 10. Cost: US$225 (1L, R, 3ON, vans).

21. Mesozoic Lakes of the Colorado Plateau [421]
Wed.–Sat., 19–22 Oct. Cosponsored by *GSA Limnogeology Division; GSA Sedimentary Geology Division.* Tim Demko, Dept. of Geological Sciences, University of Minnesota, Duluth, MN 55812, +1-218-726-8340, fax +1-218-726-8275, tdemko@umn.edu; Kathleen Nicoll; Steve Hasiotis; Lisa Park; Joe Beer. Max.: 30; min.: 10. Cost: US$300 (3L, 1D, R, 3ON, vans).

22. Birth of the Lower Colorado River—Stratigraphic and Geomorphic Evidence for its Inception and Evolution near the Conjunction of Nevada, Arizona, and California [422]
Thurs.–Sat., 20–22 Oct. Cosponsored by *GSA Quaternary Geology and Geomorphology Division.* P. Kyle House, Nevada Bureau of Mines and Geology, University of Nevada, Reno, NV 89557, +1-775-784-6691, ext. 176, fax +1-775-784-1709, khouse@unr.edu; Philip A. Pearthree; Keith A. Howard; John W. Bell. Max.: 30; min.: 12. Cost: US$245 (3L, R, 2ON, SUVs). *Begins and ends in Las Vegas.*

23. Classic Geology of Zion and Bryce Canyon National Parks and Cedar Breaks National Monument [423]
Thurs.–Sat., 20–22 Oct. Grant C. Willis, Utah Geological Survey, P.O. Box 146100, Salt Lake City, UT 84114, +1-801-537-3300, fax +1-801-537-3400, grantwillis@utah.gov; Robert F. Biek. Max.: 45; min.: 15. Cost: US$290 (3L, R, 2ON, bus).

24. Development of Miocene Faults and Basins in the Lake Mead Region: A Tribute to Ernie Anderson and Review of New Research on Basins [424]
Thurs.–Sat., 20–22 Oct. Cosponsored by *GSA Structural Geology and Tectonics Division.* Paul Umhoefer, Dept. of Geology, Northern Arizona University, Flagstaff, AZ 86011, +1-928-523-6464, fax +1-928-523-9220, paul.umhoefer@nau.edu; Thomas Hickson; Ernie Anderson; L. Sue Beard; Melissa Lamb. Max.: 33; min.: 12. Cost: US$320 (3B, 3L, 2D, R, 2ON, vans). *Begins and ends in Las Vegas.*

25. Don R. Currey Memorial Field Trip to the Shores of Pleistocene Lake Bonneville: Stratigraphy, Geomorphology, and Climate Change [425]
Thurs.–Sat., 20–22 Oct. Cosponsored by *GSA Quaternary Geology and Geomorphology Division.* Holly Godsey, Dept. of Geology and Geophysics, University of Utah, Salt Lake City, UT 84112, +1-801-209-2940, fax +1-801-581-8219, hgodsey@mines.utah.edu; Elliott Lips; David Miller; Mark Milligan; Jack Oviatt. Max.: 40; min.: 20. Cost: US$185 (3L, 1D, R, vans).

26. Paleoseismology and Geomorphology of the Hurricane Fault/Escarpment [426]
Thurs.–Sat., 20–22 Oct. Cosponsored by *GSA Structural Geology and Tectonics Division; GSA Quaternary Geology and Geomorphology Division.* Lee Amoroso, U.S. Geological Survey, 2255 N. Gemini Drive, Flagstaff, AZ 86001, +1-928-556-7186, fax +1-928-556-7196, lamoroso@usgs.gov; Cassie Fenton; Jason Raucci. Max.: 20; min.: 5. Cost: US$175 (Camping, SUVs). *Begins and ends in Las Vegas.*

27. Sedimentology and Sequence Stratigraphy of Isolated Shelf Turbidite Bodies, Book Cliffs, Utah [427]
Thurs.–Sat., 20–22 Oct. Cosponsored by *GSA Sedimentary Geology Division.* Simon A.J. Pattison, Dept. of Geology, Brandon University, Brandon, Manitoba R7A 6A9, Canada, +1-204-727-7468, fax +1-204-728-7346, pattison@brandonu.ca; Huw Williams; Trevor A. Hoffman. Max.: 30; min.: 5. Cost: US$240 (3L, R, 2ON, vans).

28. Geologic Hazards of the Wasatch Front, Utah [428]
Thurs., 20 Oct. Cosponsored by *GSA Engineering Geology Division; Association of Engineering Geologists.* Barry J. Solomon, Utah Geological Survey, P.O. Box 146100, Salt Lake City, UT 84114, +1-801-537-3388, fax +1-801-537-3400, barrysolomon@utah.gov; Francis X. Ashland; Bill D. Black; Richard L. Ford; Richard Giraud; David H. Hart; Michael D. Hylland. Max.: 42; min.: 12. Cost: US$80 (1L, R, bus).

Call for 2006 Field Trip Proposals

2006 GSA Annual Meeting

22–25 October 2006

Philadelphia, Pennsylvania

We are interested in proposals for half-day, single-day, and multi-day field trips beginning or ending in or near Philadelphia and dealing with all aspects of the geosciences.

Due Date for Field Trip Proposals:
1 December 2005

Please contact the field trip chair: Frank J. Pazzaglia, Department of Earth and Environmental Sciences, Lehigh University, 31 Williams Drive, Bethlehem, PA 18015-3188, USA, +1-610-758-3667, fax +1-610-758-3677, fjp3@lehigh.edu.

John C. Frye Memorial Award Environmental Geology

The 2005 John C. Frye Memorial Award will be presented at the GSA Annual Meeting in Salt Lake City to Carol L. Ruthven, John D. Kiefer, Stephen F. Greb, and William M. Andrews Jr. for *Geologic Maps and Geologic Issues in Kentucky: A Citizen's Guide*, University of Kentucky Special Publication 3, 2003, Kentucky Geological Survey.

Comments and Letters

Comments and letters regarding items published in *GSA Today* are welcome. The text, including references, should be no more than 350 words in length. If the number of letters or comments received exceeds the available space in the printed journal, they will be posted to the *GSA Today* Web page (www.geosociety.org/pubs/gsatoday/letters.htm). Longer comments on science articles will be published online only, but are still limited to the equivalent of one printed page, including references, figures, and tables (~900 words).

Send comments and letters to Kristen Asmus, *GSA Today*, P.O. Box 9140, Boulder, CO 80301-9140, USA, kasmus@geosociety.org. Comments related to the science article will be forwarded to the science editors for review, and the author of the original science article will be given the opportunity to write a reply.

To read a recent comment by David D. Blackwell regarding the February *GSA Today* science article, "Subduction zone backarcs, mobile belts, and orogenic heat" (Hyndman et al., 2005), go to www.geosociety.org/pubs/gsatoday/.

GSA SHORT COURSES OFFERED AT THE 2005 SALT LAKE CITY ANNUAL MEETING

Sign up for one of these great short courses at the GSA Annual Meeting in Salt Lake City. For registration information and details on student scholarships offered by GSA Divisions, see the June issue of *GSA Today* or go to www.geosociety.org/meetings/2005/. Questions? Contact Edna Collis, ecollis@geosociety.org, +1-303-357-1034.

Preregistration is recommended; on-site short course registration is an additional US$30.
Cancellation Deadline: 19 September 2005.

1. Introduction to Geographic Information Systems (GIS), Using ArcGIS9 for Geological Applications [501]

Fri.–Sat., 14–15 Oct., 8 a.m.–5 p.m. Cosponsored by *GSA Geoscience Education Division; Environmental Systems Research Institute.*

This short course will introduce the use of GIS in geology related applications through brief lectures, and hands on computer exercises. Concepts in creating a GIS project in geology will be discussed including creation of data (GPS, RS, digitizing), conversion of data, metadata, different data formats (vector and raster) and accessing data from several sources (tables, shapefiles, coverages, CAD, geodatabases and grids). Participants do not need to have experience with ArcGIS, but familiarity with Windows OS is beneficial.

Faculty: Ann B. Johnson, Higher Education Manager, Environmental Systems Research Institute, Redlands, Calif., Ph.D., California State University; Willy Lunch, Instructor, Environmental Systems Research Institute, Denver, Colo., M.S., University of Utah; Esther Worker, Education Account Manager, Environmental Systems Research Institute, Denver, Colo., B.A., University of Colorado–Boulder. Limit: 24. Fee: US$330; includes course manual and lunch. CEU: 1.6.

2. Measurement of Indoor Radon in Geologically Diverse Terrains [502]

Fri.–Sat., 14–15 Oct., 8 a.m.–5 p.m. Cosponsored by *GSA Engineering Geology Division.*

This course provides hands-on training to understand, anticipate, and measure geologically dependent indoor radon and waterborne radon. Course is designed for teachers and researchers. An optional exam earns a Radon Measurement Specialist Certificate (National Radon Safety Board, info@nrsb.org) for full- or part-time employment as a home inspector in the real estate market. A general knowledge of soil and hydrology is required. *Optional Exam: Earn a Radon Measurement Specialist Certificate. Cost: US$150.*

Faculty: Douglas Mose, George Mason University, Fairfax, Va., Ph.D., University of Kansas; George Mushrush, George Mason University, Fairfax, Va., Ph.D., Georgetown University. Limit: 40. Fee*: US$360; includes course manual and lunch. CEU: 1.6.

3. A Tracer Runs through It: Applications of the Tracer-Injection Methods [503]

Sat., 15 Oct., 8 a.m.–5 p.m. Cosponsored by *GSA Hydrogeology Division.*

Tracer-injection techniques have characterized mining-impacted watersheds, but are applicable to many water-quality problems, particularly Total Maximum Daily Load studies. This course covers theoretical and practical details of tracer-injection studies in streams and small rivers. Applications include estimation of discharge for synoptic studies and characterization of groundwater–surface water interaction. Field aspects (planning, equipment, sampling) and data analysis (loading computations) are covered. Participants should have a general background in hydrology, but detailed chemistry not required.

Faculty: Briant A. Kimball, U.S. Geological Survey, Salt Lake City, Utah, Ph.D., University of Wyoming; Robert L. Runkel, U.S. Geological Survey, Denver, Colo., Ph.D., University of Colorado–Boulder. Limit: 40. Fee: US$310; includes course manual and lunch. CEU: 0.8.

4. Science in Environmental Policymaking [504]

Sat., 15 Oct., 8 a.m.–5 p.m. Cosponsored by *GSA Geology and Society Division.*

This interactive course is for scientists whose research informs natural hazard, waste management, water, and other environmental and resource policy decisions. Participants will learn skills to help ensure that science is not ignored, marginalized, or misrepresented by decision makers. They will learn to work effectively within both the traditional adversarial regulatory process and alternative stakeholder-driven, collaborative problem solving approaches.

Faculty: Herman Karl, Massachusetts Institute of Technology, Cambridge, Mass., Ph.D., University of Southern California–Los Angeles; Judith Layzer, Massachusetts Institute of Technology, Cambridge, Mass., Ph.D., Massachusetts Institute of Technology; Christine Turner, U.S. Geological Survey, Denver, Colo., Ph.D., University of Colorado–Boulder. Limit: 30. Fee: US$340; includes course manual and lunch. CEU: 0.8.

CORRECTION

*The registration form printed in the June *GSA Today* contained a pricing error in the Short Course section. The cost for the course “Measurement of Indoor Radon in Geologically Diverse Terrains [502]” is US$360; the US$150 price noted on the form is for the optional exam. The online meeting registration form, at www.geosociety.org/meetings/2005/reg.htm, is correct.

5. **Springs Inventory and Classification Course and Field Trip [505]**

Sat., 15 Oct., 8 a.m.–5 p.m. Cosponsored by *GSA Hydrogeology Division.*

Participants will learn the theory and techniques of inventorying and classifying the physical and biological characteristics of spring ecosystems. This course includes a half-day field trip to introduce the theory and to demonstrate the materials and techniques. Anyone involved with teaching earth sciences, managing spring ecosystems, or in conducting basic science of springs should attend.

Faculty: Abe Springer, Northern Arizona University, Flagstaff, Ariz., Ph.D., Ohio State University; Larry Stevens, Stevens Ecological Consulting, Flagstaff, Ariz., Ph.D., Northern Arizona University; Heidi Kloeppel, Grand Canyon Wildlands Council, Flagstaff, Ariz., M.S., Northern Arizona University. Limit: 25. Fee: US$305; includes course manual, field trip, and boxed lunch. CEU: 0.8.

6. **Three-Dimensional Geologic Mapping for Groundwater Applications Workshop [506]**

Sat., 15 Oct., 8 a.m.–5 p.m. Cosponsored by *GSA Geology and Society Division; GSA Hydrogeology Division.*

Increased diligence in management of groundwater systems for the long term is coinciding with progress in digital data, analytical methods, and computing power. Geologic mappers seeking to support groundwater applications should attend this workshop to obtain an overview of three-dimensional methods made possible by these advances, including basin analysis, data management, model construction, geophysical methods, and hydrogeological characterization.

Faculty: Richard C. Berg, Illinois State Geological Survey, Champaign, Ill., Ph.D., University of Illinois–Urbana-Champaign; Hazen Russell, Geological Survey of Canada, Ottawa, Ontario, Ph.D., University of Ottawa; Harvey Thorleifson, Minnesota Geological Survey, University of Minnesota, Ph.D., University of Colorado–Boulder. Limit: 50. Fee: US$195; includes course manual and lunch. CEU: 0.8.

Note: The fee for this short course was incorrectly listed in the June *GSA Today* as $200 in both the short course description and on the registration form. GSA apologizes for the error.

Future GSA Annual Meetings

2006	Philadelphia (October 22–25)
2007	Denver (October 28–31)
2008*	Chicago (October 26–29)
2009	Portland, Ore. (tentative; October 18–21)
2010	Denver (October 31–November 3)
2011	Minneapolis (tentative; October 9–12)

* Joint meeting with American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America.

Call for Geological Papers

2006 GSA Section Meetings

SOUTH-CENTRAL SECTION

6–7 March 2006
University of Oklahoma, Norman, Oklahoma
Abstract Deadline: 9 December 2005
Information: Neil Suneson, Oklahoma Geological Survey, University of Oklahoma, 100 E Boyd St., Rm N131, Norman, OK 73019-0628, +1-405-325-3031, nsuneson@ou.edu

NORTHEASTERN SECTION

20–22 March 2006
Radisson Penn Harris Hotel and Convention Center
Camp Hill/Harrisburg, Pennsylvania
Abstract Deadline: 13 December 2005
Information: Noel Potter, Dickinson College, Dept. of Geology, Carlisle, PA 17013-2896, +1-717-245-1340, pottern@dickinson.edu

SOUTHEASTERN SECTION

23–24 March 2006
Marriott Hotel, Knoxville, Tennessee
Abstract Deadline: 5 January 2006
Information: Claudia Mora, University of Tennessee, Dept. of Earth and Planetary Sciences, 1412 Circle Drive, Knoxville, TN 37996-1410, +1-865-974-5499, cmora@utk.edu

NORTH-CENTRAL SECTION

20–21 April 2006
Student Center, University of Akron, Akron, Ohio
Abstract Deadline: 25 January 2006
Information: John Szabo, Dept. of Geology, University of Akron, Akron, OH 44325-4101, +1-330-972-8039, jpszabo@uakron.edu

CORDILLERAN SECTION

(Joint Meeting with PSAAPG and SPE-A)
8–10 May 2006
University of Alaska, Anchorage, Alaska
Abstract Deadline: 2 February 2006
Check future issues of *GSA Today* for more information.

ROCKY MOUNTAIN SECTION

17–19 May 2006
Western State College, Gunnison, Colorado
Abstract Deadline: 21 February 2006
Information: Rob Fillmore, Western State College, Dept. of Natural and Environmental Sciences, Gunnison, CO 81231-0001, +1-970-943-2092, rfillmore@western.edu

K–16 EDUCATION WORKSHOPS OFFERED AT THE 2005 SALT LAKE CITY ANNUAL MEETING

Attention College and University Faculty, K–12 Teachers, Undergraduate and Graduate Students, Informal Educators: Sign up for one of these exciting and diverse workshops. For registration fees and information about a special Subaru of America grant available to Utah graduate students and two-year college faculty, visit www.geosociety.org/meetings/2005/rsubaru.htm.

Saturday Workshops

1. Earthquakes—A One-Day Workshop for College and University Faculty [601]

Sat., 15 Oct., 8 a.m.–5 p.m. Cosponsored by *IRIS Consortium; U.S. Geological Survey; National Science Foundation; Purdue University.*

Intended audience: College and university faculty. Fee: US$10.

This workshop will cover the following topics: causes of earthquakes, plate tectonics, propagation of seismic waves, seismographs, statistics and data, Earth's structure, and earthquake hazards. Learning activities emphasizing hands-on and inquiry-based learning will be used to deliver content to participants. Participants are encouraged to reflect on how these activities could be used in their classrooms. Materials (hands-on activities, maps, earthquake book, posters, software and other teaching aids) will be provided to participants as part of the workshop. **Information:** Michael Hubenthal, hubenth@iris.edu; Larry Braile; John Lahr; John Taber; Lisa Wald.

2. Inquiry-Based Groundwater Science Instructional Materials and Curricula [602]

Sat., 15 Oct., 9 a.m.–5 p.m. Cosponsored by *Kansas Geological Survey; AGI Foundation.*

Intended audience: Middle and high school teachers, college and university faculty, informal educators. Fee: US$30.

Workshop attendees will be introduced to basic science concepts and inquiry-based curricular materials for use in earth and environmental science classes. Attendees will participate in demonstrations, examine AGI's curricular materials, learn about Internet resources, and play with problem-based computer software if they bring lap-top computers. All instructional and AGI curricular materials samples will be provided. **Information:** Allen Macfarlane, dowser@kgs.ku.edu; Ann Benbow, aeb@agiweb.org.

3. How to Establish and Sustain an Undergraduate Research Program [603]

Sat., 15 Oct., 1–5 p.m. Cosponsored by *Council on Undergraduate Research.*

Intended audience: College and university faculty, graduate students. Fee: US$35.

This workshop will present strategies for developing and sustaining research programs at the undergraduate level. It is open to all but is designed for new geosciences faculty, graduate students applying for academic positions, and faculty interested in expanding their research programs to include undergraduates. Presentations will cover strategies for obtaining a job at a predominantly undergraduate institution, funding opportunities to support undergraduate research, project selection and mentoring of undergraduates, and models of successful undergraduate research programs. **Information:** Lydia Fox, lkfox@pacific.edu.

4. Teaching Introductory Geology with Art: Sharing Effective Materials and Activities [604]

Sat., 15 Oct., 1–5 p.m. Cosponsored by *National Association of Geoscience Teachers; National Science Foundation.*

Intended audience: College and university faculty. Fee: US$20.

The teaching of introductory geology in conjunction with art is an emerging practice at a number of universities. This interactive workshop will provide a forum for current instructors of such courses to share effective class activities and/or materials. The workshop leaders, a geologist and an art educator who team-teach an art and geology course, will facilitate. They will also disseminate information regarding and solicit participation in their educational materials development project, the goal of which is the production of an art and geology textbook. Funding may be available to cover costs associated with workshop attendance. **Information:** Denise Battles, dbattles@georgiasouthern.edu.

Sunday Workshop

5. Designing Effective Geoscience Education Research: Qualitative and Quantitative Methods [605]

Sun., 16 Oct., 8 a.m.–noon. Cosponsored by *Ohio University; National Science Foundation.*

Intended audience: Graduate students, college and K–12 educators, and researchers. Fee: US$15.

In this workshop, participants will learn about the qualitative and quantitative data collection and analysis methods used in geoscience education research. Workshop leaders will use case studies, demonstrations, and hands-on activities to introduce participants to the variety of education research methods. This workshop is geared for students, college and K–12 educators, and researchers who are engaged in or who plan to be engaged in education research. Written materials will be handed out to augment the content in the workshop. **Information:** Julie Sexton, ju.sexton@colostate.edu; Julie Libarkin, libarkin@ohio.edu.

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New Members: GSA Welcomes You!

The following individuals joined GSA during the period of December 2004 through May 2005.

GSA Fellows

Lokesh Chaturvedi
Thomas K. Rockwell
David A. Sawyer

GSA Members

Farid Achour
Donelle Adams
Alp Akar
David K. Allerton
Michael Allis
Rubén Arellano
Jayne C. Aubele
John N. Baldwin
Charles T. Barker
Philip A. Barker
Maurice W. Baron Jr.
Quentin D. Barrett
Matthew E. Bartkiewicz
William G. Batten
L. Thomas Bayne
Jennifer Beall
Jean Beaulieu
Sara E. Bertelsen
Suranjana Bhattacharjee
Dale Bird
Jonathan I. Bloch
Steve Boand
Adria A. Bodour
Bo Bodvarsson
Rusty Boicourt
Larry Bond
Joe Bone
B.J. Bonin
Bodo Bookhagen
Erika M. Bowen
Victor Bravo
Jill Bries Korpik
Patricia Brousseau
Erik T. Brown
Francis H. Brown
Lori S. Browne
Scott Bryan
Paul E. Buchholz
Scott Burns
Andrew Bursey
Mark E. Burton
David Buss
Arturo Calvo
Barry I. Cameron
Steven R. Camp
Alex Carrillo-Chavez
Kenneth D. Carter
Rebecca J. Caudill
Esteban Cedillo
Oliver A. Chadwick
Richard L. Chaney
John E. Charlton
John Chatoian
Jim Chen
S. Chidambaram
Candace E. Chin Fatt
Steven D. Chittick
Philip R. Cook
Robert C. Cook
Steven Cordiviola
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THE GEOLOGICAL SOCIETY OF AMERICA

GSA Foundation Breathes New Life into Old Fund

Established in 1951, the Kirk Bryan Award is bestowed upon the author or authors of a published paper of distinction that advances the science of geomorphology or a related field, such as Quaternary geology.

Quaternary Geology and Geomorphology Division's Kirk Bryan Award Fund Transferred to GSA Foundation

Earlier in 2005, the Kirk Bryan Fund was located in an obscure part of the GSA normal accounting system, but it has now been moved into the GSA Foundation where it can grow! The Kirk Bryan Award had been funded from the general operating expenses of the Quaternary Geology and Geomorphology Division (QGG). We had lost track of the fund, and no money had been drawn from it for years. As the fund sat in the GSA account, it was not receiving any interest. Now that it has been moved to the Foundation, it will receive interest, and contributions can also be added.

We now have $63,367 in the fund. Up until a couple of years ago, annual awards were only $1500. This, the "original" QGG award, was being dwarfed by the other, newer QGG awards. The board voted in 2003 to increase the award to $3000 annually. This year, $1500 will come from our operating expenses and $1500 from the interest from the fund.

Our aim is to increase the award to $5000 annually in the near future. It is our intent to raise the fund's net assets to $100,000; if we can get the fund to $100,000, we will be able to award $5000 each year and draw only from the Foundation interest, with no money coming from our operating expenses.

If you are interested in helping us achieve our goal for the Kirk Bryan Fund, please send your contribution to the GSA Foundation, and designate it for the Kirk Bryan Fund.

Scott Burns, Treasurer
Quaternary Geology and Geomorphology Division

Mystery Game at the Annual Meeting

Sarah Andrews, noted geology mystery writer, is just about done with her "Mystery Challenge"—a gift to the GSA Foundation for GSA members at the 2005 Annual Meeting. Brush up on your basic geologic facts—it will come in handy in Salt Lake City. Watch for complete details in the September issue.

Got an Item for Our Auction?

The GSA Foundation's 6th Silent Auction will be held in the Foundation booth during the GSA Annual Meeting in Salt Lake City.

If you have an item you would like to donate, please contact Donna Russell, drussell@geosociety.org, +1-303-357-1054, for further information.

We accept most anything—books, rock specimens, art work, vacation packages, gift certificates, and more. All donations are tax-deductible.

Please help us make this year's auction the best yet.

Most memorable early geologic experience:

1953: Just back from a USGS assignment in Cuba, and newly married, I had a short solo in the "Pick and Hammer" show… and forgot the words… on stage!!!

—Ronald K. Sorem

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SEDIMENTARY GEOLOGY
UNIVERSITY OF WYOMING

The Department of Geology and Geophysics (http://home.gg.uwyo.edu) invites applications for a tenure-track, assistant professor position in sedimentology/stratigraphy. Higher rank (associate professor) is possible with appropriate qualifications. Ph.D. is required at time of appointment, August 2006. We seek an individual who shows the potential to develop an internationally recognized, externally funded research program, will be involved in the undergraduate and graduate teaching mission of the department, and will build on departmental strengths in sedimentation, energy research, seismology, and structural geology. Specialty is open, but may include such diverse fields as quantitative basin analysis, seismic stratigraphy, carbonate sedimentation, paleoclimate reconstruction, physical sedimentology and sediment transport. The Department is home to the Institute for Energy Research (http://www.ieronline.org/) and the University has a strong and long-standing commitment to energy-related research in the geosciences.

Applications should include a statement of research and teaching interests and accomplishments, curriculum vitae, and the names and contact information of three references. Review of completed applications will begin November 1, 2005. Send an electronic copy of your application to Ms. Carol Pribyl at cpribyl@uwyo.edu; if you have additional application materials to send, please direct them to Sedimentary Search Committee, Dept. of Geology & Geophysics, University of Wyoming, 1000 E. University Ave., Dept. 3006, Laramie, WY 82071.

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MINING ENGINEERING FACULTY POSITION
DEPARTMENT OF MINING
AND GEOLOGICAL ENGINEERING
COLLEGE OF ENGINEERING AND MINES
UNIVERSITY OF ALASKA FAIRBANKS

The Department of Mining and Geological Engineering at the University of Alaska Fairbanks invites applications for a tenure track faculty position in Mining Engineering beginning in September 2005. Candidates must possess a B.S. degree in mining/mineral engineering, preferably from an ABET accredited program, and an earned doctorate in mining/mineral engineering and be committed to excellence in teaching at the undergraduate and graduate levels. Candidates must have mining industry experience. Candidates with professional registration or eligibility for immediate registration as a professional engineer in the State of Alaska will be given preference. Preference will also be given to candidates with interest in teaching courses related to mine planning, permitting, reclamation, and environmental compliance. In addition, the candidate must demonstrate or show potential for scholarly accomplishments and the ability to attract research funding. Salary will be commensurate with education and experience.

University of Alaska Fairbanks. Established as the original site of the University of Alaska in 1917, the University of Alaska Fairbanks (UAF) is a multi-campus university based in Fairbanks, the state's second largest city, with seven extended campuses spanning two-thirds of the state. Fairbanks is a vibrant community offering a wide range of cultural as well as outdoor activities and amenities typically found only in much larger cities. The UAF campus is located on a scenic hill on the edge of Fairbanks that offers a majestic view of the Alaska Range and access to ski and hiking trails through miles of boreal forest. UAF is the doctoral degree-granting unit of the University of Alaska statewide higher education system and includes over 10,000 students with an annual operating budget of $340 million including $113 million in FY04 research expenditures.

The application deadline is opened until filled. However, initial screening of applicants will begin on August 15, 2005. Applicants should send a curriculum vitae, a statement of current and future research interests and contact information for three references to: Professor Gang Chen, Chair, Department of Mining and Geological Engineering, College of Engineering and Mines, University of Alaska Fairbanks, P.O. Box 755800, Fairbanks, Alaska 99775-5800.

WELLESLEY COLLEGE
ASSISTANT PROFESSOR
GEOSCIENCES/SURFACE PROCESSES

The Department of Geosciences at Wellesley College invites applications for a tenure-track faculty position at the rank of first-level assistant professor beginning September 2006. We seek an exceptional scientist who can integrate classroom, field and laboratory approaches to teaching undergraduates in a liberal arts environment. This individual will have broad expertise in surface processes and be expected to develop courses at all levels of our curriculum, particularly including sedimentation and earth history. The ideal candidate will also be active in research that can include students in the department. Completion of the Ph.D. is required, and previous post-doctoral and/or teaching experience would be beneficial.

Applicants should send their curriculum vitae, a statement of teaching and research interests, and the names and contact information (including email address) of three referees to Dr. Margaret D. Thompson, Chair, Department of Geosciences, Wellesley College, 106 Central Street, Wellesley, MA 02481-8203. Applications will be accepted until October 15, 2005.

Wellesley College is an Affirmative Action/Equal Opportunity educational institution and employer. The College is committed to increasing the diversity of the college community and the curriculum. Candidates who believe they can contribute to that goal are encouraged to apply.

STRUCTURE/NEOTECTONICS
CALIFORNIA STATE UNIVERSITY–BAKERSFIELD

The Department of Physics and Geology at California State University at Bakersfield (CSUB) announces a tenure track position in **structure/neotectonics** beginning in the 2006–07 school year. The successful candidate would demonstrate a strong commitment to sharing in department responsibilities toward the education of K–12 teachers-in-training as well as general education, major, and graduate courses.

The small, high-quality geology department at CSUB is very active in peer-reviewed research involving both undergraduates and M.S.-level graduate students. The department is well equipped with aqueous chemistry and hydrology labs including field hydrology equipment, an automated XRD, an ICP-MS with laser ablation system, an SEM-EDX, a research petrography lab, and a wide variety of field geophysics equipment including gravimeter, refraction seismograph, electrical resistivity system, magnetometers, sedigraph, rock crushing equipment and a ground conductivity meter. The California Well Sample Repository, located on campus, houses the largest public collection of oil and water well cores and cuttings in California. The Geotechnology Training Center is also located within the department. It includes six SGI Octane workstations, 12 PCs, and extensive software including Landmark, Geographix, Seismic Microtechnology's Kingdom Suite, Petra, and ArcGIS.

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

California State University at Bakersfield is a regional comprehensive university which prides itself in a liberal arts approach to undergraduate education and small, high-quality graduate programs. It has an enrollment of approximately 7,000 students and resides in a rapidly growing community of over 400,000 people in the southern San Joaquin Valley of central California. The campus is conveniently located near popular beach, mountain, and desert attractions and is a two-hour drive from Los Angeles.

Review of applications will begin after ***November 14, 2005***. Candidates should submit a letter of application, a current curriculum vitae, and names of at least three references to: Chair of the Geology Search Committee, Department of Physics and Geology, California State University, 9001 Stockdale Highway, Bakersfield, CA 93311-1099 USA, Web site: http://www.cs.csubak.edu/Geology/.

HYDROLOGY/GEOCHEMISTRY,
SKIDMORE COLLEGE
SPRING SEMESTER 2006

The Department of Geosciences at Skidmore College seeks a full-time, one-semester leave replacement for the spring 2006 semester. The successful candidate will be interested in undergraduate teaching excellence and will be eager to work with students on undergraduate research. Teaching responsibilities include a combined surface/groundwater hydrology course, a natural resources course, and an additional course of the candidate's specialty, preferably low-temperature or environmental geochemistry. Completion or near completion of a Ph.D. is expected at the time of appointment. Applications including a cover letter, a current c.v., and a statement of teaching interests, and three letters of recommendation should be sent to: Hydrology Search, Department of Geosciences, File #GS, Skidmore College, 815 North Broadway, Saratoga Springs, NY 12866. Review begins September 15, 2005, and will continue until the position is filled.

Skidmore encourages applications from women and men of diverse racial, ethnic and cultural backgrounds.

GEOLOGY, ASSISTANT PROFESSOR
WHITMAN COLLEGE

The Department of Geology at Whitman College invites applications for a tenure-track position as Assistant Professor beginning August, 2006. Ph.D. required. Demonstrated expertise in teaching and research in the fields of igneous and metamorphic petrology and mineralogy desirable. Candidates who have demonstrated expertise in fields that expand and strengthen the department's curriculum, such as geochemistry, environmental geology, and geographic information systems are preferred. The Department of Geology at Whitman is a member of the Keck Geology Consortium and highly values student-faculty research programs that involve undergraduate students. Teaching responsibilities consist of two courses plus labs per semester and participation in departmental field trips and senior seminar. Whitman College is a highly selective liberal arts college located at the foot of the Blue Mountains, midway between the Cascades and Rockies. Submit letter of application, curriculum vita, evidence of teaching excellence, statement of research interest, and the names of three references from whom letters have been requested to: Chair of the Geology Search Committee, Department of Geology, Whitman College, Hall of Science, 345 Boyer Avenue, Walla Walla, WA 99362. Deadline: September 30, 2005. Applicants who would enrich the diversity of the campus community are strongly encouraged to apply. For additional information about Whitman College see: http://www.whitman.edu.

COLBY COLLEGE
FACULTY FELLOW (SABBATICAL REPLACEMENT)

The Department of Geology invites applications for a one-year Faculty Fellow (sabbatical replacement) position beginning 1 September 2006. The successful applicant will be expected to teach four undergraduate courses including: a Fall '06 upper division laboratory course of his/her choice; a January Program non-major's course; and a 100-level Introductory Historical Geology and a 200-level course in Paleontology (with laboratory) in Spring '07. The Fall and January term courses should complement those already offered in the department. Colby is a highly selective liberal arts college recognized for excellence in undergraduate education and for close student-faculty interaction. A Ph.D. with teaching experience at time of employment is preferred, but ABDs are encouraged to apply. Review of applications will begin 1 November 2005; interviews will be conducted at GSA in Salt Lake City. Applicants should submit a letter of application; curriculum vitae; statement of teaching and research interests; and names, e-mail addresses, and contact information for three (3) referees, to: Dr. Robert A. Gastaldo, Chair, Department of Geology, 5807 Mayflower Hill Drive, Waterville, ME 04901. Colby is an Equal Opportunity/Affirmative Action employer, committed to excellence through diversity, and strongly encourages applications and nominations of persons of color, women, and members of other under-represented groups. For more information about the College, please visit the Colby Web site: www.colby.edu.

U.S. GEOLOGICAL SURVEY MENDENHALL POSTDOCTORAL RESEARCH FELLOWSHIP PROGRAM

The U.S. Geological Survey (USGS) invites applications for the Mendenhall Postdoctoral Research Fellowship Program for Fiscal Year 2007. The Mendenhall Program provides opportunities to conduct research in association with selected members of the USGS professional staff. Through this Program the USGS will acquire current expertise in science to assist in implementation of the science strategy of its programs. Fiscal Year 2007 begins in October 2006.

Opportunities for research are available in a wide range of topics. The postdoctoral fellowships are two-year appointments. The closing date for applications is December 1, 2005. Appointments will start October 2006 or later, depending on availability of funds. A description of the program, research opportunities, and the application process are available at http://geology.usgs.gov/postdoc. The U.S. Geological Survey is an equal opportunity employer.

Opportunities for Students

Graduate Research Assistantship: Paleoclimatology, stratigraphy, stable isotopes at the University of New Mexico (Earth & Planetary Sciences). Applications sought for M.S. or Ph.D. students researching the origins of 3rd-order (My-scale) Paleozoic sea-level fluctuations using oxygen isotopes from apatitic conodonts. Field and lab work. Contact Dr. Maya Elrick, dolomite@unm.edu, (505) 277-5077.

Attention, Students! Looking for a job or an internship? Then join us in Houston for the 8th Annual National AAPG/SEG Student Expo on October 6–8, 2005! The Expo is a great opportunity for students to meet representatives from oil and gas and environmental companies, some of which recruit only at the Expo. Students will have the chance to showcase their research in a poster session and network with potential employers. Successful job searches result from the Expo every year. And use this occasion to explore Houston, a vibrant city, an oil capital, and home to the largest geoscientist population in the world! For registration and more information, please visit http://www.studentexpo.info/.

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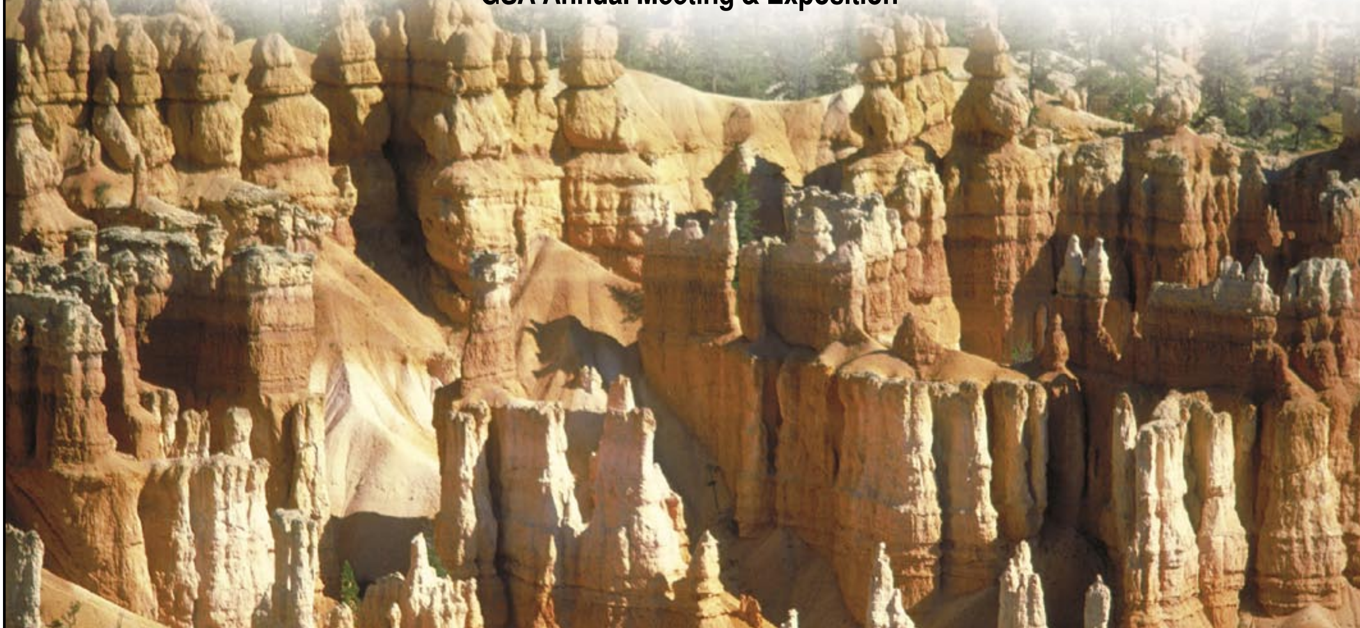

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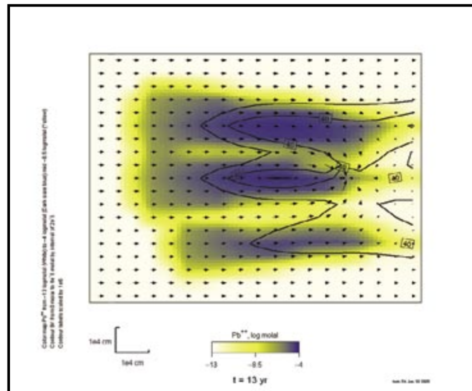

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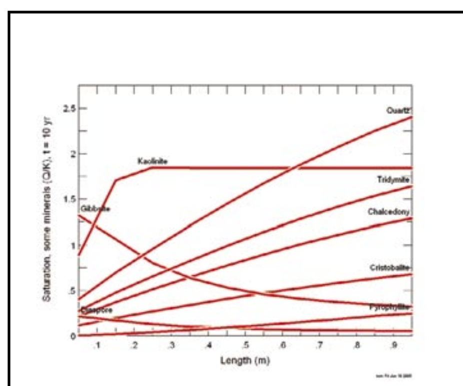

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