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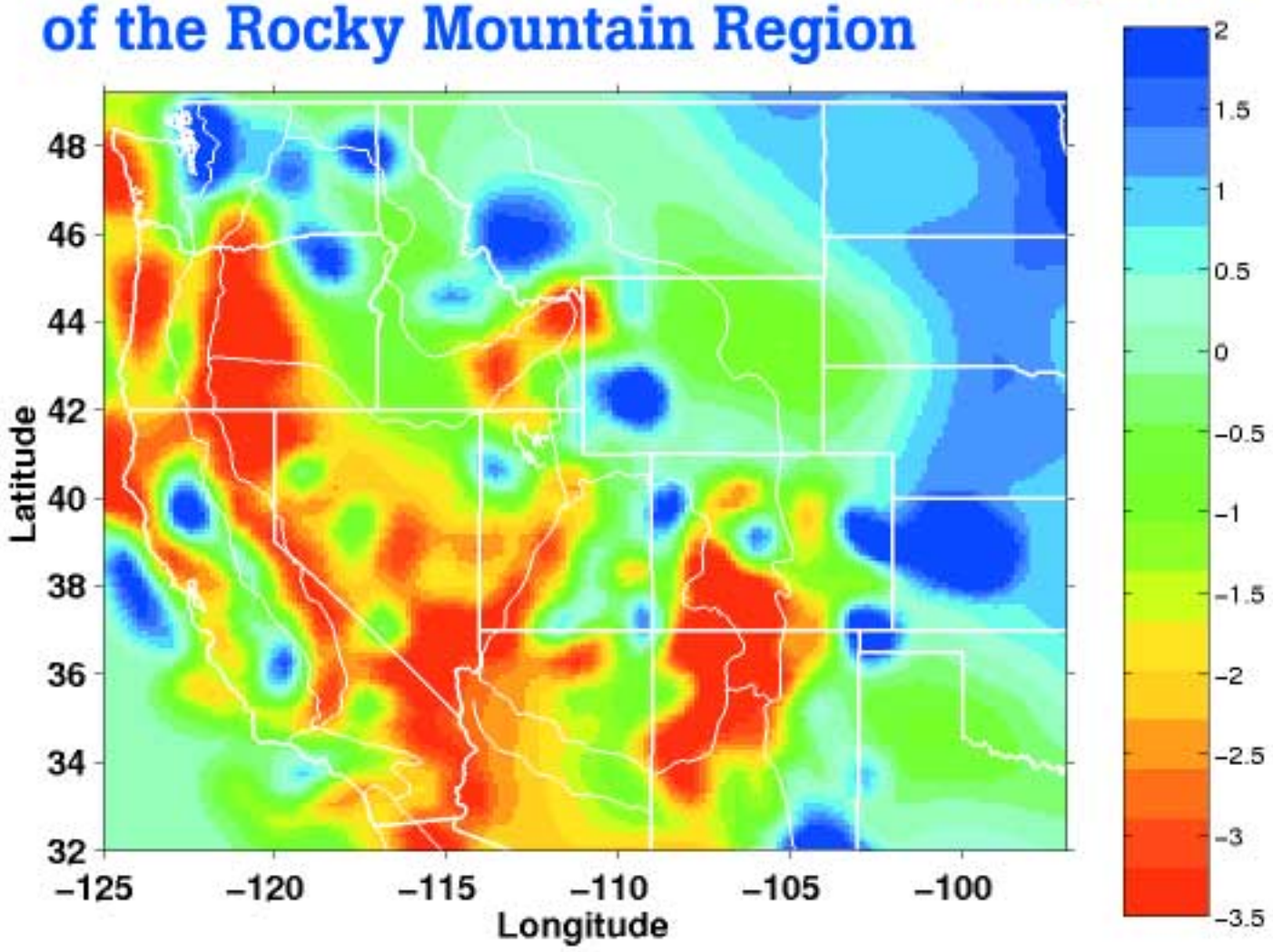
Thick-Structured Proterozoic Lithosphere of the Rocky Mountain Region



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science article

Ed. note: "Dialogue" will resume in 2002.

Thick-Structured Proterozoic Lithosphere of the Rocky Mountain Region

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ABSTRACT

A new tomographic image of the western United States shows three northeast-trending, low-velocity, upper mantle anomalies in the Rocky Mountain–Colorado Plateau region: the Yellowstone, Saint George, and Jemez lineaments. Each is characterized by small compressional wave-speed anomalies (±2% perturbations) that extend to 200–250 km depth. A fundamental question is whether they represent ongoing asthenospheric convection or old lithospheric compositional bodies. This puzzle is compounded by the observation that each is aligned with both young volcanic fields and Proterozoic crustal grain and/or sutures. We suggest that the low-velocity bodies are lithospheric anomalies and that they were derived from melting of hydrated olivine-poor lithologies (oceanic slabs, their associated sediments, and batholith residue) that were tectonically emplaced during Proterozoic suturing events. Such lithologies would be hydrated by the water in oceanic slabs and sediments trapped during the suturing processes. Our suggestion is consistent with the geochemical fingerprint of most of the young volcanics that indicate melting of an old and chemically diverse lithosphere that often contains a subduction zone trace-element signature. In addition, the sharp and dipping lateral velocity gradients bounding the low-velocity bodies, in particular where extensional deformation is small, suggest these bodies are not upwelling asthenosphere. This suggestion that the low-velocity bodies follow Proterozoic lithospheric sutures is supported by new teleseismic data from the Continental Dynamics–Rocky Mountains project that reveal a surprisingly thick continental lithosphere. In our transect across the Proterozoic Jemez suture, we find the coincidence of young lithospheric volcanism, a low-velocity mantle anomaly, and deep lithospheric layering (to 170 km). In our Wyoming-Colorado transects across the Archean-Proterozoic Cheyenne suture, we find the coincidence of deep mantle layering and a north-dipping, high-velocity slab, which extends (to 200 km depth) from the base of an imbricated Moho, directly under the Cheyenne suture. We suggest this slab was trapped against the edge of the thick, Archean-age Wyoming lithosphere after the subduction polarity flipped from south- to north-directed after and/or during accretion of the first Proterozoic arc along Wyoming's southern margin 1.78–1.75 Ga. Such a tectonic model for the evolution of the Cheyenne belt is consistent with observations along many other Archean-Proterozoic sutures worldwide. Overall, our results demonstrate that Proterozoic crustal sutures in the Rocky Mountain region extend throughout a thick chemical lithosphere and that young lithospheric melting has been focused along old suture zones. The coincidence of old deep structure and young tectonism supports the hypothesis that the lithospheric structure created during Proterozoic assembly provides a first-order control on the complex history of exhumation, deformation, sedimentation, and magmatism of this fascinating, tectonically active region.

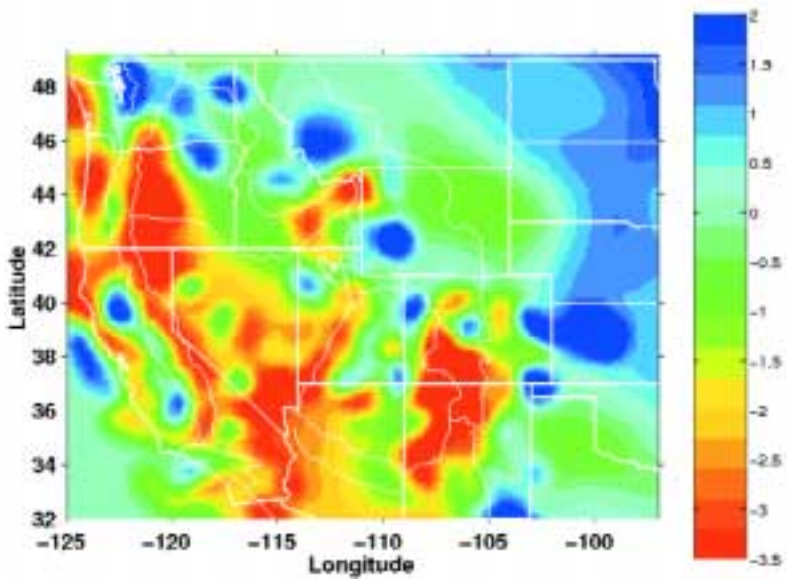

Figure 1. Image of compressional-wave velocity structure at 100 km depth made from combined inversion of P-wave data used to construct Fig. 2 and shear-wave velocity model of van der Lee and Nolet (1997). High velocities (blue shading) on eastern side of image reflect cold, stable tectospheric root present beneath North American craton, and low velocities (yellow and red shading) on western side of image reflect the generally thin lithosphere and warm asthenosphere. In between these two "end-member" regions is average velocity (green shading) Rocky Mountain region that is actively being reworked by interactions between lithosphere and asthenosphere. More detailed results from Continental Dynamics–Rocky Mountain project (Karlstrom, 1999) presented herein attempt to determine relationship between old lithospheric architecture associated with Archean-Proterozoic accretionary history of Rocky Mountain region and today's restless underlying asthenosphere.

INTRODUCTION

The active tectonics of the western United States represent widespread magmatic, strike-slip, and extensional activity

within a wide, deforming plate margin, where past and present tectonism is superimposed on a variety of lithospheric types. Figure 1 shows a tomographic image that depicts upper mantle P-wave velocity at 100 km depth. The high-velocity mantle on the easternmost side (beneath the western Great Plains) is the western edge of the lithospheric root of the North American plate, which extends to depths of 200–250 km (van der Lee and Nolet, 1997). This chemical lithosphere is thought to be high velocity because a buoyant, chemically differentiated root stabilizes the mantle root against convective disruption. This allows a cold, cratonic geotherm to be developed to 200–250 km depth, hence the thick chemical lithosphere coincides with thick thermal lithosphere. On the westernmost side of this image, very low velocities are found beneath the western United States plate margin and Basin and Range province (notable exceptions being the high-velocity subducting Juan de Fuca plate and the high-velocity body beneath the Sierra Nevada batholith). In this region, the thermal lithosphere is thin. In between these two velocity provinces lies a domain of average velocities beneath the Rocky Mountains and High Plains physiographic provinces (green colors on Fig. 1). This transitional domain is an important natural laboratory in which to study lithospheric evolution because it is a domain where the lithosphere is in a state of transition. We argue that in this area, the chemical lithosphere is still thick, while the thermal lithosphere is thinning.

WESTERN UNITED STATES TOMOGRAPHIC IMAGE

Western United States compressional wave images of the upper mantle (Fig. 2) demonstrate the heterogeneous nature of the velocity structure in the upper mantle. This high-quality image (i.e., 72% variance reduction) was created by inversion of ~80 000 hand-picked P-wave times from the more than one thousand short-period seismic stations operating in the western United States (Humphreys and Dueker, 1994). The majority of the velocity heterogeneity resides above 200 km depth, where lateral compositional and thermal variations are largest and the occurrence of partial melt is possible (Goes and van der Lee, 2001; Humphreys and Dueker, 1994). This image covers the area west of the stable North American interior and can be divided into two domains: (1) a margin-parallel domain dominated by the effects of plate subduction, and (2) an interior western United States

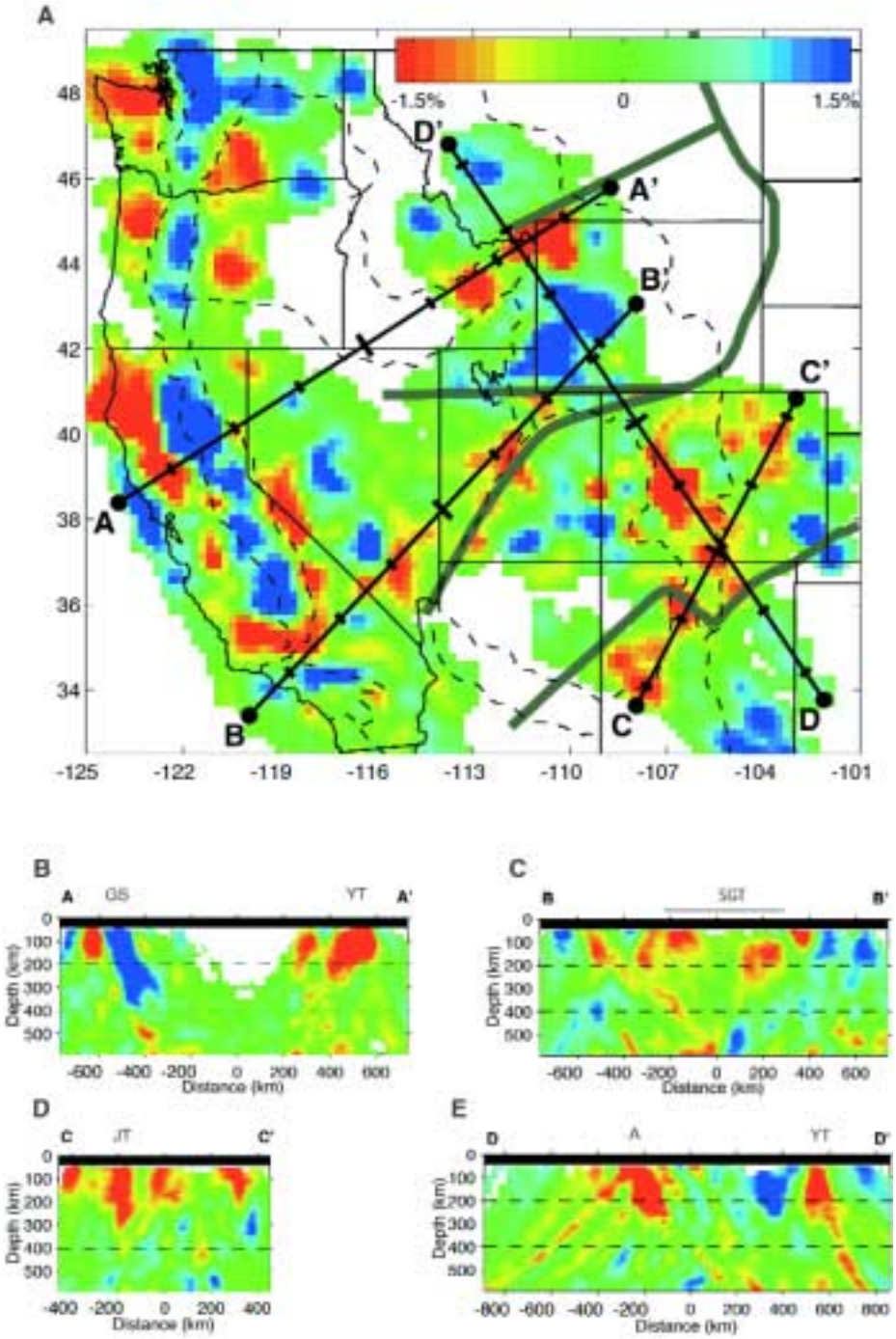

Figure 2. Tomographic P-wave velocity variations. Velocity variations are in percent P-wave velocity variations with red and blue representing slow and fast velocities respectively. Gray lines are Proterozoic lithospheric boundaries as described in text. **A:** Map view at 100 km depth with cross-sectional lines. Tic marks every 200 km along cross-section lines correspond to distance along cross sections. (Big tic mark is 0 km offset). **B:** High-velocity Gorda slab (GS) and Yellowstone trend (YT). **C:** Saint George trend (SGT). **D:** Jemez trend (JT). **E:** Yellowstone trend (YT) and Aspen anomaly (A).

domain where the effects of a thicker Archean-Proterozoic lithosphere, perhaps underlain by an organized pattern of asthenospheric activity, exist.

In the plate margin domain, the primary grain of the image is dictated by: the high-velocity slabs associated with subduction of the Juan de Fuca plate beneath Oregon, Washington, and northern California; the evolution of the low-velocity "slab window" beneath the San Andreas transform; and the high-velocity body beneath the Sierra Nevada batholith, which could be either late Cenozoic slab fragment(s) or the eclogitic facies root of the Sierra batholith (Ducea, 2001). In the interior western United States domain, the primary grain of the image is dictated by 100–200 km diameter low-velocity anomalies that line up to produce three northeast-southwest oriented, low-velocity trends associated with the Yellowstone, Saint George, and Jemez volcanic lineaments. The low-velocity body beneath central Colorado (the Aspen anomaly; Fig. 2E) being the notable exception to the northeast trends.

Do these low-velocity anomalies represent ongoing asthenospheric convection? An asthenospheric model to explain the origin of these low-velocity bodies and trends suggests they manifest the upwelling limbs of upper mantle convective rolls (Richter, 1973). Such a model would be supported in two ways: (1) When the asthenosphere is sheared by plate motion, modeling shows that convective roll axes preferentially align with their axes parallel to the shear, i.e., parallel to the southwest drift of the North American plate over the deeper mantle; (2) The preferred aspect ratio of such convective rolls is ~1, which for upper mantle processes predicts a roll spacing of 400–500 km. This would explain the anomalies (excluding the Aspen anomaly). A notable feature is the noncontinuous (i.e., blob-like) character of the low-velocity trends (e.g., the four low-velocity bodies beneath the Jemez lineament shown in Fig. 2D); this is consistent with lithosphere/asthenosphere dynamic simulations that include partial melt production and extraction (Tackley and Stevenson, 1993; Schmeling, 2000). Implicit in this asthenospheric model is that the Yellowstone hotspot is not the track of a deep mantle plume (Humphreys et al., 2000), but instead results from the organization of asthenospheric convection predicted to develop beneath moving plates. The force driving the volcanic propagation is the interaction between an actively melting asthenosphere, the depleted residuum this creates, and the upper mantle plate shear which "drags" the depleted residuum downstream of an active melt event or "burp" (see Schmeling [2000] for two-dimensional simulations of propagating melt instabilities that move at 2–4 cm/yr rates).

Or, do the low-velocity anomalies represent compositional variations within a thick lithosphere? A lithospheric model to explain these low-velocity trends (Karlstrom and Humphreys, 1998) suggests that low melting point materials trapped in Proterozoic suture zones localize melting of the lithosphere. For example, the Jemez and Saint George volcanic lineaments (Smith and Luedke, 1984) follow the suture zones associated with the 1.75–1.70 Ga Mojave-Yavapai suturing event and the 1.65 Ga Yavapai-Mazatzal suturing event, respectively. Direct evidence that low melting point materials reside in the mantle lithosphere beneath these regions comes from mantle xenoliths (e.g., Helmstaedt et al., 1975) and geochemical study of magmatic intrusions (Carlson and Nowell, 2001). However, this lithospheric suture model may fail to explain the Yellowstone volcanic track where no suture has been documented. Yet, it has been noted that the Yellowstone volcanic track does follow a Proterozoic structural trend and is coincident with a major crustal shear zone (the Madison shear zone; Erslev, 1993) that is coincident with a prominent magnetic and gravity lineament (Lemieux et al., 2000). If this crustal shear zone penetrates the entire lithosphere, it could provide a favorable rheologic anisotropy along which a lower lithosphere convective downwelling could develop, especially when the lithosphere is extending as it is along the Yellowstone hotspot.

These are end-member models, and the suggestion that either the lithosphere or the asthenosphere fully controls the evolution of these low-velocity trends is almost certainly incorrect because of the strong feedbacks between lithospheric and asthenospheric dynamics. For instance, to trigger the melting of low-solidus materials in suture zones requires an increase in heat input from the mantle and/or lithospheric thinning. One possible process to increase the heat input into the lithosphere would be to place the suture over the top of an upwelling asthenospheric roll. However, as the suture zone is rheologically weakened by the input of asthenospheric heat and melt, extensional deformation could localize along the upwelling, which would further enhance the asthenospheric upwelling. In the end, perhaps the young volcanic activity east of the central Basin and Range results from the parallelism between North America's absolute plate motion and the northeast-trending Proterozoic suture and/or shear zones. This scenario would favor the organization of the asthensophere into convective rolls parallel to the dominant northeast-southwest trend of the lithospheric boundaries discussed.

CONTINENTAL DYNAMICS–ROCKY MOUNTAINS PROJECT TOMOGRAPHIC IMAGE

A critical test of the importance of the lithospheric controls is to evaluate how thick the lithosphere is in the Rocky Mountain region and whether the lithosphere changes across old boundaries. Figure 3 shows new high-resolution tomographic images of the compressional- and shear-wave velocity structure beneath the Continental Dynamics–Rocky Mountains project (CD-ROM) transects. The 73% variance reduction of these images, along with resolution tests, indicates that these are high-quality images. The P- and S-wave images are well correlated, which suggests that the large-scale features in these images are correct. These transects were designed to image the deep structure beneath two major geologic boundaries in the Rockies. The Cheyenne belt is a suture in southern Wyoming between the Archean Wyoming craton to the north and the accreted Proterozoic island arcs to the south (Karlstrom and Houston, 1984). The Jemez lineament is an alignment of young volcanic centers in New Mexico that is believed to coincide with the boundary between two of the

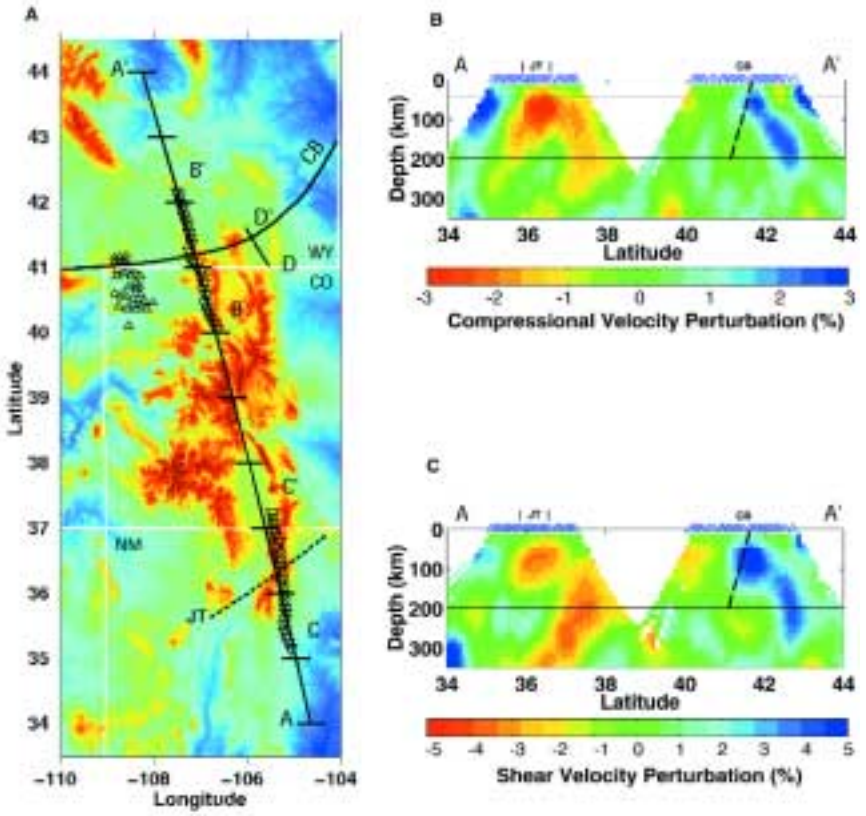

Figure 3. Tomographic image of P- and S-wave velocity variations beneath Continental Dynamics–Rocky Mountain project (CD-ROM) transects. Color bar denotes percent variation of velocity anomaly, with red and blue representing slow and fast velocities, respectively. CB—Cheyenne belt; JT—Jemez trend. Dashed black line under CB is deep expression of suture as found in Fig. 4. **A:** Topography and cross-sectional lines for Figs. 3 and 4. CD-ROM PASSCAL/IRIS broadband stations denoted as triangles. WY—Wyoming; CO—Colorado; NM—New Mexico. **B:** P-wave image. **C:** S-wave image.

Proterozoic arc terranes—the Yavapai province to the north and the Mazatzal province to the south (Karlstrom and Humphreys, 1998).

Beneath the Cheyenne belt, the primary structure seen in the tomography is a north-dipping, high-velocity "slab," which extends to 200 km depth. If this feature's velocity anomaly results from purely thermal effects, then it must be of late Cenozoic origin; otherwise, thermal diffusion would have smoothed the sharp lateral velocity variations along its margins. The two possible ways to produce a late Cenozoic thermal anomaly here would be either a convective instability of the lower lithosphere (Schott et al., 2000) or the stalling of a subducting slab. We dismiss the first possibility because the anomaly has features inconsistent with dynamical modeling of convective instabilities, i.e., the anomaly extends all the way to the base of the crust (see Fig. 4), and it has a 45° dip. The second possibility is dismissed because this feature is more than 1000 km inboard of the western United States plate margin and orientated at a high angle to the Cenozoic plate boundary. Therefore, because the velocity anomaly is correlated directly with an old suture, we interpret it to be a fossil oceanic slab dating back to the time of suturing along the Cheyenne belt at 1.78–1.75 Ga. Of course, the thermal signature of such an old slab would be long gone, thus the slab's velocity anomaly must result from some combination of a compositionally fast structure (e.g., a garnet-rich eclogite "slab" juxtaposed against a pyrolitic mantle) and/or an anisotropically fast structure where the seismically fast crystallographic A-axis of olivine is steeply plunging. We note that a sharp change in shear-wave splitting fast-axis orientation across the Cheyenne suture (Fox and Sheehan, 2001) supports the notion that sharp lateral variations in the lithospheric fabric are present. Given the geologic constraint that the accretion of the first Proterozoic arc along the Archean margin involved long-lived south-dipping subduction (Karlstrom and Houston, 1984), a tectonic model to emplace a north-dipping slab would require a polarity flip of the subduction zone during late stages of accretion of the first Proterozoic arc. In a recent review of the deep structure of Archean-Proterozoic margins, Snyder (2002) reports that cratonic margins, with outward-facing subduction zones, commonly flip subduction polarity during collision; furthermore, he cites the ongoing collision of the Banda arc with Australia as a modern-day example of an arc-continent collision in the process of flipping subducting polarity.

The primary velocity feature beneath the Jemez transect (JT in Fig. 3) is a low-velocity body that extends to 120 km. From a regional context (Fig. 2), this low-velocity body is one of a series of northeast-southwest–trending, upper mantle, low-velocity bodies that reside beneath the Jemez trend. A potential complication with this interpretation would be the adjacent Rio Grande rift. However, Figure 2 shows that the northeast-southwest–trending low-velocity bodies under the Jemez lineament dominate the upper mantle structure of this region, not the north-south–trending Rio Grande rift. This lack of an upper mantle seismic signature is consistent with the quite modest (<30 km) total net dilatation across the Rio Grande rift. Thus, our tomographic images in tandem with the lithospheric geochemical fingerprint of the Jemez volcanics (McMillan, 1998) suggest that the Jemez lineament is the dominant upper mantle structure here, not the Rio Grande rift. Finally, we note the south-dipping low-velocity "pipe" between 150 and 350 km depth (strongest in the S-wave image; Fig. 3C). Interestingly, the projection of this anomaly toward the surface connects it to the low-velocity Aspen anomaly beneath central Colorado (label A in Fig. 2E). One interpretation of this anomaly is as a mantle plume; yet, the 45° dip of the pipe is inconsistent with plume models. Another interpretation, given its strong dip, is as a

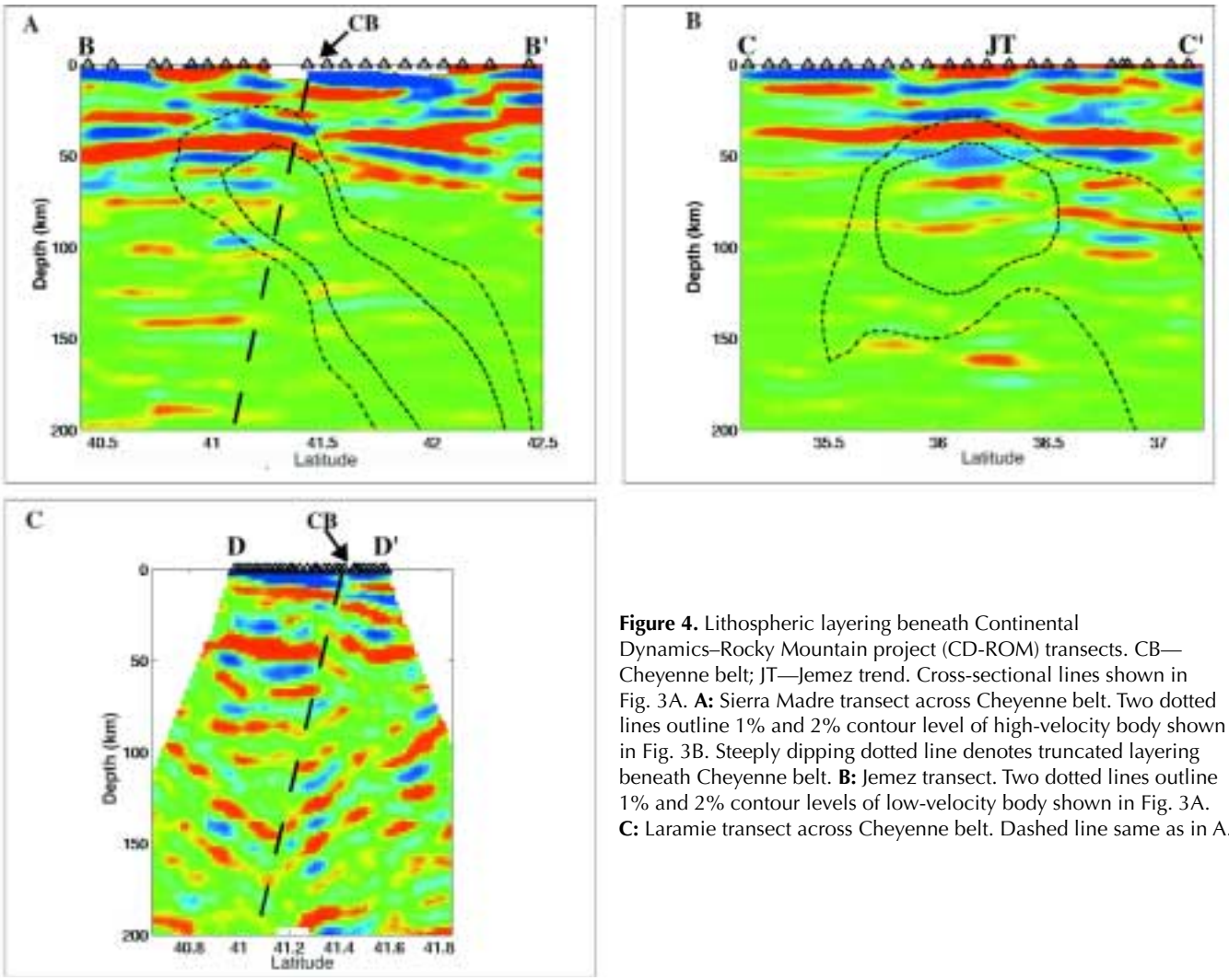

Figure 4. Lithospheric layering beneath Continental Dynamics–Rocky Mountain project (CD-ROM) transects. CB—Cheyenne belt; JT—Jemez trend. Cross-sectional lines shown in Fig. 3A. **A:** Sierra Madre transect across Cheyenne belt. Two dotted lines outline 1% and 2% contour level of high-velocity body shown in Fig. 3B. Steeply dipping dotted line denotes truncated layering beneath Cheyenne belt. **B:** Jemez transect. Two dotted lines outline 1% and 2% contour levels of low-velocity body shown in Fig. 3A. **C:** Laramie transect across Cheyenne belt. Dashed line same as in A.

lithospheric zone of low-solidus material that is partially molten. However, this interpretation would require a 350-km-thick chemical lithosphere, which conventional wisdom would say is too thick for this region. Thus, the best answer is: We do not know what this feature is.

LITHOSPHERIC LAYERING IMAGES

In Figure 4, images of shear-wave velocity discontinuities (called reflectors in active source seismology) from the surface to 200 km depth are shown. These images are constructed from earthquake recordings and consequently have much lower resolution than reflection data, but they can be used to image layering to much greater depths. To suppress unwanted reverberations in the image, velocity analysis has been used to identify direct arrivals and their associated reverberations. The red and blue shading represent significant interfaces with an increase in velocity (red) or decrease in velocity (blue) with depth. For example, in both transects at 40–50 km depth, the Moho is clearly imaged as a velocity increase (red). Given that velocity gradients reflect changes in the composition and/or fabrication of lithosphere, these images provide a snapshot of lithospheric layering or stratigraphy.

Two images of the lithospheric stratigraphy beneath the Cheyenne belt transects show a disrupted Moho directly beneath the surface exposure of the Cheyenne belt (Fig. 4A and 4C). In both transects the Proterozoic lower crust is underthrust beneath the Archean Moho, and mantle layering between the Moho and 100–190 km depth is truncated by the downward projection of a steeply south-dipping Cheyenne suture. In the Sierra Madre transect (B–B′), the Proterozoic mantle layering appears to truncate at the north-dipping, fossil slab imaged by tomography. Whereas in the Laramie basin transect (Fig. 4C), a lithospheric-scale "chevron fold" is observed between 100 and 170 km depth. This structure may be a fold or just a series of oppositely dipping, truncated reflections that match up. This structure is broadly consistent with the complex shortening history across the Cheyenne belt (Chamberlain, 1998) and further supported by the crustal wedging imaged by the CD-ROM reflection line (Morozova et al., 2001). The occurrences of diamond-bearing kimberlite pipes (McCallum et al., 1975) of Devonian age at the southernmost end of the Laramie transect (near label D in Fig. 3A) are good evidence that the lithosphere extended into the diamond stability field (i.e., 170 km depth). We

suggest that the sharp variations in mantle stratigraphy across the Cheyenne belt are good evidence that the arc-continent collision that formed the Cheyenne belt was a thick-skinned tectonic event with a signature that is still preserved in a 200-km-thick lithosphere.

The New Mexico transect (Fig. 4B) shows some difference with respect to the Cheyenne belt transects. Most notably, the Moho is relatively flat with no break in structure across the Proterozoic-Proterozoic Jemez suture, and there is less coherent structure below 90 km depth. We suggest these observations result from the thermal lithosphere being thinner (i.e., <120 km) and hotter than the lithosphere beneath the Cheyenne belt. However, the observation that horizontal mantle layering exists within the core of the low-velocity body, and the lithospheric geochemical fingerprint of the overlying Ocate volcanic field (McMillan, 1998), suggest that the low-velocity body is lithospheric, not asthenospheric. Further, the weak south-dip of the anomaly is in agreement with a set of south-dipping lower crustal reflectors (Magnani et al., 2001), which suggests an overall southerly dip for a Proterozoic paleosuture in this region. Whether the lithosphere is thinner here because the collisional processes that make continental lithosphere did not thicken the lithosphere as much as beneath the Cheyenne belt, or because there is warmer, low-velocity mantle beneath this region (Fig. 1) that has eroded and/or disrupted the preexisting lithosphere is unknown at this time.

CONCLUSIONS

Our foremost conclusion is that the chemical lithosphere, defined as the material that has been moving as part of the North American plate since the times of lithospheric formation, is thick for both Proterozoic and Archean lithosphere east of the Basin and Range province. This statement is supported by numerous xenolith and geochemistry studies. Thus, even though the subcrustal lithosphere is generally hot beneath the western United States, this mantle has been moving with the North American plate since it formed. To speculate what makes this possible, we note three outstanding observations: (1) The event that made the Transcontinental Proterozoic provinces (of which the lithosphere of the American Southwest is just a small part) was one of the largest crustal formation events in the history of the planet and suggests a massive interchange of mass and heat between the upper and lower mantle (Van Schmus et al., 1993); (2) The curiously slow cooling of the Proterozoic lithosphere in the southwestern United States (~1 °C/Ma; Bowring and Karlstrom, 1990) requires that a thick chemical lithosphere was constructed by the Proterozoic accretionary event; (3) The juxtaposition of this region next to one of the planet's largest tectospheric roots may shield it from the asthenosphere's convective forces.

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Doris M. Curtis Memorial Fund for Women in Science Award


Doris Curtis

Sponsored by Subaru of America, Inc.

The Women in Science Award is awarded to a woman or group of women who, based on their Ph.D. research, have made a major impact on the geosciences. This award is named in honor of Doris Curtis, a pioneer in the field.

The 2001 recipient is Ingrid Hendy, who received her Ph.D. in geological sciences in 2000 from the University of California at Santa Barbara. Her thesis was entitled "Rapid Climate Change Recorded in the North Pacific; Triggers, Processes and Effects."

In 2001, two women received honorable mentions. Emily E. Brodsky received her Ph.D. from the California Institute of Technology in 2000. Her thesis was entitled "Studies in Fluid Dynamics as Applied to Seismology and Volcanology." Carrie E. Schweitzer received her Ph.D. from Kent State University in 2000. Her dissertation was entitled "Systematics and Paleobiogeography of Fossil Decapod Crustaceans of the North Pacific Ocean."

SUBARU

Sponsored by Subaru of America, Inc.

Check the Web for 2002 GeoCorps America™ Positions

Positions available for the summer 2002 GeoCorps America™ program will be posted at www.geosociety.org in mid-December. You may apply online or download an application.

GeoCorps America filled 34 positions in national parks and forests in 2001. Through GeoCorps America, GSA works to increase the number of geoscientists working on public lands, raising awareness of the geosciences among the general public, the media, and land managers.

Coming in January: report on 2001 GeoCorps America participants.

www.geosociety.org

What's New on the Web?

Bookstore — *New and improved bookstore*

Online Journals — *Submit manuscripts online for* GSA Bulletin *and* Geology

Professional Development — *GSA Employment Service ads, classified ads, and GeoCorps America™ information*

New Process for Election of GSA Fellows

The election of Fellows by Council will now take place once a year at the spring Council meeting. This means all nomination paperwork needs to arrive at GSA Headquarters by **January 15, 2002.** On the new nomination form, in addition to your supporting statements of the nominee's qualifications, you'll be asked to provide a brief statement of why the nominee should be elected. This statement will go to Council along with the Committee on Membership's recommendation, and it will be published in *GSA Today* should that nominee be elected a Fellow.

In the past, all three nominators were required to be GSA Fellows. Now, one of the supporting signatures may come from a GSA member. As before, at least one of the three nominators must be from an organization other than that of the nominee. New Fellows will continue to be recognized at the Presidential Address and Awards Ceremony at the GSA Annual Meeting.

More information and the nominating form are available in the Member Services section of the GSA Web site, www.geosociety.org, or you may contact Joanna Conley at (303) 357-1007 or jconley@geosociety.org.

UPCOMING DEADLINES

Committee Service
Nominations Due February 1, 2002

Candidates are needed for service on the following GSA committees: Annual Program; Arthur L. Day Medal Award; Education; Geology and Public Policy; Honorary Fellows; Joint Technical Program; Membership; Minorities and Women in the Geosciences; Nominations; Penrose Conferences and Field Forums; Penrose Medal Award; Professional Development (formerly Continuing Education); Publications; Research Grants; and Young Scientist Award. Service begins July 2002.

Candidates are also needed for a GSA representative to the North American Commission on Stratigraphic Nomenclature. Service begins in July 2002.

For complete information on committee service, current vacancies, and required qualifications, see the October 2001 issue of *GSA Today*. Nomination form and instructions are available at www.geosociety.org/aboutus/commtees/, or from Member Services, (303) 447-2020, 1-888-443-4472, or member@geosociety.org.

Officers and Councilors
Nominations Due February 1, 2002

The GSA Committee on Nominations requests nominations for officers (vice president and treasurer) and councilors to serve on the GSA Council beginning in 2003. Each nomination should be accompanied by basic data and a description of the qualifications of the individual for the position recommended. Send nominations and background material to Administrative Services Dept., GSA, P.O. Box 9140, Boulder, CO 80301-9140.

Medals and Awards
Nominations Due February 1, 2002

Nominations of candidates are requested for the following medals and awards: Penrose Medal, Day Medal, Honorary Fellows, Young Scientist Award (Donath Medal), GSA Public Service Award, and Distinguished Service Award. For details on the awards and nomination procedures, see the October 2001 issue of *GSA Today*, go to our Web site at www.geosociety.org, or call (303) 357-1037. Materials and supporting information for any of the nominations may be sent to GSA, Grants, Awards, and Medals, P.O. Box 9140, Boulder, CO 80301-9140.

Congressional Science Fellowship
Applications Due February 1, 2002

For application information for the 2002–2003 GSA–U.S. Geological Survey Congressional Science Fellowship, check the Web site at www.geosociety.org/science/csf/, or contact Karlon Blythe, Program Officer, GSA Headquarters, (303) 357-1036, kblythe@geosociety.org.

Cole Awards
Applications Must Be Postmarked by February 1, 2002

The Gladys W. Cole Memorial Research Award provides support for the investigation of the geomorphology of semiarid and arid terrains in the United States and Mexico. GSA Members and Fellows between the ages of 30 and 65 who have published one or more significant papers on geomorphology are eligible for the award.

The W. Storrs Cole Memorial Research Award supports research in invertebrate micropaleontology for a GSA Member or Fellow between the ages of 30 and 65 who has published one or more significant papers on micropaleontology.

For application forms or for more information, contact Leah Carter, Grants, Awards, and Medals, GSA, P.O. Box 9140, Boulder, CO 80301-9140, lcarter@geosociety.org. Application forms are also available at www.geosociety.org.

2002 Doris M. Curtis Memorial Fund for Women in Science Award
Sponsored by Subaru of America, Inc.
Nominations Due February 1, 2002

The Doris M. Curtis Memorial Fund for Women in Science Award goes to a woman or group of women who have had a significant impact on the geosciences based on their Ph.D. research. For nomination, eligibility, and award details, visit www.geosociety.org/aboutus/admin/curtis.htm. Send nomination material to Grants, Awards, and Medals, GSA, P.O. Box 9140, Boulder, CO 80301-9140.

Student Research Grants
Applications Must Be Postmarked by February 1, 2002

For information on 2002 Research Grant Program for Students, see the October issue of *GSA Today* or visit www.geosociety.org. Application forms are available online, at the geology departments of colleges and universities offering graduate degrees in earth sciences, or from Grants, Awards, and Medals, GSA, P.O. Box 9140, Boulder, CO 80301, lcarter@geosociety.org.

Medlin Scholarship
Applications Due February 15, 2002

GSA Coal Geology Division's Antoinette Lierman Medlin Scholarship in Coal Geology for the 2002–2003 academic year: For details, see page 27 of this issue. Send application materials to: Leslie F. Ruppert, Coordinator, A. Lierman Medlin Scholarship Committee, U.S. Geological Survey, 956 National Center, Reston, VA 20192, (703) 648-6431, lruppert@usgs.gov.

John C. Frye Environmental Geology Award

Nominations Due March 31, 2002

Candidate nominations are needed for the John C. Frye Environmental Geology Award. For details, see the October 2001 issue of *GSA Today*, visit www.geosociety.org, or call (303) 357-1037. Materials and supporting information may be sent to GSA, Grants, Awards, and Medals, P.O. Box 9140, Boulder, CO 80301-9140.

National Awards

Nominations Due April 30, 2002

Candidate nominations are needed for the following national awards: William T. Pecora Award, National Medal of Science, Vannevar Bush Award, and Alan T. Waterman Award. For details, see the October issue of *GSA Today*. Nominations should be sent to GSA, Grants, Awards, and Medals, P.O. Box 9140, Boulder, CO 80301-9140.

Do all these deadlines make you want to get away?

Participate in a Field Forum to the Blue Ridge and Piedmont provinces of the Virginia Appalachians, or take a GeoTrip to Grand Canyon.

Field Forum Scheduled

Strain and Vorticity in High-Strain Zones, April 16–21, 2002, Virginia Blue Ridge and Piedmont. Cost: $625 ($300 for students), including guidebooks, handouts, meals, lodging (double occupancy), refreshments, and transportation to and from the Charlottesville airport. Registration, applications, and information: Christopher (Chuck) M. Bailey, Department of Geology, College of William & Mary, Box 8795, Williamsburg, VA 23187, (757) 221-2445, fax 757-221-2093, cmbail@wm.edu. For complete information, see the September issue of *GSA Today*, also available at www.geosociety.org/pubs/gsatoday/. (Incorrect costs were published in the November issue. *GSA Today* regrets the error.)

GeoVentures

GeoTrip: Geology of Grand Canyon—Lee's Ferry to Diamond Creek, April 21–28, 2002. Fees and payment: $2,050 for GSA Members; $2,150 for nonmembers. A $300 deposit is due with your reservation and is refundable through January 15, 2002, less a $50 processing fee. The total balance is due **February 21, 2002**. For complete information, see the October or November issues of *GSA Today*, also available at www.geosociety.org/pubs/gsatoday/.

Final Announcement

NORTHEASTERN SECTION, GSA

37th Annual Meeting • Springfield, Massachusetts • March 25–27, 2002

The hosts for the 2002 meeting of the GSA Northeastern Section are geologists from the University of Massachusetts, Mount Holyoke College, Greenfield Community College, Smith College, Amherst College, and Hampshire College. Meeting in conjunction are the Eastern Section of the Society for Sedimentary Geology (SEPM), the Northeastern Section of the Paleontological Society (NEPS), the Eastern New England Sections of the National Association of Geology Teachers (NAGT), the Association for Women Geoscientists (AWG), and the Council on Undergraduate Research (CUR), Geology Division. The meeting will be held at the Sheraton Springfield at Monarch Place, One Monarch Place, Springfield, MA 01144.

REGISTRATION

Preregistration deadline: February 15, 2002

Registration will be handled by GSA Headquarters. To obtain lower registration fees and to assist planning by the local committee, please preregister online at www.geosociety.org or use the preregistration form on p. 18.

Preregistration discounts are given to members of GSA and the associated societies listed on the preregistration form. Students and K–12 teachers must send or show a current ID in order to obtain these rates. Preregistration forms must be received by GSA no later than February 15, 2002. Register only one professional or student per form and retain a copy for your records. If you preregister, your badge will be mailed to you approximately two weeks prior to the meeting. For detailed information, visit www.geosociety.org/sectdiv/northe/02nemtg.htm.

CANCELLATIONS, CHANGES, AND REFUNDS

All requests for additions, changes, and cancellations must be made in writing and received by February 22, 2002. There will be NO refunds for on-site registration, *Abstracts with Programs*, or ticket sales. Members pay less. You can join now or at the meeting. Contact GSA Headquarters at 1-888-443-4472 or member@geosociety.org for further information.

ON-SITE REGISTRATION SCHEDULE

Sheraton Springfield, Lobby Area

Sunday, March 24	4–8 p.m.
Monday, March 25	7 a.m.–4:30 p.m.
Tuesday, March 26	7 a.m.–4:30 p.m.
Wednesday, March 27	7–10 a.m.

ACCESSIBILITY FOR REGISTRANTS WITH SPECIAL NEEDS

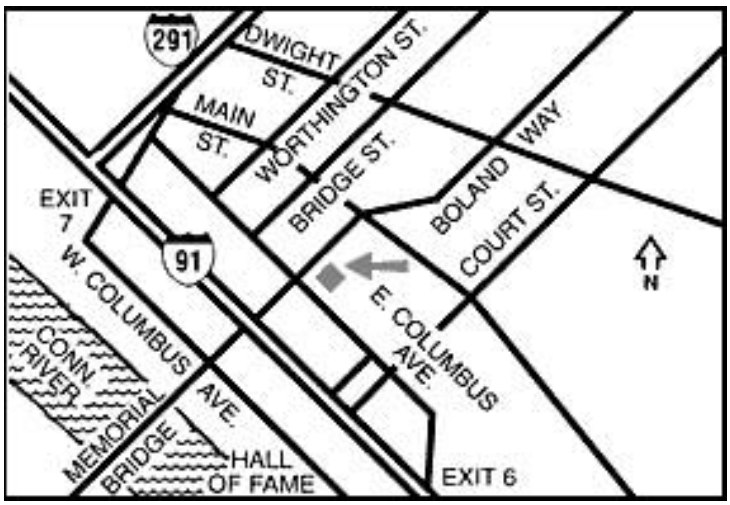
The GSA Northeastern Section is committed to making every event at its 2002 meeting accessible to all people interested in attending. If you have special requirements, please indicate this on the meeting registration form, or contact Sheila Seaman, Department of Geosciences, University of Massachusetts, Amherst, MA 01003, (413) 545-2822, fax 413-545-1200. Please let us know your needs by February 22, 2002.

LOCATION AND DIRECTIONS

Meeting registration, technical sessions, poster sessions, and exhibits will be in the Sheraton Springfield, One Monarch Place, Springfield, Mass. (See accompanying map or the GSA Web site.) Springfield is located on the eastern bank of the Connecticut River, just south of the intersection of I-91 and the Massachusetts Turnpike (I-90). Take exit 7 off of I-91 if traveling south to Springfield. Take exit 6 off of I-91 if traveling north to Springfield. The metropolitan area has a population of approximately 160,000 and was both the birthplace of basketball and the home of Dr. Seuss. The five colleges sponsoring the meeting are all located north of Springfield, in Amherst (University of Massachusetts, Amherst College, Hampshire College), South Hadley (Mount Holyoke College), and Northampton (Smith College). Temperatures in late March range from the 30s to the 50s (°F). The area is served by Bradley International Airport approximately 18 miles south and by both rail and bus service.

TECHNICAL PROGRAM

Oral sessions will normally include 15 minutes for presentation and five minutes for questions and discussion. Two 35 mm slide projectors, two screens, one overhead projector, one computer projector, and one laptop computer will be provided in each of the oral sessions. If you choose to use the computer projector, please arrive 45 minutes before the beginning of your session to load your presentation from your Zip disk onto the computer's hard disk. Please bring overheads of your presentation for use in case of computer, projector, or software incompatibility or malfunction. If you have any quesitons about the audiovisual set-up, please contact the technical services chair, Steve Dunn, Department of Earth and Environment, Mount Holyoke College, South Hadley, MA 01075, (413) 538-2531, fax 413-538-2239, sdunn@mhc.mtholyoke.edu, several weeks before the meeting.



Speaker Ready Room

A speaker ready room will be available at the Sheraton Springfield on Sunday, March 24, 6–10 p.m., Monday and Tuesday, March 25 and 26, 7 a.m.–9 p.m., and Wednesday, March 27, 7 a.m.–noon for previewing slides. Additional carousel trays may be signed out from the speaker ready room For those wishing additional technical services, please contact Steve Dunn, Department of Earth and Environment, Mount Holyoke College, South Hadley, MA 01075, (413) 538-2531, fax 413-538-2239, sdunn@mhc.mtholyoke.edu.

Poster Sessions

Poster sessions will allow three hours of display time; the authors must be present for two hours. Two 4 × 4 foot and one 4 × 8 foot boards will be provided for each U-shaped booth. Access to electrical outlets and furniture for poster sessions must be requested well in advance. Contact Peter Crowley, Department of Geology, Amherst College, Amherst, MA 01002, (413) 542-2715, fax 413-542-2713, pdcrowley@amherst.edu.

ABSTRACTS

Abstracts deadline: December 18, 2001

Abstracts for all sessions must be submitted online at the GSA Web site, www.geosociety.org. If you are unable to submit your abstract electronically, please contact the GSA technical program officer, Nancy Carlson, (303) 357-1061, ncarlson@geosociety.org. Only one volunteered paper may be presented by an individual. However, a person may be a co-author on other papers. Also, those invited for symposia may present additional papers.

SYMPOSIA

Symposia will include invited papers and selected volunteered papers. Prospective authors are encouraged to contact individual conveners directly. Address requests for general information regarding symposia to Mark Leckie or Michele Cooke, Department of Geosciences, University of Massachusetts, Amherst, MA 01003, (413) 545-1848 or (413) 547-3142; fax 413-545-1200, mleckie@geo.umass.edu; cooke@geo.umass.edu.

1. **Paleozoic Tectonics of the Northern Appalachian Mountains: New Insights and Persistent Problems: First Annual NETectonics Symposium.** Michael L. Williams, (413) 545-0745, mlw@geo.umass.edu; Scott E. Johnson, (207) 581-2142, johnsons@maine.edu.
2. **Geochemistry of Sedimentary Systems.** *Cosponsored with SEPM.* Bosiljka Glumac, (413) 585-3680, bglumac@science.smith.edu; Stephen Burns, (413) 545-0142, sburns@geo.umass.edu.
3. **New Perspectives on the Grenville Orogeny in the United States and Canada: A Symposium in Honor of James M. McLelland.** Art Goldstein, (315) 228-7203, agoldstein@mail.colgate.edu; Bruce Selleck, (315) 228-7200, bselleck@mail.colgate.edu; William Peck, (315) 228-6798, wpeck@mail.colgate.edu.
4. **Studies of Depositional Systems and Sedimentary Rocks: A Symposium in Honor of Edward Scudder Belt.** Allen Curran, (413) 585-3943, acurran@science.smith.edu.
5. **Tectonostratigraphy of Ophiolites.** Lirim Hoxha, 355-42-28703, lirimhoxha@yahoo.com.
6. **Fracture Hydrogeology in New England: Can it Be Deciphered? Challenges, Approaches, and Needs.** Gary Robbins, (860) 486-1392, gary.robbins@uconn.edu.

THEME SESSIONS

Theme sessions will include only volunteered papers. Prospective authors are encouraged to contact individual conveners directly. Address requests for general information regarding symposia to Michele Cooke (cooke@geo.umass.edu) or Mark Leckie (mleckie@geo.umass.edu).

1. **Holocene Climate and Lakes.** Mark Abbott, (412) 624-1408, mabbott@geo.umass.edu; Andrea Lini, (802) 656-0245, alini@zoo.uvm.edu.
2. **New Advances in Sedimentary Processes and Accumulation Forms: From the Shelf to the Estuaries.** Jon Boothroyd, (401) 874-2191, jon_boothroyd@uri.edu; Larry Ward, (603) 862-2175, lgward@cisunix.unh.edu.
3. **Rift Basins of the Northeast.** *Cosponsored with SEPM.* John Hubert, (413) 545-1525, jhubert@geo.umass.edu.
4. **New Frontiers in Geologic Microanalysis.** Michael J. Jercinovic, (413) 545-2431, mjj@geo.umass.edu; Michael L. Williams, (413) 545-0745, mlw@geo.umass.edu.
5. **Fractures, Lineaments, and Implications for Fluid Flow.** Michele Cooke, (413) 547-3142, cooke@geo.umass.edu; Robert Jacobi, (716) 645-6800, ext. 2468, rdjacobi@acsu.buffalo.edu; Ken Hardcastle, (603) 279-4425, Hardcastle@eggi.com; Steve Mabee, (413) 545-4814, sbmabee@geo.umass.edu.
6. **Watershed and Wetland Hydrology of the Adirondacks.** Christopher P. Cirmo, (607) 753-2924, cirmoc@cortland.edu; Edwin Romanowicz, (518) 564-2152, romanoea@plattsburgh.edu.
7. **Environmental Isotopes as Tracers in Water Resources Investigations.** Doug Burns, (518) 285-5662, daburns@usgs.gov; Robert Newton, (413) 585-3946, rnewton@science.smith.edu.
8. **Assessment of Anthropogenic Impact on Ground- and Surface-Water Quality.** Anna Veeger, (401) 874-2187, veeger@uri.edu; Tom Boving, (401) 874-7053, BOVING@URI.EDU; Lois K. Ongley, (207) 783-6952, loisongley@earthlink.net.
9. **K–16 Education: Earth and Environmental Science.** Richard Little, (413) 775-1445, RDLITTLE2000@cs.com; Mark McMenamin, (413) 538-2280, mmcmenam@mhc.myholyoke.edu.
10. **Undergraduate Research.** *Sponsored by the Geology Division of the Council on Undergraduate Research.* Peter Crowley, (413) 542-2715, pdcrowley@amherst.edu. POSTERS ONLY

SHORT COURSES

For more information on short courses, contact the short course organizer, Chris Condit, ccondit@geo.umass.edu.

All short courses will be held in Morrill Science Center, University of Massachusetts at Amherst. Please contact the instructors for further information.

1. **Geophysical Methods of Prospecting.** Sun., March 24, 9 a.m.–4 p.m. Frank Revetta, (315) 267-2289, revettfa@potsdam.edu, State University of New York—Potsdam. Most appropriate for those without experience in geophysical methods. Will include field exercises. Cost: $30 professional; $20 student. Max.: 10.
2. **Using CARIS GIS Software with a Focus on Producing Digital Geological Maps.** Two days, Sat. and Sun., March 23–24, 9 a.m.–5 p.m. Maria Luisa Crawford, (610) 526-5111, mcrawfor@brynmawr.edu, Bryn Mawr College; Walter van de Poll,

(506) 458-8533, vdp@unb.ca, University of New Brunswick; Allan Ludman, (718) 997-5900, allan_ludman@qc.edu, Queens College (City University of New York). Cost: $125 professional; $100 student. Max.: 40.

3. **The Construction of Dynamic Digital Maps and Virtual Field Trips.** Sun., March 24, 9 a.m.–5 p.m. Chris Condit, (413) 545-0272, ccondit@geo.umass.edu, Department of Geosciences, University of Massachusetts. Cost: $30 professional; $20 student. Max.: 20.

4. **Microprobe Monazite Geochronology: Methods, Applications, and Challenges for the Future.** Sun., March 24, 1–5 p.m., Room 161, Morrill Science Center South. Michael L. Williams, (413) 545-0745, mlw@geo.umass.edu; and Michael J. Jercinovic, (413) 545-2431, mjj@geo.umass.edu, University of Massachusetts. Cost: $30 professional, $20 student. Max.: 20.

WORKSHOPS

1. **Roy J. Shlemon Mentor Program in Applied Geology.** Mon., March 25, 11:30 a.m.–1:30 p.m., Suffolk Room, Sheraton Springfield. Practical advice for graduate and undergraduate students with career interests in consulting. This is a workshop on professional opportunities and challenges in the applied geosciences. Cost: $5 (includes lunch). Max.: 20. Preregistration is required, however, meeting registration is not required to attend this workshop.

2. **Workshops for Geoscience Educators.** Tues., March 26, Ballroom South, Sheraton Springfield. Workshops will be followed by the NAGT Luncheon (see Special Events), by the afternoon theme session "K–16 Education: Earth and Environmental Science," and by the late afternoon–early evening tour of the Springfield Science Museum (see Special Events).

   8:30–9:30 a.m.: Introduction to Connecticut Valley Geology. Richard Little, Greenfield Community College, (413) 775-1445, little@gcc.mass.edu. Learn the basics of our region's exciting and diverse geologic history in this fast-paced presentation. Educational materials will be available.

   9:45–10:45 a.m.: Emerging Themes in Geology. Six college staff members. Find out what's new in the earth sciences. This workshop will explore topics that have not generally made it into the textbooks yet.

   11 a.m.–noon: Effective Teaching and Learning Through STEMTEC. Panel discussion. The Science Technology, Engineering, and Mathematics Teacher Education Collaborative, a multiyear National Science Foundation–funded initiative, is a partnership between public and private two- and four-year colleges and school districts with a varied population. The focus is on improving teaching and learning in the classroom, motivating college science majors to consider teaching as a career, and providing support for new and veteran teachers in K–12 classrooms. Come and see how some new ideas and approaches can be integrated into your K–16 classroom.

FIELD TRIPS

Trips planned at this time are listed below. The trips will run depending on weather. Wear boots and warm clothing! For more information on field trips, contact either of the field trip committee chairs, Michael Williams (mlw@geo.umass.edu) or John Hubert (jhubert@geo.umass.edu).

1. **Mesozoic Deerfield Basin, Massachusetts.** *Cosponsored by SEPM.* Sun., March 24, 9 a.m.–4:30 p.m. John F. Hubert, jhubert@geo.umass.edu; Peter T. Panish, panish@acad.umass.edu; James A. Dutcher, University of Massachusetts. Meet in parking lot 62, south of Morrill Science Center, University of Massachusetts at Amherst. Lunch provided. Due to late winter conditions, all participants must ride on the bus in which the geology of each stop will be presented. No private cars. Max.: 30; min.: 12. Preference given to registered professionals. Cost: $35.

2. **Dynamic Events and Processes in the Devonian Catskill Front, Eastern New York.** *Cosponsored by SEPM.* Sun., March 24, 7 a.m.–6 p.m. Chuck Ver Straeten, (518) 486-2004, cverstra@mail.nysed.gov, New York State Museum. Meet in the lobby of the Sheraton Springfield. Lunch provided. Max.: 30. Cost: $60 professionals; $50 students.

3. **A Tectonic-Stratigraphic Examination of the New England Caledonides in West-Central Massachusetts.** Sun., March 24, 8 a.m.–5 p.m. Peter Robinson, Peter.Robinson@ngu.no, University of Massachusetts and Geological Survey of Norway. Meet in parking lot 62, south of Morrill Science Center, University of Massachusetts at Amherst. Lunch provided. Max.: 20. Cost: $40 professionals; $30 students.

STUDENT AWARDS AND TRAVEL ASSISTANCE

The Kenneth N. Weaver Student Award Program of the Northeastern Section, in cooperation with the GSA Foundation, will provide travel assistance to students presenting papers at the Springfield meeting. Travel awards are open to both graduate and undergraduate students. Completed applications are due January 25, 2002. Undergraduates in the Northeastern Section, who are juniors in the 2001–2002 academic year, are also eligible to apply for a research grant under the Kenneth N. Weaver Student Award Program. Completed proposals are due February 22, 2002. For information and application forms, please contact Stephen Pollock, Secretary and Accounting Officer, GSA Northeastern Section, pollock@usm.maine.edu.

EXHIBITS

Exhibits will be located in Ballroom North of the Sheraton Springfield; snacks and refreshments will be available for exhibit visitors. The deadline for reserving space is March 14. The cost of standard booths will be $400 for commercial exhibitors and $200 for educational or nonprofit groups or institutions. For further information and space reservations, contact the exhibits coordinator, Sheila Seaman, Department of Geosciences, Morrill Science Center, University of Massachusetts, Amherst, MA 01003, (413) 545-2822, sjs@geo.umass.edu.

SPECIAL EVENTS

GSA Northeastern Section Management Board Meeting. Sun., March 24, 5–7 p.m., Sheraton Springfield, Executive Boardroom.

Welcoming Reception. Sun., March 24, 6–9 p.m., Sheraton Springfield, Mahogany Room/Atrium.

Paleontological Society Northeastern Section Luncheon. Mon., March 25, noon–1:30 p.m. Sheraton Springfield, King George Room. Cost: $27 professionals; $15 students. Preregistration required. Max.: 30.

Eastern Section of SEPM Business Meeting and Reception. Mon., March 25, 5–7 p.m. Sheraton Springfield, Mahogany Room.

Map Blast V. Mon., March 25, 7:30–9:30 p.m. Sheraton Springfield, Longford Room. An informal session for display and discussion of newly published, unpublished, or in-progress geologic maps of any sort. Contact Michael Williams, Department of Geosciences, University of Massachusetts, Amherst, MA 01003, (413) 545-0745, mlw@geo.umass.edu.

Association for Women Geoscientists Breakfast Buffet. Tues., March 26, 6–8:30 a.m. Sheraton Springfield, Mahogany Room. Cost: $18 professionals; $10 students. Preregistration required. Max.: 40.

Northeastern Section of NAGT Luncheon and Business Meeting. Tues., March 26, noon–1:30 p.m. Sheraton Springfield, Mahogany Room. Cost: $27 professionals; $15 students. Max.: 30.

Springfield Science Museum Tour and Reception. Tues., March 26, 4–7 p.m., with refreshments. Cost: $15 professionals; $10 students.

GSA Northeast Section Reception and Banquet. Tues., March 26, 6–9 p.m. Sheraton Conference Center, Ballroom South. Speaker: Lynn Margulis, Department of Geosciences, University of Massachusetts, Amherst, Mass. Cost: $28–$33 professionals; $18–$23 students. Preregistration is required for the banquet.

ACCOMMODATIONS

Meeting participants will get special rates at the Sheraton Springfield, (413) 781-1010 or 1-800-426-9004. *Reservations must be made by March 1, 2002.* In order to receive the GSA rate, telephone requests must identify affiliation with the Northeastern Section, GSA. Rates cannot be changed at check-in or check-out for guests who fail to identify their affiliation at the time the reservation is requested. Reservation requests received after March 1, 2002 will be accepted on a space-available and rate-available basis. Single or double: $109 plus tax; triple or quadruple: $114 plus tax.

PARKING

The Sheraton Springfield has indoor parking spaces directly beneath the hotel, as well as enclosed spaces in the Interstate 91 South lot connected to the hotel by an enclosed skywalk. Day parking has been discounted to $4 per day for those attending the meeting. The parking charge for overnight guests is $10 per night.

GUEST ACTIVITIES AND EVENTS

Additional guest activities and events will be listed on the Web site as they become available.

Fun Run. Mon., March 25, and Tues., March 26, mornings. Information available at the registration desk.

Yankee Candle Company and Car Museum, South Deerfield. Mon., March 25, 9 a.m.–2 p.m. The flagship store of the famous candle company features candles, gifts, a restaurant, and a car museum. Cost: $25.

Downtown Northampton, Mass. Mon., March 25, 10 a.m.–3 p.m. Great specialty stores, restaurants, the Words and Pictures Museum (of visual arts), bookstores, Smith College campus with arboretum. Cost: $25.

Basketball Hall of Fame, Springfield, Mass. Tues., March 26, 1–3:30 p.m. Cost: $27.

Emily Dickinson Homestead, Amherst, Mass. Tues., March 26, 1–5 p.m. Tour of the home of the famous poet and of The Evergreens, the recently renovated next-door estate of her brother, Austin Dickinson, and his wife, Susan. Cost: $30.

DETAILED INFORMATION

For further information, see www.geosociety.org or contact the general chair, Sheila Seaman, Department of Geosciences, University of Massachusetts, Amherst, MA 01003, (413) 545-2822, sjs@geo.umass.edu, or the technical program chairs, Michele Cooke, (413) 547-3142, cooke@geo.umass.edu, and Mark Leckie, (413) 545-1948, mleckie@geo.umass.edu, Department of Geosciences, University of Massachusetts, Amherst, MA 01003.

Preregistration Form

GSA NORTHEASTERN SECTION MEETING • SPRINGFIELD, MASS. • MARCH 25–27, 2002
Preregistration deadline: February 15, 2002 Cancellation deadline: February 22, 2002
Register online at www.geosociety.org.

GSA Mbr #_____

First Name _____ Last Name _____

Mailing address Is this a permanent address? ☐ Yes ☐ No Is this home ☐ or work ☐

City _____ State or Province _____ ZIP or Postal Code _____ Country _____

E-mail _____ Daytime Phone _____ Fax _____

Badge Information

First Name/Nickname _____

School/Company _____ City/State/Prov. _____

Spouse/Guest First Name/Nickname _____ Last Name _____ City/State/Prov. _____

Do you or your guest require any special considerations? ☐Yes ☐No

Check member affiliation(s) (to qualify for registration member discount): ☐ (a) GSA
☐ (b) AWG ☐ (c) CUR ☐ (d) NAGT ☐ (e) NEPS ☐ (f) PS ☐ (g) SEPM

Preregistration Fees (US$)	Full Meeting	US$ Amt.	One Day	US$ Amt.
Professional Member*	(10) $75	$_____	(11) $45	$_____
Professional Member 70 & Older	(12) $30	$_____	(13) $25	$_____
Professional Nonmember	(14) $95	$_____	(15) $60	$_____
Student Member or Student Associate*	(30) $27	$_____	(31) $22	$_____
Student Nonmember	(32) $37	$_____	(33) $32	$_____
Guest or Spouse**	(90) $20	$_____	N/A	$_____
K–12 Professional	(60) $35	$_____	(61) $20	$_____
Short Course or Field Trip Only	(95) $ 5	$_____	N/A	$_____
			Total	$_____

*Member fee applies to any current Professional OR Student Member of GSA or Associated Societies listed above. Discount does not apply to guest registrants. **Guest or Spouse registration fee does not allow access to technical sessions.

FAX TO: **303-357-1071 or 303-357-1072**

MAIL TO: **2002 GSA NORTHEASTERN SECTION MEETING**
P.O. BOX 9140, BOULDER, CO 80301-9140

Remit in U.S. funds payable to 2002 GSA Northeastern Section Meeting

*(All preregistrations must be prepaid. **Purchase orders not accepted.**)*

Payment by (check one): ☐ Check #_____ ☐ American Express ☐ VISA ☐ MasterCard ☐ Discover

Card Number _____ Expires _____

Signature _____

GSAT Jan.02

TICKETED EVENTS

			Qty	Amount
1. Paleontological Society Luncheon—Mon., March 25	Professional	(301) $ 27	_____	$_____
	Student	(301) $ 15	_____	$_____
2. AWG Breakfast Buffet—Tues., March 26	Professional	(302) $ 18	_____	$_____
	Student	(302) $ 10	_____	$_____
3. NAGT Luncheon—Tues., March 26	Professional	(303) $ 27	_____	$_____
	Student	(303) $ 15	_____	$_____
4. Springfield Science Museum Tour and	Professional	(304) $ 15	_____	$_____
Reception—Tues., March 26	Student	(304) $ 10	_____	$_____

5. GSA Northeastern Section Reception and Banquet—Tues., March 26

	Chicken Marsala	Vegetable Ravioli		
Professional	☐ (305) $ 33	☐ (306) $ 28	_____	$_____
Student	☐ (305) $ 23	☐ (306) $ 18	_____	$_____

FIELD TRIPS

1. Mesozoic Deerfield Basin—Sun., March 24		(401) $ 35	_____	$_____
2. Devonian Catskill Front—Sun., March 24	Professional	(402) $ 60	_____	$_____
	Student	(402) $ 50	_____	$_____
3. New England Caledonides—Sun., March 24	Professional	(403) $ 40	_____	$_____
	Student	(403) $ 30	_____	$_____

SHORT COURSES

1. Geophysical Prospecting—Sun., March 24	Professional	(501) $ 30	_____	$_____
	Student	(501) $ 20	_____	$_____
2. Using CARIS—Sat. and Sun., March 23–24	Professional	(502) $125	_____	$_____
	Student	(502) $100	_____	$_____
3. Dynamic Digital Mapping—Sun., March 24	Professional	(503) $ 30	_____	$_____
	Student	(503) $ 20	_____	$_____
4. Microprobe Monazite Geochronology—Sun., March 24	Professional	(504) $ 30	_____	$_____
	Student	(504) $ 20	_____	$_____

GUEST ACTIVITIES

1. Yankee Candle Company & Car Museum—Mon., March 25		(101) $ 25	_____	$_____
2. Downtown Northampton, Mass.—Mon., March 25		(102) $ 25	_____	$_____
3. Basketball Hall of Fame—Tues., March 26		(103) $ 27	_____	$_____
4. Emily Dickinson Homestead—Tues., March 26		(104) $ 30	_____	$_____

WORKSHOP

1. Roy Shlemon Mentor Program in Applied Geology	Student	(601) $ 5	_____	$_____

Student Workshop—Mon., March 25 ***(Meeting registration is not required to attend this workshop.)***

Subtotal $_____

Registration Fees $_____

TOTAL FEES REMITTED **$**_____

The Geological Society of America

Science at the Highest Level

Denver 2002

IMPORTANT DATES

January 17, 2002	Pardee Keynote Symposia and Topical Session proposals due. Forms are available at www.geosociety.org/meetings/2002/.
April 2002	Call for Papers in April issue of *GSA Today*
June 2002	Registration and housing information in June issue of *GSA Today*
July 16, 2002	Abstracts due

Exhibit Space is available. Call Brenda Martinez at 1-800-472-1988, ext. 1038, for an Exhibitor Prospectus.

For more information, contact:

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ROCK STARS

Francis Parker Shepard, 1897–1985

Joseph R. Curray
Professor of Geology Emeritus, Scripps Institution of Oceanography

Francis Parker Shepard—"Fran" to his colleagues and students—was not of humble beginnings, but was the son of a moderately wealthy family of Peaches Point, Marblehead, Massachusetts, where he attended mainly private schools. At 14, he took his first trip to Europe and discovered a love for mountains, even though he broke his leg on his first venture into the Dolomites. Discovering this fascination with mountains was certainly an early influence in his life and career. Another influence—the fact that his father owned a rather large and comfortable yacht—undoubtedly led to his turning to marine geology.

Shepard's career in geology had two periods: structural geology and mountains, and marine geology (he called it submarine geology). But throughout both careers, he showed the same characteristics. He was an observer who interpreted what he observed. He was skeptical of theoretical analyses and preferred to overwhelm his opposition with extensive collection of data. He was efficient, hardworking, and prolific: He published more than 200 papers and authored or co-authored ten books. And he loved to challenge and upset cherished dogma. In the second and greater of two careers, Shepard was frequently called the Father of Marine Geology. In a wonderful story about his first meeting with the venerable Madame Klenova of the USSR Institute of Oceanography in 1956, she remarked warmly, "You are the father of marine geology, and I am the mother of marine geology." To this, Elizabeth, Shepard's lovely wife for well over 50 years, replied, "And that, in turn, must make me the concubine."

Shepard described himself as a poor student, but he earned his degree in geology at Harvard in about two and a half years, before and after serving briefly in the Navy during the First World War. R.A. Daly, J.B. Woodward, and Charles Palache were among his influential professors. Also while at Harvard, he met one of his sister's friends from Vassar, Elizabeth Buchner. When selecting a graduate school, he was influenced by the fact that Elizabeth lived in Milwaukee, and he decided on the University of Chicago. There, he fell under the influence of R.D. Salisbury, J. Harlan Bretz, and Rollin T. Chamberlin, son of T.C. Chamberlin. During his three years at Chicago, immediately after T.C. Chamberlin's retirement, students and colleagues took Chamberlin's ideas almost as a religion, and the general attitude was that most of the important problems in geology had been solved. Shepard was challenged to prove otherwise.

Francis Parker Shepard ca. 1920 as a navy cadet at Harvard with his future bride, Elizabeth Buchner.

R.C. Chamberlin was working in the Rocky Mountains, so Shepard took up the study of structural geology, and did his dissertation on the Rocky Mountain Trench. He and Elizabeth spent their honeymoon in the field, camping in a pup tent for three months. They had no car, so they traveled by train from area to area, packing with them Elizabeth's wardrobe trunk with her trousseau. The trunk sat unopened at each railway station during the three-month trip, while the couple traveled with two duffel bags in ranchers' cars, by horseback, by wheelbarrow, and by backpacking. Elizabeth, who helped keep records organized, was always a true partner in Shepard's research, from that first adventure to the cruises I took with the two of them many years later.

Shepard received his Ph.D. in 1922 and became an instructor at the University of Illinois. His interest in structural geology and tectonics continued, and he published his first 11 papers on the subject. As a young graduate student, I remember reading his 1923 paper "To question the theory of periodic diastrophism." I did not realize it at the time, but this was the start of his lifelong love of challenging recognized authority in geology. Only a year after receiving his Ph.D., he was questioning the ideas of T.C. Chamberlin, R.T. Chamberlin, Charles Schuchert, Bailey Willis, and others.

Shepard's father, the head of Shepard Steamship Line, was an avid sailor, and when Elizabeth was expecting her first child in 1923, he offered his son the use of his yacht that summer so he could do "some kind of geological work," rather than field work in the mountains. This was to be the start of the second phase of his career. The story has become legend in marine geology that he took surface sediment samples from the continental shelf off the New England coast and did not find what theory had predicted. Some of the coarsest sediments do not lie near the shore, but near the shelf edge. After several more summers in Marblehead broadening his survey area, and after considerable study of the notations on published navigation charts, he published a 1927 abstract, "Influence of oscillating sea level on the development of the continental shelf," to be followed by his classic 1932 paper, "Sediments of the continental shelves." This was the first study of the subject documented with observations and interpretations. He also challenged existing ideas, proposing a glacial origin of some of the trough-shaped valleys off the northeastern Canadian coast and a lowered sea level–river erosion origin of other submarine valleys.

Shepard was now well into the second and more important stage of his career: that of a submarine geologist. The ready availability of ship time was certainly a contributing factor in this change. His interests broadened through increasing study of published charts. He was given a grant from the University of Illinois to obtain charts from all over the world. As he published papers on submarine canyons, submerged deltas, sea-level changes, and continental shelves, he was able to back up observations from his study area with global observations from these charts. And he continued to challenge authority by rejecting some of the ideas on coast classification of the eminent coastal geomorphologist, Douglas Johnson. Also during this period, he developed a mutually beneficial relationship with the U.S. Coast and Geodetic Survey, and worked with the captains of several of its vessels off other U.S. coasts.

Shepard started working on California submarine canyons during a sabbatical leave in 1933. In 1936, he made another major career change. In that year, Charles Palache, his former professor at Harvard, became the president of the Geological Society of America. He changed the GSA policy of making only small research grants and recommended that Shepard apply for a "very large" grant of $10,000. T. Wayland Vaughn (see "Rock Stars," *GSA Today*, November 1995, v. 5, p. 233–234), then the director of the Scripps Institution of Oceanography, encouraged Shepard to use the institution's new ship, the 96-foot *E. W. Scripps*, for his research on canyons of the California continental margin. So, in 1937, he took a leave from the University of Illinois, and brought his family and two of his promising graduate students—Robert S. Dietz, who arrived by hitchhiking, and K.O. Emery, who rode boxcars—to La Jolla. For the $10,000, Shepard had six months ship time and paid his two assistants, who developed and built the necessary equipment. He continued teaching at the University of Illinois, but now also had a formal relationship with Scripps.

Francis Parker Shepard in 1937 with a model of one of the submarine canyons he had surveyed.

Shortly after the bombing of Pearl Harbor, Shepard moved to La Jolla to join the University of California Division of War Research. During the war, he compiled continental-shelf sediment charts for use in submarine warfare and conducted harbor approach studies in California, Hawaii, and Midway. After the war, he resigned from Illinois and accepted a permanent appointment at Scripps, where he spent the rest of his distinguished career.

Many geologists know Shepard's subsequent career from his many papers and books. His first text, *Submarine Geology*, was a standard for the subject for many years after publication of the first edition in 1948. He completed publication of his prewar surveys of California submarine canyons and the Gulf of California, and he continued his work on submarine canyons and coastal processes and classification. From 1951 to 1960, he was in charge of the American Petroleum Institute study (API Project 51) of the coastal, deltaic, and continental-shelf areas of the northwest Gulf of Mexico. The study produced a remarkable collection of papers by Shepard, his students, and his colleagues, compiled in a summary volume in 1960.

After leading the API Project 51, Shepard once again returned to his earlier interests: submarine canyons, coastal processes and features, and sea-level changes. By this time, his international recognition started bringing him awards and honors. He was an honorary member and president of international geological societies, received two honorary doctorates, and received the Wollaston Medal from the Geological Society of London and the Sorby Medal from the International Association of Sedimentologists. Each year, the Society for Sedimentary Geology awards one of its major medals, the Francis P. Shepard Medal, for excellence in marine geology.

Shepard conveyed his enthusiasm to all those around him and to two generations of graduate students over his long years of teaching. To them and to his colleagues and associates, he was an ever kind and generous friend. His manner was gentle, even courtly. He continued to work long after his formal retirement in 1966, spending at least a part of every weekday in his office, until frailty and illness made his visits less frequent. Even then, he continued working at home, literally until the day before his death.

Acknowledgments

I thank Tom Shepard, Tim Shepard, and Dave Moore for assistance in preparation of this brief biography. I have also drawn extensively from Shepard's unpublished autobiography.

Further Reading

Dietz, R.S., and Emery, K.O., 1971, Portrait of a scientist, Francis Shepard: Earth Science Reviews, v. 7, p. A9–A15.

Dietz, R.S., and Emery, K.O., 1976, Early days of marine geology: Oceanus, v. 19, p. 19–22.

Rusnak, G.A., 1991, Afoot and afloat along the edge: Adventures of an ingenious beachcomber—A tribute to Francis Parker Shepard (1897–1985): From shoreline to abyss: SEPM (Society for Sedimentary Geology) Special Publication 46, p. 1–7.

"Rock Stars" is produced by the GSA History of Geology Division. Editorial Committee: Michele Aldrich, Robert Dott, Robert Ginsburg (editor of this profile), and Gerard Middleton.

Roy J. Shlemon Mentor Workshops Enjoy Fifth Year of Success

Leaving the safe haven of student life and entering the real world can be intimidating. Faculty can advise geology students who are headed for academic careers, but what about everyone else? How can a geology student find meaningful work using real-world applications of geology? The Roy J. Shlemon Mentor Program, that's how.

Shlemon never had a mentor—that's why he endowed the program, which is administered through the GSA Foundation. The program just completed a successful fifth year.

"I started my career in geology as a full-time academic, but later took the risk of cutting the academic umbilical to see if I could make it in the real world," Shlemon explained. "Perhaps I was lucky, have therefore succeeded to some extent, and thus am able to give back to the profession. How much more efficient it would have been for me—and for all my geological compatriots at the time—to receive advice and to be able to marshal questions about practical career decisions and present them to an experienced professional for comment and general counsel—and at no cost!"

Applied geologists mentor students at GSA section meetings in the spring. Mentors and students are mutually enriched by this experience: These one- to two-hour get-togethers spark friendships and change lives and careers.

Mentors Make Connections Coast to Coast

For 2001, the Shlemon mentoring events began at the Northeastern Section Meeting in Burlington, Vermont. Special thanks go to mentors Peter N. Gale, Stone Environmental, Inc., Montpelier, Vermont; Craig D. Heindel, Heindel and Noyes, Burlington; David M. Streetsmith, Tetra Tech EM, Inc., Philadelphia, Pennsylvania; Kristen L. Underwood, Griffin International, Inc., Bristol, Vermont; and Christine Massey, who served as the faculty coordinator.

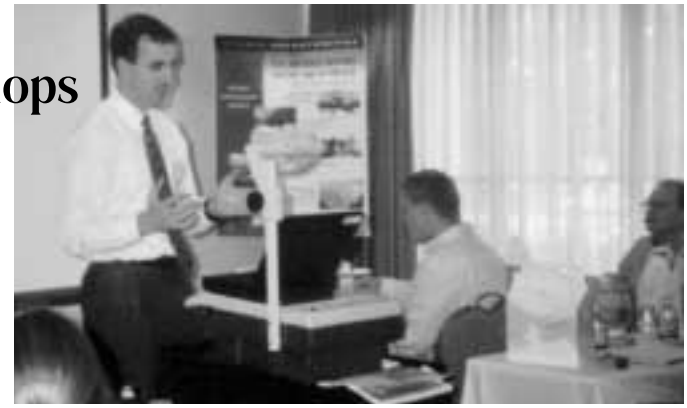
Here's what students had to say:
"This was a great opportunity and gave me a chance to entertain new ideas about jobs and internships and helped connect me to local firms."

"I love the one-on-one roundtable aspect of the discussions. The panelists are very accessible. They love their careers, and this gives me inspiration."

The Southeastern Section meeting in Raleigh, North Carolina, hosted the next workshop. Kudos go to mentors Brian J. Bellis, Law Engineering and Environmental Services, Inc., Raleigh; Alex S. Glover, Zemex Industrial Minerals, Feldspar Corporation, Spruce Pine, North Carolina; John D. Kiefer, Kentucky Geological Survey, Lexington; Marilyn J. Suiter, National Science Foundation, Arlington, Virginia; and to the local chair, Skip Stoddard, and student assistant Susan Gidley, both from North Carolina State University, for their help.

Student comments:
"The wide variety of fields represented provided good insights."

"All of [the mentors] had valuable information that I will be carrying with me."



Daniel Clayton Steward at the Cordilleran meeting.

Next came Los Angeles and the Cordilleran Section meeting at Universal City.

Thanks go to mentors Erin A. Campbell-Stone, Chevron, Bakersfield, California; Eldon M. Gath, Earth Consultants International, Orange, California; hydrogeologist and photographer of geologic sites John A. Karachewski, Weiss Associates in Emeryville, California; Daniel Clayton Steward, Chevron, Bakersfield; and faculty coordinator Kathleen M. Marsaglia, California State University at Northridge. But the icing on the cake for this event was having Roy J. Shlemon himself join the group! Thanks, Roy. That was special.

Student comments on their experiences:
"Quantity/quality of info I would not have access to otherwise…. Thank you for offering the opportunity!"

"Highly relevant and ideal for a young geologist who has a lot to learn from experts in the field."

The North-Central Section meeting workshop took place in Bloomington-Normal, Illinois. Mentors Arthur C. Pincomb, Associated Geologists, Inc., and Gordon M. Stevens, Versar Inc., did a great job!

Here's student feedback:
"I was very pleased to have an opportunity to ask questions of non-academic-centered geologists."

"It was great to hear about the 'real world'."

The last mentor workshop took place at the joint Rocky Mountain and South-Central Sections meeting in Albuquerque, New Mexico. Thank you to our mentors Sean D. Connell, New Mexico Bureau of Mines and Mineral Resources; Deborah Green, Tilford & Green, Placitas, New Mexico; and James P. McCalpin, Crestone Science Center and GEO-HAZ Consulting, Inc., Colorado; and to faculty coordinator Gary A. Smith, University of New Mexico.

A sampling of student kudos:
"It's great to hear from working geologists!"

"Covered practical subjects that it's hard to get information on."

Wanted: Mentors for 2002

The fifth year of the Roy J. Shlemon Mentor Program in Applied Geology has been a great success. But we need your help! If you'd like to become a mentor for our 2002 workshops, please contact program officer Karlon Blythe, kblythe@geosociety.org, (303) 357-1036.

Denver 2002:
Science at the Highest Level
Call for Proposals for Keynote Symposia and Topical Sessions

Proposal Deadline: January 17, 2002
Submit Session Proposals at www.geosociety.org.

The GSA Annual Meeting returns to Denver, the Mile High City and a favorite of many geoscientists, in 2002. You can help make this an exciting and successful meeting by submitting proposals for topical sessions and Pardee Symposia. Your participation is what will make this meeting *the* meeting of the year for earth scientists.

We welcome proposals for Pardee Keynote Symposia and topical sessions. They must be sent electronically on or before January 17, 2002. Go to www.geosociety.org/meetings/2002/.

Many session rooms in Denver will allow for combined oral and poster presentations to accommodate the use of these different presentation methods in a single session.

PROGRAM OPPORTUNITIES

The GSA 2002 Annual Meeting program structure offers opportunities for effective and dynamic program building and flexibility by allowing a mixture of invited and volunteered papers and different session formats. Joint Technical Program Committee (JTPC) representatives from the different GSA Divisions play a large role in program decisions. Descriptions of the various program options and guidelines are at www.geosociety.org. Please read these guidelines carefully before submitting a proposal. Two types of sessions may be proposed:

Pardee Keynote Symposia, made possible by a grant from the Joseph T. Pardee Memorial Fund, are *special events* of broad interest to the geoscience community. Topics appropriate for these symposia are those that are on the leading edge in a scientific discipline or area of public policy; address broad, fundamental problems; are interdisciplinary; or focus on global problems. The primary criterion for selection is excellence. Selection is on a competitive basis with four to eight half-day, nonconcurrent sessions offered. All speakers will be invited; each convener is provided with a budget of $2,000. We strive for a good mix of Pardee Keynote Symposia of interest to GSA and Associated Society members.

Topical sessions promote the exchange of timely or state-of-the-art information with respect to a focused topic and allow scheduling of interdisciplinary talks that bear on a specific topic. Organizers (advocates) may invite specific papers to ensure a successful and excellent session and are encouraged to solicit volunteered contributions. A maximum of four invited speakers may be allowed. An advocate may request more invitations if he or she can justify the larger number. However, sessions must include volunteered abstracts, which are solicited in *GSA Today* for all approved topical sessions. Advocates may request special formats. All requests are reviewed by the JTPC. All topical sessions must receive a minimum of 12 abstracts to be part of the technical program. Advocates are encouraged to submit their proposals as poster sessions to accommodate the growing technical program.

Oral and Poster General Sessions

Consisting entirely of volunteered papers, these sessions remain an important component of the GSA Annual Meeting. The number of abstracts received determines the number of general sessions in each discipline. The rejection rate for recent GSA Annual Meetings has been much less than 5%. The goal of the technical program chair and the JTPC representatives is to provide presenters the best possible opportunity for communicating new scientific information rather than to dictate what can or will be presented. Poster sessions have been expanded to allow presentation of more papers. To allow for well-attended, dynamic sessions, an effort will be made in scheduling to avoid overlap of poster and oral sessions in the same discipline.

Hot Topics

These popular, hour-long lunchtime forums, held Sunday through Wednesday, differ from technical sessions in that the focus is on discussion, with plenty of audience participation. Depending on the subject, a debate format is recommended, and panels are discouraged. Each session must have a moderator. Titles should be catchy and provocative. If you are interested in organizing one of these sessions, contact the technical program chair, John Geissman.

Be a Part of Denver 2002

Topical session organizers have the ability to ensure a successful, excellent program with a limited number of invited speakers, and all geoscientists may contribute papers to sessions. Pardee Keynote Symposia expand the opportunity for high-profile sessions on important developments that have an impact on our science.

Help us make the GSA Annual Meeting increasingly dynamic and stimulating for all GSA and Associated Society members as well as one that appeals to a wide audience. We look forward to working with you. If you have any questions or concerns regarding the program, please call or e-mail one of us.

Rob Van der Voo
Annual Program Chair (2000–2002)
(734) 764-8322 voo@umich.edu

John Geissman
2002 Technical Program Chair
(505) 277-3433 jgeiss@unm.edu

Denver 2002 Dates and Deadlines

2002

January 17	Proposals due by midnight, MST. Electronic submission required.
April 1	Electronic abstract form will be at www.geosociety.org for active submission.
April	First announcement in April issue of *GSA Today.*
June	Second announcement, including registration and housing information, in June issue of *GSA Today.*
July 16	Electronic abstracts due by midnight, MST.
August 5	Technical Program schedule finalized.
September 1	All accepted abstracts will be posted at www.geosociety.org after September 1. Speakers and titles will be listed with links to those abstracts.

Exhibit space is available. Call Brenda Martinez at 1-800-472-1988, ext. 1038, for the Exhibitor Prospectus.

GSA Foundation Update

Donna L. Russell, *Director of Operations*

Last month, we focused attention on the benefits that planned giving can bring to GSA members and the Foundation. I am sharing another article written by our planned giving consultant, Janet Doolin, this one focusing on the new tax laws. **A special note: When forming your plans for any type of planned giving, please seek out the assistance and professional guidance of your personal advisors to help you understand the many, many far-reaching and important changes in the new law.**

Vital News about the New Tax Laws: Will You Be Paying Less Income Tax in 2002? Will You Be Free from Estate Taxes in 2002?

Janet Doolin, J.D.

For many individuals, the 2001 Tax Act enacted in May 2001 was great news, resulting in one of the largest federal tax reductions in decades. Income tax rates are down, with immediate reductions beginning July 2001. Additional rate reductions will occur in the coming years, and more retirement saving incentives will be granted for IRAs and 401(k)s.

At year-end and in the first quarter of the new year, many people take the time to check in with their advisors to redefine their plans—both financial and estate plans.

The new tax law also offers many other income tax changes that you will want to check out with your financial advisors. Changes in the child-care credits, the "marriage penalty tax," incentives for savings for higher education, and student loan assistance are just a few of the many positive changes to explore further.

Big Estate Tax Changes

One of the most important changes in the new tax law is the **gradual** elimination of the federal estate tax that has been with us since 1917. The emphasis here is on the word *gradual*. So many people, both in the news media and in the financial services world, mistakenly use the word "repeal" when talking about the **glacial** phased-in nature of the estate tax law changes.

The estate tax is not totally eliminated or repealed until 2010. The top estate tax rate will be reduced from 55% to 50% in 2002. Beginning January 1, 2002, the increase in the exemption is raised to $1 million. The good news is that it is estimated that this initial 5% rate reduction may eliminate estate tax to approximately 50% of those whose estates could now be subject to it.

Spouses may still transfer unlimited amounts to each other during their lifetimes and at death, so with proper planning it will not be necessary for married couples to pay estate taxes at the death of the first spouse. By combining their individual exemption amounts, couples can continue to maximize their tax relief. Again, this is an area where you will want to receive the advice of an attorney or tax advisor skilled in estate planning.

The Pace of Estate Tax Change Slows After 2002

In the years following 2002, the estate tax gradually is reduced to 49% in 2003, 48% in 2004, and then 1% each year until reaching 45% in 2009. Then, in 2010, the estate tax is finally repealed FOR ONE YEAR ONLY and is reinstated in 2011.

Charitable Giving: How Can You Help GSA Foundation with Your Planned Gifts?

Charitable gifts continue to be fully deductible under the new tax law. **Reduced income taxes may result in more disposable income from which to make gifts to your family and your favorite charities and causes.**

The GSA Foundation offers charitable gift annuities, a retirement planning option you may wish to consider. A charitable gift annuity is a gift to the Foundation. The Foundation then creates an annuity arrangement for you or a loved one and that annuity pays a lifetime income stream back to you or the person you name. Your gift creates a charitable income tax deduction, and possible capital gain tax savings. It's a win-win for both the GSA Foundation and you and your family. It's an attractive gift idea with tax advantages that you may wish to explore further. Contact the Foundation to learn about the benefits.

With the new tax law's reductions in estate taxes, individuals will have more freedom than ever to decide how their assets will be distributed instead of being forced to surrender those assets to estate taxes. Giving to the GSA Foundation through your will or trust is always popular and may easily be arranged as part of your planning or by

Most memorable early geologic experience

I ran "lantern slides" in 1935 at the New York City annual meeting (held at Christmastime). Much excitement still at GSA because of the Penrose Grant a few years earlier.

—Richard H. Mahard

revising your current plans.

The GSA Foundation encourages you to consider including the Foundation in your will, trust, retirement plans, or other estate plans. We are always happy to answer any questions you may have and can provide the appropriate bequest language upon request. Please contact Donna Russell at the GSA Foundation and let her know your needs.

Janet Doolin, J.D., is a consultant to nonprofits and foundations in Colorado and nationally and consults with the GSA Foundation. She serves on the faculty at Regis University, Denver, Colorado, in the Master for NonProfit Management Program.

Focus on a Foundation Fund

The Roy J. Shlemon Scholarship Fund for Engineering Geology

The Roy J. Shlemon Scholarship Fund for Engineering Geology was established by Shlemon in 1999 and is administered by the GSA Engineering Geology Division. The fund has two components. The first provides scholarship funds to graduate students pursuing research in the general field of engineering geology. The second funds students so they may attend field trips and short courses at GSA Section Meetings and the GSA Annual Meeting.

Shlemon is a consulting geologist in Newport Beach, California, and has specialized in the application of Quaternary geology, geomorphology, and soil stratigraphy to engineering geology practice. In addition to degrees from Fresno State College, the University of Wyoming, and the University of California at Berkeley, Shlemon has held teaching and/or research positions at the University of California at Davis, Louisiana State University, Stanford University, the University of California at Los Angeles, and California State University, Los Angeles.

Shlemon points out that today's engineering geologist should be well versed in many disciplines, particularly Quaternary geology, geomorphology, soil stratigraphy, and field geology. He hopes that awards from this fund will encourage students to conduct research in traditional engineering geology and to attend as many field trips as possible during their careers.

The net assets of the fund at the end of August 2001 were $121,300.

Student Financial Support for Field Trips and Short Courses

The Engineering Geology Division encourages its student members to apply for a Roy J. Shlemon Meeting Award. This award will cover the cost of field trips and/or short courses, as well as meeting registration at GSA Section Meetings. Applications and information are available at http://rock.geosociety.org/egd/index.html (see Scholarships), or www.geosociety.org/profdev/grants/.

The postmark deadline for applications for each meeting is as follows:

Northeastern Section Meeting	January 4, 2002
North-Central and Southeastern Sections Joint Meeting	January 4, 2002
South-Central Section Meeting	January 18, 2002
Cordilleran Section Meeting	February 15, 2002
Rocky Mountain Section Meeting	March 1, 2002

GSA Foundation

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drussell@geosociety.org

Enclosed is my contribution in the amount of $_____.

Please credit my contribution to the:

- ☐ Unrestricted Fund
- ☐ Other: _____ Fund

☐ I have named GSA Foundation in my will.

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BOOK REVIEWS

The Dating Game—One Man's Search for the Age of the Earth

Cherry Lewis, *Cambridge University Press, 2000, 216 p., $24.95.*

This is an eminently readable book that takes the reader through both the attempts to find an absolute scale for the age of Earth, and the life of the man who is identified with that quest, Arthur Holmes. The eternal problem in writing history is whether to follow a strictly chronological sequence or to follow each idea from beginning to end. This author has generally done the latter, which leads to a bit of chronological indigestion, but which allows coherent discussion of topics.

Arthur Holmes (1890–1965) is the person most associated with early belief in and application of radioactivity to determine the age of Earth. His work at the Royal College of Science (the Imperial College after 1910) was interrupted by the need to earn a more substantial salary, a constant circumstance that led to the other fascinating stories in this book, those of Holmes's mineral exploration in Mozambique and the oil search in Burma. However, Holmes's lifetime very nearly coincided with the discovery and elucidation of radioactivity itself, and the possibility of using it to determine the age of Earth was his nearly constant preoccupation. The author reviews the history of attempts—scientific, philosophical, and religious—to find the age of Earth. Interpretation of the amount of salt in the oceans, the thickness of strata, evolution of fossil forms, and Lord Kelvin's impressive work with heat had all provided estimates. The discovery of radioactivity, which is given a good capsule history here, showed that methods based on cooling curves were erroneous but still provided another method to measure time.

Discovery was not enough: The decay paths and times of appropriate elements as well as manageable daughter products needed to be found in order to apply them to rock and/or mineral ages, and there had to be a fair degree of certainty that none of the measured daughter products had escaped. In this process, some of the multiple isotopes of uranium and lead were discovered. Far from having a "eureka" moment, Holmes worked on the problem for most of his life. That story is told here, interwoven with the contributions of many other scientists.

The lack of an index is annoying, as is the chronological rather than alphabetical bibliography. However, it is a coherent accounting of a long, complex, and valuable episode in the history of geology.

Sally Newcomb
Silver Spring, Md.

Coal Division Offers Medlin Award

The GSA Coal Geology Division announces the availability of the Antoinette Lierman Medlin Scholarship in Coal Geology for the 2002–2003 academic year. The scholarships provide full-time students who are involved in coal geology research (origin, occurrence, geologic characteristics, or economic implications of coal and associated rocks) with financial support for their projects for one year.

Scholarship funding can be used for field or laboratory expenses, sample analyses, instrumentation, supplies, or other expenses essential to the successful completion of the research project. Approximately $2,000 will be available for the 2002–2003 scholarship award. In addition, the recipient of the scholarship may be provided with a stipend of up to $750 to present results of the research at the 2003 GSA Annual Meeting. For the academic year 2002–2003, the Coal Geology Division is also offering a field study award of $1,500. The recipient of this award will also be eligible to receive up to $750 in travel funds to present results of their study at the 2003 GSA Annual Meeting.

Proposals for the scholarship and the field study award will be evaluated by a panel of coal geoscientists. Applicants may apply for the scholarship award, the field study award, or both, however only one award will be made to a successful applicant.

Interested students should submit five copies of the following:

(1) a cover letter indicating which award(s) is (are) sought;

(2) a concise (no more than five double-spaced pages, including references) statement of objectives and methods and of how the scholarship funds will be used to enhance the project; and

(3) a letter of recommendation from the student's immediate advisor that includes a statement of financial need and the amount and nature of other available funding for the research project.

Send the material to: Leslie F. Ruppert, Coordinator, A. Lierman Medlin Scholarship Committee, U.S. Geological Survey, 956 National Center, Reston, VA 20192, (703) 648-6431, lruppert@usgs.gov.

The proposal and letter of recommendation must arrive no later than February 15, 2002. Applicants will be notified of the Scholarship Committee's decision by April 1, 2002.

The scholarship was established in 1987 as a memorial to Antoinette "Toni" Medlin who, for many years, dedicated her efforts toward the advancement of coal geoscience and to the encouragement of students in coal geology. Monies for the scholarships are derived from the annual interest income from the scholarship fund, which is managed by the GSA Foundation.

LETTERS

Siegel's "Winning Tenure in Geoscience Departments: Some Unsolicited Advice to Faculty Aspirants" (Commentary, *GSA Today*, October 2001, p. 31) provokes a response concerning what might be appropriate advice to faculty aspiring to win tenure. First, Siegel argues that winning tenure is "...about getting external reviewers to say 'yes' to the questions asked in...letters soliciting...reviews.…" Of course, there is truth in this statement in the sense that, without positive answers to these questions, the aspirant is unlikely to win tenure in a research university. On the other hand, to undervalue teaching is misleading. Teaching is not subject to the same external peer review, but it is important nonetheless. At Maryland, for example, one cannot win tenure without a demonstrated ability to teach in a stimulating way to students from freshman to graduate, and to advise research training. We might debate how or how well we evaluate teaching and advising, but that's NOT the point at issue here. Can one win tenure as a poor teacher? No, one cannot! One may posit that being a good teacher is only a qualifying step along the road to tenure, but there is nothing wrong with such a situation providing there is a minimum standard that must be achieved. To suggest that "...winning a teaching award means little" is cynical. We must celebrate good teaching equally with good research, for both together are the sine qua non of a great university. Stellar research no longer will save an aspirant in a state-funded research university in circumstances where she or he cannot also develop the skills necessary to be a successful teacher. Of the several reasons why not, prominent are the increased accountability and the realization that good teaching is an important recruitment tool vital to the long-term health of these universities.

A second issue concerns the "minimum" level of performance in research to win tenure. It is dangerous to suggest levels of performance in ways that imply achieving these levels will lead to success. The number of peer-reviewed publications and where they are published, the number and size of research grants, and interaction with the peer community all are important. However, one cannot specify quantitatively what is necessary to achieve tenure. If one could do this, the opinion of external evaluators would not be needed—any administrator can count the publications, divide by the number of years, and compare with the standard "required." Further, what is expected, in the sense of what is the norm for rate of publication and average dollar amount of a grant, varies according to the culture of each subdiscipline. It should be sufficient to explain to the aspirant that she or he must have demonstrated the potential to be an intellectual leader in her or his specialty. However, it must be made clear to the aspirant what is needed to demonstrate intellectual leadership.

There is a common peer community that will not only be asked to review the individual's papers and proposals, but most likely will be asked to write letters of evaluation as part of the promotion process. Thus, success in publication and funding breeds familiarity within the peer community. Although there should be evidence of regular productivity, the number of papers published is less important than their impact. After all, if nobody ever reads the publications, it may be inferred that the aspirant doesn't have anything new to add to our knowledge. The research has to be useful to others; just publishing per se has no value, and simply increasing the amount of rarely read, rarely cited papers is not evidence of intellectual leadership. Further, in the university tenure system, there is no such thing as an equivocal evaluation letter—equivocalness can only be read as negative. Thus, faculty must write papers that have potential impact, and submit them for publication where they might be read by the peer community and be influential—remember, peer-reviewed doesn't necessarily mean widely read or high quality. I recommend aspirants submit papers only to journals that are in the top 10%–20% of those listed in the ISI Journal Citation Reports earth science groupings combined, as ranked by impact factor.

Third, we should remember that universities invest considerable resources (money, time, and effort) into recruitment of and development of faculty. An administrator must stress to the aspirant and to her or his colleagues that individual success is important to the department, and the administrator must create an environment in which the department is supportive of junior faculty. Of course, denying tenure is devastating to the individual. However, it may also be problematic for the department, particularly a smaller department in the process of building a reputation, where the "lost" years may represent a considerable setback. To generalize that all administrators provide false advice is an offensive unfounded assertion. Many administrators endeavor to provide a nurturing environment for junior faculty, and, within the legal framework within which they are required to operate, to provide the best possible advice. This is their job. Whether that advice is followed is another matter!

Michael Brown
University of Maryland

I read with interest the article in *GSA Today* on winning tenure (Commentary, *GSA Today*, October 2001, p. 31). As an untenured faculty member at the University of South Carolina, I just want to note that there are no illusions in our department about what it will take to get tenure here. We are reviewed by the department every year, and every third year by the college, with the clear message that what counts is publications and funding. While good teaching and service are necessary, they won't get me tenure. And whereas I suppose not everyone will take the advice of peers, failing to achieve tenure here will not result from lack of communication.

The key to tenure success, I believe, is having good faculty mentors, and a yearly review system for all faculty members. Our yearly reports involve compiling exactly the information required for submission to our tenure and promotion committee: students advised, theses completed, publications, grants applied for and funded, services provided to the community (science fairs, K–12 presentations, etc.), committees served on, editorial responsibilities, reviews provided for journals, NSF, etc. These reports are used each year by the chair to assign raises, and it's a simple matter to staple these reports together for T&P at 3 and 6 years. The reports also provide an overview of what we do as professors and what it will take to get tenure.

While I believe it is ultimately my responsibility to find out what it takes to get tenure, there are practices that could be instituted by each department to facilitate this.

Matthew J. Kohn
University of South Carolina

Don Siegel's comments (Commentary, *GSA Today*, October 2001, p. 31) are accurate only up to a point. Having written many such "tenure" letters during my previous life as a faculty member at the University of Illinois at Urbana and the University of Pennsylvania, including service on tenure and promotion committees, I learned quickly that outside evaluations are not the only factor in making tenure decisions. I know of instances where a fresh set of letters were requested, and where authors of letters such as Siegel described are told up front that their letters may or may not be used in evaluating a candidate's qualifications.

It is also a mistake to assume that teaching is not considered one of several factors in tenure decisions, particularly in state universities where parents are telling their legislators that they demand better teaching for their children in state-supported campuses. I recall being asked on several occasions to write about a candidate's teaching qualifications based on what I knew about their presentations at annual meetings, their interactions with our own students during a colloquium visit, and the career paths of a candidate's students, if this was known. Moreover, teaching is usually evaluated internally using certain criteria that are selected from teaching evaluations submitted by students, and I know of many instances where letters from students are solicited for inclusion in the final evaluation package. Thus junior faculty should be admonished to provide acceptable teaching, but get back to the lab or field and keep working on those papers. Scheduling office hours (and sticking to them) will help. Doing one's share of departmental (but not college) committee work is also expected to meet the test of "collegiality," an intangible that crops up during internal reviews.

Perhaps the most disturbing item in Siegel's comments include references to students that "don't have a clue" and the comment about junior faculty having "to get some papers out" being "lame ducks." These comments clearly speak to a lack of mentoring of both graduate students by their advisors, and junior faculty by their senior colleagues and department chairs or heads. This lack of mentoring shows up when reviewing résumés of young people (as I did at the Reno GSA Annual Meeting), their performance during interviews, and the limitations in the promotional packages that Siegel read. During an earlier time, faculty provided such mentoring and helping students develop career paths for themselves. Such mentoring included sponsoring students to join professional societies, including those that were germane to their career paths. However, since about the mid-1980s, such mentoring was ridiculed within faculty circles, and those that continued to offer it informally were considered academically incorrect. The career paths of students as they move into the professional stage of their lives clearly depends on mentoring from faculty, and the tragedy today is that such little mentoring is done and it shows.

What should GSA do? Begin offering mentoring services, sessions, and workshops to students at regional and national meetings so as to meet the shortfalls of a higher education system that is long on political correctness and social and "feel good" issues, and short on excellence and professional development of its students and junior faculty.

George D. Klein
SED-STRAT Geoscience Consultants, Inc.

Siegel responds: I am delighted my essay on tenure and promotion has hit a chord in the academic community. I think the respondents to my article and I essentially concur on most points. I certainly agree with Michael Brown and George Klein that teaching well is important in academia. And yes, candidates can sometimes win tenure and promotion with outstanding teaching portfolios and modest research credentials, and sometimes, new external reviews are requested. I also agree with Brown that faculty should try to send their papers to top-end journals for the most impact. Matt Kohn is very lucky to be in a place where mentoring is taken so seriously.

The essential point of my essay was to suggest a T&P package that I know would have a decent **probability** of success at most colleges and universities, but not at all of them. Young faculty need to understand that a professor who earns tenure literally is offered a lifetime appointment doing what he or she wants to do for a living—without meaningful constraints. Young faculty should put themselves in the shoes of their administrators. What level of performance is sufficient to award someone a job for 30+ years knowing that you can't seriously administrate what that person does? Tenure is not a trivial thing.

Don Siegel
Syracuse University

Field Forum
REPORT

Bolide Impacts on Wet Targets

Conveners:

John Warme, *Coordinator, Department of Geology and Geological Engineering, Colorado School of Mines*

Christian Koeberl, *Geochemistry Institute, University of Vienna*

Philippe Claeys, *Department of Geology, Vrije Universiteit, Brussels*

Walter Alvarez, *Department of Geology and Geophysics, University of California, Berkeley*

This meeting brought together experts on wet impact processes and products to study outcrop examples, present case studies, exchange ideas, generate discussions and debate, and integrate knowledge of impacts on various wet targets, such as standing water of different depths, saturated ground, and ice. Platforms for field discussion were the proven impact-related Alamo Breccia in southern Nevada and the controversial Upheaval Dome in eastern Utah. The 38 participants included 11 from outside the United States and eight U.S. and foreign students. We convened on Sunday, April 22, in Las Vegas, Nevada, and officially ended on Saturday, April 28, in Moab, Utah. Twenty hardy individuals remained in Moab to traverse the Upheaval depression on April 29. The Alamo Breccia Research Page, http://talus.mines.edu/students/m/mmorgan, contains complete information, plus photos contributed by Steve Dutch.

The forum included daily field traverses to Alamo Breccia localities mixed with inhouse orientation talks on the Breccia (Kuehner, Morgan, Morrow, Warme), five keynote addresses on various topics (Dypvik, King, Melosh, Milkereit, Simonson), 29 posters on specific topics or case studies, open discussions, and field team reports.

Alamo Breccia

An overview of the Alamo Breccia and of interpretation problems that were presented as challenges to the attendees appear on the Alamo Breccia Research Page and in Warme and Kuehner (1998). After two days of field stops and orientation sessions, the expert workforce was divided into teams and given a list of problems on which to focus in the field. The controlling question was whether we can see through the Breccia to solve major problems of its genesis. Sample topics for investigation included: mechanisms of Breccia emplacement (ejecta curtain, fallout, tsunami, slide, or?); identification and preservation of primary ejecta, matrix, and carbonate impact lapilli ("spherules"); formation and preservation of the lapilli; origin of the widespread basal Breccia detachment surface and of megaclasts over it; possibility for compound origins (e.g., direct ejecta, deposits from one or more slides, or resurge gullying); evidence for fluidization and/or liquefaction of clasts and matrix; estimates of crater size, geometry and location; and size and composition of projectile.

The teams took on these overlapping tasks: search for evidence of shock or ground motion within or under the Breccia; characterize wet impact signatures and impact stratigraphy exhibited in the Breccia; interpret the paradoxical distribution of carbonate impact lapilli within the Breccia; and develop a comprehensive scenario for the position and proportions of the crater, character of the projectile, and sequence of Breccia formation.

The Shock Team presented a model whereby near-surface seismic waves could account for the detachment horizon along the base of the Breccia (Dutch, Masaitis, Melosh). The lack of shattercones suggested that the Breccia localities we visited were distal with respect to the crater, although the wet environment may have subdued shattercone development (Dutch, Gaffney, Ryder). The Crater Stratigraphy Team contributed an important hypothesis, generated by comparison of the Alamo Breccia with impact breccias associated with the Lockne impact structure in Scandinavia (Ormo, Von Dalwigk) and other examples. Multiple, delayed resurge events into a crater or into a slump-scar trench could explain the multiple-graded units toward the top of the Breccia and allow time for the carbonate impact lapilli beds to harden and then fragment as the isolated lapilli clasts that occur mixed into the Breccia. Thus, the impact event and the formation of the Breccia may be related but separated by perhaps many days (Kenkmann, Ormo). A recurring idea is that there was more than one impact, which could explain many of the puzzles contained in the Breccia (McElvain). Although a new model was presented that could account for rapid cementation of the lapilli beds by impact calcining and rapid dehydration and cementation (Morgan, Kuehner, Warme), the scattered lapilli clasts in the Breccia could be more easily explained if sufficient time elapsed between impact with its lapilli formation and some fashion of collapse and lapilli bed breakup and redistribution. The Lapilli Team suggested that the beds may have been in the form of rafts, similar to pumice rafts, that broke up, cemented, and sank during the formation of the Breccia, accounting for the disjunct distribution of lapilli clasts (Bell).

One style of deformation between the Carmel Formation and the overlying Entrada Sandstone, Arches National Park, Utah. Photo by John Warme.

Several workers suggested that the Alamo impact occurred on or near a slope (Masaitis) and that the crater may have been destroyed by slumps that created tsunamis and/or resurge deposits, possibly filling a depression from different directions and at different times and accounting for the stacked graded beds that comprise the Breccia (Ormo).

The Grand Scenario Team was reluctant to present a detailed synthesis for the genesis and evolution of the Alamo Breccia because of uncertainties about Late Devonian paleogeography in Nevada (Warme). A major problem is whether the current Breccia represents its original distribution or is the product of significant

post-Devonian thrusting, in addition to some measure of Cenozoic extension. Crustal shortening could result in east-west scrambling of the outcrops visited. The plan of the epiplatform Alamo Breccia now forms an eastward-extending semi-circle, although deep-water equivalents have been identified as mass flows 100 km or more west of the carbonate platform study area (Morrow).

Recent thrust-belt models for the late Paleozoic of the Great Basin of Nevada suggest that crustal shortening was significant. If so, stacked thrust sheets may still cover the crater, or significant uplift and erosion may have destroyed some or all of it. Impact modelers require reliable information about the original area of the Breccia and distance from the periphery to the center. Their conclusion: Structural problems must be resolved before modeling can confidently predict the size and position of the Alamo crater and the character of the impactor.

Upheaval Dome

On Thursday, Huntoon and Koeberl introduced the Upheaval Dome and the forum moved to Moab, Utah, where we closed in on structure for the next three days. The dome is emphatically interpreted as both a salt piercement structure (e.g., Jackson et al., 1998) and as an impact crater (e.g., Huntoon, 2000). The wet impact theme applies there because stratigraphic features we visited can be interpreted as having formed by impact on layers of variably saturated rock. Friday, we visited two outlying areas that contain deformation features that potentially support the impact hypothesis (Alvarez et al., 1998). Alvarez and Shimabukuro led us through portions of Arches National Park, ~40 km from Upheaval Dome, where the boundary between the Jurassic Carmel and Entrada formations is deformed. In some localities, the upper Carmel mudstone beds are segmented and appear thrusted or dragged upward to pierce the overlying Entrada, which locally appears fluidized and loaded into the Carmel to form tongue-shaped bodies with fluid escape structures. Chan showed us the Dubinky Well area in Canyonlands, ~25 km from Upheaval, that exhibits sandstone pipes penetrating the Carmel (Alvarez et al., 1998). Synsedimentary deformation in both areas draw attention because of their unusually large scale, suggesting that they may have formed through extraordinary processes such as impact at Upheaval Dome.

On the Alamo Breccia at the type locality near Hancock Summit, Nevada. Photo by Goeff Notkin.

On Saturday, Huntoon led us to Roberts Rift, ~30 km from Upheaval. This unusual feature, filled with debris that includes propant fragments from underlying formations, is proposed as a radial fracture from Upheaval Dome (Huntoon and Shoemaker, 1995). The last formal stop of the forum was Upheaval Dome, now an erosional depression. Huntoon and Plescia introduced the feature, and a roundtable discussion ensued. Unfortunately, the pinched-off salt diapir proponents declined to join the forum; they would have had eager listeners and perhaps concurrence from within our group. We traversed part of the depression rim to view the spectacular exposures in the central uplift. On Sunday, Huntoon and Plescia led an optional 15-km-long foot traverse into the center of the depression.

The forum catalyzed new ideas, acquaintances, after-dinner discussions, and field debates that furthered our understanding of the geological effects of wet impacts. In retrospect, however, the days and nights were too full and the participants too numerous to effectively wring out all of what we observed in the field and brought to the table through our varied career experiences with impact structures. No synthesis was achieved or possible. One post-forum comment provides perspective: "I submit there are an almost unlimited variety of shapes, compositions, sizes, and densities of potential impactors traveling around within the gravitational influence of Earth and the solar system. Impactors of radically different natures would cause a variety of different types of craters and other geomorphic and formational effects that could be preserved in the geologic record." We learned that the inventory is not complete, and the interpretations ongoing, as with any live branch of science.

Acknowledgements

We gratefully acknowledge the following cosponsors and organizations for financial support that contributed to the size and success of this Field Forum: for student support, The Pretorious Fund of the GSA Foundation and the NASA Planetary Geology and Geophysics Program; for sponsoring foreign speakers, the donors of the Petroleum Research Fund of the American Chemical Society; and for important discretionary funds, the Barringer Company, the Colorado School of Mines, and the Global Impacts Studies Program.

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Forum Participants

Dallas Abbott	Victor Masaitis
Walter Alvarez	Tim McElvain
Mary Sue Bell	Jay Melosh
Bernd Bodiselitsch	Bernd Milkereit
Margie Chan	Matthew Morgan
Jocelyne Comstock	Jared Morrow
Steven Dutch	Geoff Notkin
Henning Dypvik	Jens Ormo
Edward Gaffney	Lucille Petruny
Manuel Grajalas	Betty Pierazzo
Sam Harvey	Jeff Plescia
Mary Hubbard	David Powars
Peter Huntoon	Graham Ryder
Dwight Jurena	Jill Savage
Thomas Kenkmann	David Shimabukuro
David King	Bruce Simonson,
Chris Koeberl	Roman Skala
Hans Kuehner	Ilka Von Dalwigk
Keenan Lee	John Warme

ANNOUNCEMENTS

MEETINGS CALENDAR

2002

January 13–17	American Meteorological Society 82nd Annual Meeting, Orlando, Florida. Information: Stephanie Kenitzer, kenitzer@dc.ametsoc.org, (425) 432-2192, www.ametsoc.org/ams.
May 20–24	Sixth International Symposium on the Geochemistry of the Earth's Surface (GES-6), Honolulu, Hawaii, USA. Information: (808) 956-6344, fax 808-956-7112, www.soest.hawaii.edu/oceanography/ges-6/, ges6@soest.hawaii.edu.
June 16–21	16th Caribbean Geological Conference, Bridgetown, Barbados. Information: Leslie Barker, General Coordinator, 16th Caribbean Geological Conference, Energy and Natural Resources Division, c/o National Petroleum Corporation Building, Wildey, St. Michael, Barbados, cgc16th@hotmail.com, www.fiu.edu/orgs/caribgeol. *(Abstracts deadline: January 20, 2002.)*
July 29–August 2	51st Annual Denver X-ray Conference, Colorado Springs, Colorado, USA. Information: Denise Flaherty, Conference Coordinator, ICDD, 12 Campus Blvd., Newtown Square, PA 19073, (610) 325-9814, fax 610-325-9823, dxc@icdd.com, www.dxcicdd.com.

NRC Seeks Applications for Awards

The National Research Council announces the 2002 Postdoctoral and Senior Research Associateship Programs to be conducted on behalf of 120 research laboratories throughout the United States, representing nearly all U.S. government agencies with research facilities. Approximately 300 full-time associateships will be awarded on a competitive basis to Ph.D., Sc.D., or M.D. scientists and engineers for research in the fields of chemistry, earth and atmospheric sciences, engineering, applied sciences and computer science, life and medical sciences, mathematics, space and planetary sciences, and physics.

Applications are accepted throughout the year. Those postmarked by January 15, 2002, will be reviewed in February; by April 15, 2002, in June; and by August 15, 2002, in October. For information on specific research opportunities, participating federal laboratories, and application materials, see www.national-academies.org/rap, or contact National Research Council, Associateship Programs (TJ 2114/D3), 2101 Constitution Ave. NW, Washington, D.C. 20418, (202) 334-2760, fax 202-334-2759, rap@nas.edu.

National Security Education Program Fellowships 2002

The Academy for Educational Development (AED) invites applications for the 2002 National Security Education Program's David L. Boren Graduate Fellowships competition. Fellowships are awarded in a broad range of academic and professional disciplines including business, economics, history, international affairs, law, applied sciences and engineering, health and biomedical sciences, political science, and other social sciences. Award recipients incur a requirement to work for an agency or office of the federal government involved in national security affairs or in the field of U.S. higher education in an area of study for which the fellowship was awarded. For details and eligibility and application information, see www.aed.org/nsep, or contact AED at 1-800-498-9360, (202) 884-8285, or nsep@aed.org. Applications must be postmarked by February 1, 2002.

In Memoriam

Richard Goldsmith
Marblehead, Massachusetts
September 27, 2001

Douglas C. Kellogg
West Chester, Pennsylvania
April 7, 2001

Donald H. Lokke
Dallas, Texas
August 2001

Nicholas Rast
Lexington, Kentucky
August 28, 2001

Please contact the GSA Foundation for information on contributing to the Memorial Fund.

Position Announcements

The following employers were among those that participated in GSA's Employment Interview Service at the GSA Annual Meeting in Boston.

AMHERST COLLEGE—SEDIMENTOLOGIST

The Department of Geology at Amherst College solicits applications for a tenure-track position at the level of assistant professor to begin in the fall of 2002. We seek a sedimentologist whose interests and expertise may also include stratigraphy, paleontology, paleoclimatology, marine geology, and/or oceanography.

The successful candidate will teach sedimentology and an additional upper-level course or courses that will strengthen our undergraduate major and complement the present departmental offerings in tectonics, structural geology, hydrogeology, aqueous geochemistry, petrology, and geophysics. All geology faculty teach at the introductory level as well. Preference will be given to candidates with a demonstrated interest in continued development and teaching of our introductory course in surficial earth systems and the environment. Geology faculty also supervise undergraduate research projects annually.

Candidates must have an ongoing program of research. Amherst College provides competitive start-up funds in support of research. A Ph.D. is required and postdoctoral experience is desirable.

Submit a résumé, a brief statement of your research interests, transcripts, and three letters of recommendation to: Professor Tekla A. Harms, Chair of the Search Committee, Department of Geology, Amherst College, Amherst, MA 01002-5000 (taharms@amherst.edu). Review of applications began on November 20, 2001, but applications will be accepted until a pool of qualified candidates is identified. Amherst College is an equal opportunity/affirmative action employer. Women, minorities, and persons with disabilities are particularly encouraged to apply.

COLLEGE OF CHARLESTON
TENURE-TRACK ASSISTANT PROFESSOR
ENVIRONMENTAL GEOCHEMIST

The Department of Geology and Environmental Geosciences at the College of Charleston invites applications for a tenure-track assistant professor position in environmental geochemistry beginning in August 2002. We are seeking a broadly trained low-temperature geochemist with a Ph.D. and experience in environmental applications to surface and ground water resources. Candidates having experience in aqueous and environmental geochemistry, particularly dealing with environmental issues and hazards of the Southeastern U.S. coastal region, are particularly encouraged to apply. The successful candidate will demonstrate a serious commitment to undergraduate teaching and research, and have a strong background in computer applications pertinent to their discipline. The candidate will be expected to: (1) teach an undergraduate-level course in geochemistry, one or more graduate-level courses in environmental geochemistry, and undergraduate introductory geology courses; (2) develop a successful research program that leads to professional publications; and (3) seek external funding for research.

For more information, visit our departmental Web site at www.cofc.edu/~geology/, or contact Dr. Mitchell Colgan, (843) 953-7171; mcolgan@loki.cofc.edu.

Interested persons should send a letter stating their interest in the position, curriculum vitae, statements of teaching philosophy and research interests, unofficial transcripts, and names of three references to: Geochemistry Search Committee, Department of Geology, College of Charleston, Charleston, SC 29424. Review of applications will begin January 8, 2002, and continue until the position is filled. The College of Charleston is an AA/EO/ADA employer and does not discriminate in employment or the provision of services on the basis of disability.

ASSISTANT PROFESSOR OF HYDROGEOLOGY
CSU—SAN BERNARDINO

We seek candidates for an entry-level tenure track appointment in the Department of Geological Sciences beginning fall of 2002. The successful candidate will teach already established courses in hydrogeology, introductory and other geology courses, general education courses offered by the College of Natural Sciences, and courses in his/her field of expertise. We seek a geologist with experience in hydrological field methods who will bring additional strength to our program and will be able to develop ties with local consulting firms. The successful candidate will be committed to undergraduate teaching, and would be expected to develop an independent, externally funded research program including undergraduate students. Preferred candidates will be expected to demonstrate interest or experience in at least one of the following strategic plan areas: (a) alternative modes of instructional delivery to include off-campus and distance learning; (b) the learning process, i.e., innovative teaching strategies and/or research on how students learn and apply knowledge over an extended period of time; and (c) partnership with community to enhance social, economic, and cultural conditions. A Ph.D. is required.

Please send a letter of application, curriculum vitae, official transcripts from both undergraduate and graduate education, a detailed statement of research and teaching interests, three letters of recommendation, as well as a description of any interest or experience in one of the three strategic plan areas to: Dr. Alan L. Smith, Department of Geological Sciences, Attn: Hydrogeology Search, California State University, 5500 University Parkway, San Bernardino, CA 92407-2397, alsmith@csusb.edu; the deadline for applications is December 31, 2001. CSU San Bernardino is committed to diversity and equality in education and employment.

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GEOGRAPHIC INFORMATION SCIENCE/SPATIAL ANALYSIS MONTCLAIR STATE UNIVERSITY

The Department of Earth and Environmental Studies, Montclair State University, invites applications for a full-time, tenure-track faculty position at the assistant or associate rank starting September 2002. This position requires expertise in GIS, spatial analysis, modeling and visualization, and/or remote sensing with specific emphasis on applications that reflect the current research strengths of the department.

The successful candidate will be responsible for teaching major and graduate GIS/RS-related courses as well as expanding our programs and course offerings in this area. Excellence in teaching and pursuit of a funded research program are expected. Candidates must have completed a doctorate prior to September 2002.

MSU, the second largest public university in New Jersey, is characterized by a strong general education program and a deep commitment to the values of multicultural diversity.

Send CV, three letters of recommendation and statement of professional goals, research interests and teaching philosophy to: William D. Solecki, Earth and Environmental Studies, MSU, Upper Montclair, NJ 07043. Screening began Nov. 15 and continues until the position is filled. MSU is an EO/AA employer. Women and minorities are encouraged to apply. Subject to available funding. Further information is available at: www.csam.montclair.edu/earth/eesweb.

UNIVERSITY OF NORTH CAROLINA AT CHARLOTTE

The Department of Geography and Earth Sciences invites applications for a tenure track geoscientist (Ph.D. required) at the assistant professor level with research expertise in surface/near surface processes in one of the following areas: hydrogeology, contaminant transport or low-temperature aqueous geochemistry, or soil science. The successful candidate will be expected to develop a strong and externally funded research program encompassing both the basic and applied aspects of the shallow subsurface environment.

The individual hired will be expected to teach at both the introductory and upper division undergraduate levels in areas of her/his specialization, complement and interact with existing faculty, and contribute to student research experiences. The individual will also teach graduate courses and direct graduate student research.

The Department of Geography and Earth Sciences has 24 faculty, nine of whom are earth scientists. The department offers B.A. and B.S. degrees in earth sciences, a B.S. degree in geology, and has recently established a Master's in earth sciences. There are approximately 60 undergraduate earth sciences majors with about 20 graduating each year.

The position begins in August 2002. Interested individuals should submit a letter articulating qualifications, teaching interests and experience, research goals, and a curriculum vitae with the names of at least three references to Dr. Owen J. Furuseth, Chair, Department of Geography and Earth Sciences, University of North Carolina at Charlotte, Charlotte, NC 28223. Review of applications began November 30, 2001, and will continue until the position is filled. AA/EOE.

SEARCH REOPENED: ASSISTANT PROFESSOR IN IGNEOUS OR METAMORPHIC PETROLOGY UNIVERSITY OF NEW ORLEANS

The Department of Geology and Geophysics invites applications for a tenure-track position in igneous or metamorphic petrology to begin fall 2002. We seek a person who will undertake an innovative teaching and research program on high-temperature earth processes. We are particularly interested in individuals with multidisciplinary approaches or who welcome interaction with research groups in tectonics, mineralogy, sedimentary petrology, and geochemistry. The successful candidate will be expected to develop an active research program with external funding, teach undergraduate and graduate courses, and supervise graduate students at the M.S. and Ph.D. levels. The department maintains a full suite of analytical tools for modern petrologic research as well as a new computational facility through the Keck Foundation (see www.uno.edu/geology).

Applicants should submit a curriculum vitae, a statement of research and teaching interests, and the names of at least three references to: Terry Pavlis, Search Committee Chair, Department of Geology and Geophysics, University of New Orleans, New Orleans, LA 70148. Closing date: December 31, 2001.

The University of New Orleans, a member of the Louisiana State University System, is an equal opportunity/affirmative action employer.

ENVIRONMENTAL STUDIES PROGRAM AND GEOSCIENCES DEPARTMENT PACIFIC LUTHERAN UNIVERSITY

The Environmental Studies Program and Geosciences Department at Pacific Lutheran University invite applications for a combined tenure-track assistant professor position serving a vigorous and highly successful interdisciplinary program. Ph.D. required.

Central responsibilities: coordinate and teach in the central interdisciplinary methods course for the ES program (currently taught with a watershed focus), supervise ES senior projects, and teach undergraduate geoscience courses, including introduction to environmental sciences and at least two upper division courses in his/her specialty.

Qualifications: an active research program open to undergraduate participation, dedication to liberal arts education, and leadership capability in programmatic and curricular development. Preference given to candidates capable of excellent teaching in environment-related courses such as Geographic Information Systems, earth surficial processes, low-temperature aqueous geochemistry, or closely allied fields.

Pacific Lutheran University, 40 miles from Seattle near Mount Rainier, is a comprehensive institution that enrolls 3,400 students. Its mission is to educate for lives of thoughtful inquiry, service, leadership, and care. PLU enjoys a healthy and progressive relationship with the Evangelical Lutheran Church in America, serves a diverse clientele, and actively seeks applications from women and persons of color. For more information see Web site www.plu.edu/~envt/.

Send complete curriculum vitae, undergraduate and graduate transcripts, statement of teaching philosophy, summary of plans for undergraduate research and three letters of recommendation to: Search Committee, Environmental Studies Program, Pacific Lutheran University, Tacoma, WA 98447. Review of applications begins December 1, 2001.

ASSISTANT PROFESSOR IN HYDROGEOLOGY LOUISIANA STATE UNIVERSITY

The Department of Geology and Geophysics and the Louisiana Geological Survey (LGS), both at Louisiana State University, invite applications for a joint, tenure-track faculty position in hydrogeology at the assistant professor level. The successful candidate must have a Ph.D. at the time of appointment, fall 2002. Postdoctoral or professional experience in hydrogeology is preferred. We are looking for an outstanding, quantitative scientist with demonstrated teaching ability and research interests in the development of water resources, field methods and equipment, subsurface transport, groundwater flow and aquifer characterization. The candidate should have a working knowledge of computer modeling software and techniques used in hydrogeology.

The successful candidate will be expected to contribute to the teaching programs in the Department of Geology and Geophysics and develop courses in his/her area of specialization. Development of a strong research program, including supervision of graduate student research, publication in peer-reviewed journals and LGS technical reports and generation of external funding, is required. Active participation in ongoing and development of new LGS research projects on the subsurface water resources of Louisiana is expected.

The Department of Geology and Geophysics consists of 20 faculty members covering a wide range of expertise. In support of our faculty and students, we have many well-equipped analytical and computational laboratories. Geology and geophysics has strong support from the LSU administration as evidenced by our selection as one of the 12 priority departments at LSU. For more information about our department, see our Web site at www.geol.lsu.edu.

The Louisiana Geological Survey consists of a staff of 22, including faculty and research associates. It has a number of ongoing funded research projects in hydrogeology, environmental geology, GIS, geologic mapping and oil and gas projects, with necessary equipment and support. The LGS Web site is www.lgs.lsu.edu.

Interested persons should send a copy of their vita, a statement of their research and teaching interests, and the names, addresses, and phone numbers of at least three references to: Chair, Hydrogeology Search Committee, Department of Geology and Geophysics, Louisiana State University, E235 Howe Russell Geoscience Complex, Baton Rouge, LA 70803. The review process will begin December 1, 2001. The search will be continued until a suitable candidate is found. Louisiana State University is an equal opportunity employer.

STRATIGRAPHER/SEDIMENTOLOGIST

The Earth Sciences Department at Southern Connecticut State University (www.scsu.ctstateu.edu) invites applications for a tenure-track position at the assistant or associate professor level, beginning August 2002. A Ph.D. is required at the time of appointment. We seek a broadly educated, collegial, field-based geoscientist with specialization in stratigraphy/sedimentology and a strong commitment to undergraduate education. Teaching responsibilities may include introductory geology lecture and laboratory, stratigraphy and sedimentation, and historical geology. Candidates with expertise in Mesozoic stratigraphy, Pleistocene stratigraphy, or paleontology are particularly suitable. A willingness to encourage undergraduate research and to participate in a potential summer field program is also desirable.

The Earth Sciences Department is a comprehensive earth sciences department with six full-time faculty who support a broad-based earth science curriculum with concentrations in geology, oceanography, meteorology, environmental earth science, mineral resources, and earth science education.

To apply, please send a curriculum vitae, a statement of teaching and research interests and experience, copies of transcripts, and letters from three references by February 15, 2002, to Dr. John W. Drobnyk, Chairman, Earth Sciences Department, Southern Connecticut State University, 501 Crescent Street, New Haven, CT 06515.

SCSU is on EEO/AA Employer. Women and members of minority groups are encouraged to apply.

TWO TENURE-TRACK POSITIONS: (1) ENVIRONMENTAL GEOLOGIST/HYDROGEOLOGIST; (2) MINERALOGIST/PETROLOGIST/ STRUCTURAL GEOLOGIST, WINONA STATE UNIVERSITY

The Department of Geoscience, Winona State University, Winona, MN, is hiring two entry-level, tenure-track, assistant professors with a starting date of August 26, 2002. Candidates must have the Ph.D. in hand by start date. Salary is commensurate with rank and experience. We are seeking candidates who have a strong commitment to undergraduate teaching and who have expertise in the fields of environmental geology, hydrogeology, and/or geomorphology, or who have expertise in the fields of structure, mineralogy, petrology, and/or tectonics.

The successful environmental candidate will assume an active role in a growing interdisciplinary environmental science option within the geoscience major, and will also direct the work of the department's water resources center. Environmental geologists and/or hydrogeologists who also have a background in geomorphology, geology of soils, geochemistry, and/or geophysics are especially encouraged to apply. The successful hard-rock/structure candidate will assume an active role in a geology program with a strong field component. Structural geologists and/or mineralogists/petrologists who are broadly trained, field oriented, and able to apply these disciplines to the solution of environmental problems in geoscience are especially encouraged to apply.

Applications must include a cover letter, at least three letters of recommendation, and transcripts of all academic work. Please submit applications to: Office of Human Resources, Geoscience Search, Somsen Hall, Winona State University, Winona, MN 55987. Dossiers will be reviewed beginning December 3, 2001, although the positions will remain open until filled.

Winona State University is a comprehensive four-year institution with about 50 geoscience majors. The campus is located in the upper Mississippi River Valley at the base of 600-foot-high bluffs of Cambrian and Ordovician sandstone and carbonate. Karst topography in the upland to the west, Pleistocene and Holocene gravel in the Mississippi River Valley, and the river and associated wetlands, provide opportunities for student and faculty research in environmental geology and groundwater geology. Precambrian terranes of Minnesota and Wisconsin lie within easy driving distance, and provide student and faculty research opportunities in structure, petrology, and tectonics.

For a complete job description, see the Human Resources Office Home Page: www.winona.edu/Human-Resources or contact our office: affaction@vax2.winona.msus.edu, (507) 457-5639. For additional departmental information, go to www.winona.edu/geology

Positions available pending budgetary approval. Winona State University (MnSCU) is an equal opportunity educator and employer. Women, minorities and individuals with disabilities are encouraged to apply.

CLASSIFIED Advertising

Ads (or cancellations) must reach the GSA Advertising office one month prior. Contact Advertising Department, (303) 357-1053, 1-800-472-1988, fax 303-357-1070, or e-mail acrawford@geosociety.org. Please include complete address, phone number, and e-mail address with all correspondence.

Classification	Per Line for 1st month	Per line for each addt'l month (same ad)
Situations Wanted	$1.75	$1.40
Positions Open	$6.50	$5.50
Consultants	$6.50	$5.50
Services & Supplies	$6.50	$5.50
Opportunities for Students		
first 25 lines	$0.00	$2.35
additional lines	$1.35	$2.35
Code number: $2.75 extra		

Agencies and organizations may submit purchase order or payment with copy. Individuals must send prepayment with copy. To estimate cost, count 54 characters per line, including all punctuation and blank spaces. Actual cost may differ if you use capitals, centered copy, or special characters.

Positions Open

UNIVERSITY OF MINNESOTA DULUTH
TWO TENURE-TRACK POSITIONS
SEDIMENTOLOGY/STRATIGRAPHY/
PALEONTOLOGY/BASIN ANALYSIS/
TECTONICS/STRUCTURE

The Department of Geological Sciences at the University of Minnesota Duluth seeks to fill two tenure-track positions in the general areas of sedimentology, stratigraphy, paleontology, basin analysis, tectonics, or structure. The subdiscipline is open. We seek individuals to complement existing departmental strengths. Both positions will be at the assistant professor level and begin as early as September 2002. Essential qualifications are: a Ph.D. in the geosciences required at time of appointment; evidence of potential for achievement in research and teaching. We seek versatile geoscientists who may collaborate with faculty in the Geosciences Department (http://www.d.umn.edu/geology), the Large Lakes Observatory (http://www.d.umn.edu/llo), the Natural Resources Research Institute (http://www.nrri.umn.edu), or the Water Resources Sciences graduate program (http://wrs.coafes.umn.edu). The successful applicants will be expected to develop active externally funded research programs, supervise M.S. and Ph.D. students, and teach appropriate undergraduate and graduate courses in their disciplines. Teaching load is flexible depending upon research activities and departmental teaching needs.

Applicants should send a letter of application including a statement of research and teaching experience, philosophy and interests, a curriculum vitae, reprints of significant publications, a summary of relevant coursework, and the names and addresses of at least three references to: Dr. Howard Mooers, Search Committee Chair, University of Minnesota, Department of Geological Sciences, 230 Heller Hall, 1114 Kirby Dr., Duluth, MN 55812. Review of completed applications will begin January 1, 2002, and continue until the positions are filled. Prospective candidates with questions regarding this position may contact Howard Mooers by email at hmooers@d.umn.edu.

The University of Minnesota is an equal opportunity educator and employer.

ST. CLOUD STATE UNIVERSITY
DEPARTMENT OF EARTH SCIENCES

St. Cloud State University seeks applications for an assistant professor in the Department of Earth Sciences to begin June 1, 2002. Salary commensurate with qualifications and experience.

Responsibilities: Teach undergraduate physical geology for majors and general education earth science courses. Additional teaching to include two or more of the following upper division courses for majors: earth materials (mineralogy and petrology), field geology, tectonic systems (structural geology and tectonics), or geophysics. Additional responsibilities include participation in undergraduate research program, appropriate scholarly activity, continued professional development, advising, and university/community service.

Qualifications: Ph.D. in geology with specialty in a solid earth discipline required; field geology experience desirable. Evidence of a commitment to excellence in teaching required with university-level teaching experience preferred. Evidence of ability to establish a research program involving undergraduates required. Demonstrated ability to teach and work with persons from diverse backgrounds desired.

Apply to: Anthony Hansen, Search Committee Chair, Department of Earth Sciences, MS 49, St. Cloud State University, 720 4th Avenue South, St. Cloud, MN 56301-4498. A completed application must include a letter of application, vitae, transcripts (copies acceptable for initial screening), and three recent letters of references. Review of applications will begin January 7, 2002, and the position will remain open until a suitable candidate is found.

SCSU is committed to excellence and actively supports cultural diversity. To promote this endeavor, we invite individuals who contribute to such diversity to apply, including minorities, women, GLBT and persons with disabilities.

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 2003. The Mendenhall Program provides an opportunity to conduct research in association with selected members of the USGS professional staff. Through this program, the USGS will bring current expertise in science to assist in implementation of the science strategy of its programs. The program is also intended to provide research fellows with experiences that enhance their personal scientific skills and accomplishments. Fiscal Year 2003 begins in October 2002.

Opportunities for research are available in a wide range of areas including: application of stable isotope and trace element techniques to ecological studies; hydrogeology of fractured-rock aquifers; gas hydrate field and lab investigations; bitumen generation and oil expulsion; landslide process studies; exploring active volcano-tectonic processes; in situ studies of faulting and earthquake generation; carbon dioxide sequestration; carbon cycling; remote sensing research; applications of numerical modeling; and developing magnetic models linking geophysics and geology.

The postdoctoral fellowships are 2-year USGS appointments with full benefits and salaries. The closing date for applications is January 18, 2002. Appointments will start between October 2002 and May 2003, depending on availability of funds. A complete description of the program, research opportunities, and the application process are available via the WWW at http://geology.usgs.gov/postdoc. The U.S. Geological Survey is an equal opportunity employer.

FACULTY POSITION IN EARTH SURFACE SYSTEMS
NORTHWESTERN UNIVERSITY

The Department of Geological Sciences at Northwestern University invites applications for a tenure-track faculty position in the area of modern and ancient earth surface systems. Subdisciplines of interest include geochemistry/biogeochemistry, process sedimentology, geomorphology, and paleoclimatology. The position is at the rank of assistant professor, but exceptional candidates at a higher rank will be considered. Candidates are expected to complement existing areas of departmental expertise, and to develop strong programs of cross-disciplinary research and teaching. Applications should include a statement of research accomplishments and future directions, curriculum vitae, copies of significant publications, names of at least three professional references, and be received no later than Jan. 15, 2002. Address applications to: Search Committee, Department of Geological Sciences, 1847 Sheridan Road, Northwestern University, Evanston, IL 60208-2150.

Women and members of minority groups are encouraged to apply. Northwestern is an Affirmative Action and Equal Opportunity Employer.

GEOLOGY FACULTY, UTAH VALLEY STATE COLLEGE

The Department of Earth Science at Utah Valley State College (UVSC) is seeking a student-oriented, motivated teacher and scientist to participate in the continued growth of our department. The department is dedicated to innovative and effective undergraduate teaching, and we take advantage of Utah's diverse geologic setting to incorporate field-based learning into our programs. Candidates for this tenure-track faculty position must have an earned Ph.D. by June 2002, with expertise in one or more of the following areas: environmental geology/hydrogeology, mineralogy/petrology, or sedimentology/stratigraphy. The successful candidate will have a broad technical background, the drive and ingenuity to develop new courses and programs, and the ability to attract and retain students. Duties will include teaching lower-division and upper-division geology courses, developing new courses and study programs, and participating in department field trips and projects. UVSC faculty are expected to maintain knowledge in their fields by conducting research, professional work, and/or activity in professional organizations. The position may involve maintenance and of the department's laboratory equipment and supplies. UVSC in an equal opportunity/affirmative action/equal access employer and encourages applications from women and minorities. Final approval for the position is pending funding. Applicants must submit a letter of interest, a statement of teaching philosophy, a curriculum vitae, copies of transcripts/degrees, and three letters of recommendation. Submit application materials to Human Resources, MS #184, Utah Valley State College, 800 West University Parkway, Orem, Utah 84058, (801) 222-8207. We began reviewing applications on November 30, 2001. For more information, contact Daniel Horns (Earth Science Department Chair) at (801) 222-8582, hornsda@uvsc.edu, or see an expanded job description at http://www.uvsc.edu/hr/employ/job_announcements/.

DEPT. OF EARTH AND ENVIRONMENTAL SCIENCES
CALIFORNIA STATE UNIVERSITY, FRESNO

Faculty Positions. The Department of Earth and Environmental Sciences of the California State University, Fresno invites applications to fill two tenure-track positions starting August 2002 at the assistant professor level in the following areas. (1) Igneous petrology/mineralogy. Teaching responsibilities will include igneous and metamorphic petrology, crystallography, and mineralogy, and graduate courses in area of expertise as well as introductory and general education courses. (2) Environmental science. Responsibilities will include teaching in one of the following areas: environmental hydrology, earth resources and sustainable development, atmospheric pollution and global change. A Ph.D. is required. Candidates nearing completion of the Ph.D. may be considered. To ensure full consideration, applicants are advised to submit an application including a resume, list of publications, statements of teaching and research interests, and the names of at least three references by: February 4, 2002. For the environmental science position, application should be sent to Dr. C. John Suen, johns@csufresno.edu, and for the igneous petrology/mineralogy position, to Dr. Fraka Harmsen, fraka_harmsen@csufresno.edu, at the following address: Department of Earth and Environmental Sciences, California State University, Fresno 2345 E. San Ramon Avenue, M/S-MH24 Fresno, CA 93740-8031. Phone: (559) 278-3086; fax: (559) 278-5980. California State University, Fresno is an Affirmative Action/Equal Employment Opportunity Employer.

EVOLUTIONARY PALEOBIOLOGIST
UNIVERSITY OF WISCONSIN—MILWAUKEE

The Department of Geosciences at the University of Wisconsin—Milwaukee seeks to hire an evolutionary paleobiologist at the tenure-track assistant professor level. Applicants must hold a Ph.D. in geology or related field and have demonstrated field and research experience in evolutionary paleobiology. Postdoctoral experience is desirable. The successful candidate is expected to conduct an active research program, and teach undergraduate and graduate courses in paleontology, historical geology and related subject areas. Information is available online regarding the department at http://www.uwm.edu/Dept/Geosciences/.

Candidates must mail a curriculum vitae with a research plan, a statement of teaching philosophy, and three letters of reference postmarked by January 30, 2002, to Norman P. Lasca, Chair, Department of Geosciences, University of Wisconsin—Milwaukee, P.O. Box 413, Milwaukee, WI 53201, fax: 414-229-5452; e-mail: nplasca@uwm.edu. The University of Wisconsin—Milwaukee is an Equal Opportunity/Affirmative Action Employer.

TWO TENURE-TRACK
POSITIONS—BIOGEOCHEMISTRY
UNIVERSITY OF SASKATCHEWAN

The Department of Geological Sciences at the University of Saskatchewan is accepting applications for two tenure-

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track positions in the field of biogeochemistry. For the first position, we are seeking a candidate with a background in stable isotope methods applied to biogeochemical problems in modern or ancient oceanography, climatology, or ecology. The successful candidate will have strong analytical training. For the second position, we are seeking a candidate with a research focus in environmental biogeochemistry of trace metals. This candidate will work both within the department and the broader cross-campus interdisciplinary toxicology program.

Both candidates should be prepared to develop vigorous research programs, and participate in undergraduate and graduate student teaching and research. Candidates must hold a Ph.D. when appointed. Previous teaching experience is preferred, although not essential. Appointments will be at the assistant professor level (tenure-track), although outstanding candidates may be considered at a higher level.

The department has 15 full-time faculty, including two endowed research chairs in geochemistry. The analytical infrastructure is one of the finest in North America with TIMS, IRMS, MC–ICP–MS, laser ablation quadrupole ICP–MS, electron microprobe, XRD, SEM, and trace-metal clean room. Exceptional opportunities exist for innovative collaboration with researchers from the Colleges of Agriculture, Engineering, Medicine, and Veterinary Medicine, and the Toxicology Centre. Also located on campus are the Canadian Wildlife Service and National Water Research Institute. The University of Saskatchewan is home to the first synchrotron light source in Canada (under construction).

Applications, including full resume and three letters of reference will be addressed to Dr. James Basinger, Head, Department of Geological Sciences, University of Saskatchewan, Saskatoon, SK S7N 5E2, Canada. E-mail: jim.basinger@usask.ca; fax: 306-966-8593; www.usask.ca/geology/. We will begin reviewing applications on December 10, 2001.

Both positions have been cleared for advertising at the two-tier level. Applications are invited from qualified individuals regardless of their immigration status in Canada. The University of Saskatchewan is committed to employment equity. Members of designated groups (women, Aboriginal people, people with disabilities and visible minorities) are encouraged to self-identify on their applications.

GEOLOGY INSTRUCTOR

Santa Monica Community College is accepting applications for a full-time, tenure-track geology instructor to start fall 2002. Will teach introductory lecture and laboratory courses in physical, historical geology and physical oceanography, and further develop the geology curriculum; conduct field work with students separate from or as a part of assigned class load; teach evening classes and/or Saturday classes as needed; serve as a proponent for geology education on campus and in the community; participate in the development of geology, academic and administrative programs. The minimum qualifications for this position are a master's in geology, geophysics, earth sciences, meteorology, oceanography or paleontology or bachelor's in geology and master's in geography, physics or geochemistry, or the equivalent. Advanced graduate work in physical geology and/or historical geology and/or oceanography is preferred. Fieldwork experience, demonstrated experience and interest in teaching college level geology and oceanography lecture and laboratory courses are desirable. Ability to use technology as a teaching tool. Salary: $39,456–$81,361. Deadline to apply: February 14, 2002. Please call (310) 434-4336 for a district application and detailed job description, or write to Santa Monica College, Human Resources, 1900 Pico Blvd., Santa Monica, CA 90405. EOE.

ENVIRONMENTAL GEOLOGIST
NORTHERN KENTUCKY UNIVERSITY

The Department of Physics and Geology invites applications for a tenure-track position in environmental geology beginning in August 2002. Undergraduate teaching experience and a Ph.D. in geology with experience in environmental geology are required. Teaching responsibilities will include upper division undergraduate courses and introductory geology courses with labs. Preference will be given to individuals with strong backgrounds in hydrogeology and environmental studies of groundwater quality. Candidates will be expected to develop a research program that will include undergraduate geology and environmental science majors. The candidate will also be expected to contribute to the department's educational outreach programs to P–12 and nontraditional science students. The ability to collaborate with NKU's emerging Environmental Science program, Environmental Resource Management Center and/or the Center for Integrative Natural Science and Mathematics will offer the successful candidate additional professional opportunities. Rank and salary will be commensurate with qualifications. Send letter of application, curriculum vitae, separate statements of teaching philosophy and research interests, and the names, addresses, phone numbers, and e-mail addresses of three references to: Geology Search Committee, Department of Physics and Geology, Northern Kentucky University, Highland Heights, KY 41099-1900, by Jan. 7, 2002. Candidates may be required to submit additional documentation. For additional information on Northern Kentucky University visit http://www.nku.edu. Northern Kentucky University is an Equal Opportunity/Affirmative Action Employer.

TENURE-TRACK FACULTY POSITIONS
UNIVERSITY OF PITTSBURGH

The Department of Geology and Planetary Science at the University of Pittsburgh seeks applicants for two full-time, tenure-track faculty positions beginning in September 2002, pending budgetary approval. We expect to fill one position up to the associate professor level and the other at the rank of assistant professor. Each successful candidate will be expected to develop an active, externally funded research program. Teaching duties will include undergraduate and graduate courses in geology and planetary science, as well as supervision of M.S. and Ph.D. students and undergraduate research projects. Necessary qualifications include a Ph.D. at time of appointment, as well as demonstrated excellence in teaching, research, and intellectual leadership.

For the first position, we seek applications from individuals with expertise in planetary surface processes/volcanology. Our preferred candidate would have an active research program in physical volcanological processes on Earth and other planets, with additional research interests in areas such as remote sensing, geophysics, and Mars-related mission activities. We seek someone who will contribute to one or more of the department's focused research groups in remote sensing, spectroscopy, and volcanology; in astrobiology and geochemistry; and in paleomagnetics and tectonics.

For the second position, in astrobiology/life history, applications are invited from individuals with expertise in paleontology, geomicrobiology, or biogeochemistry who can work in modern environments as well as the fossil record. We seek individuals who examine the impact of life on geological processes and earth history, and who have interests in the evolution of life in extreme / extraterrestrial environments and in the geological factors that have guided evolution. The successful candidate could interact with colleagues currently pursuing research in paleoclimate reconstruction, environmental and earth surface processes, and planetary geology and geochemistry.

Qualified applicants should send a curriculum vitae (including past and current grant support and relevant publications), statements of research and teaching interests, and the names, addresses, phone numbers, and e-mail of at least four referees to: Faculty Search Committee, Department of Geology and Planetary Science, 200 SRCC Building, University of Pittsburgh, Pittsburgh, PA 15260, USA. Please specify the position to which you are applying. Evaluation of applications will begin January 15, 2002, and continue until the position is filled. For additional details and information about the department please see our Web site: http://www.geology.pitt.edu/.

The University of Pittsburgh is an affirmative action, equal opportunity employer. Women and members of under-represented minority groups are especially encouraged to apply.

ANALYTICAL FACILITIES TECHNICIAN
UNIVERSITY OF TEXAS AT EL PASO

The Department of Geological Sciences at the University of Texas at El Paso invites applications for a full-time position as analytical facilities technician. The department is equipped with numerous analytical instruments located in an outstanding facility that is the centerpiece of the university.

Duties will include maintenance of a Cameca SX50 electron microprobe, a Scintag XDS2000 XRD, a gamma-ray detection INAA unit, a variety of optical microscopes and other equipment, as well as assistance and training of faculty and students from diverse backgrounds in the successful use of the facilities. Collaborative or independent research is encouraged, however, the primary focus of the position is successful operation of the facility. The candidate would also assume a variety of other duties including serving as safety officer and monitoring inventory.

Minimum requirements include an M.S. or Ph.D. in geosciences, material sciences, or related fields. Direct experience with an electron microprobe and good communication skills are essential.

Interested persons should send a resume, and names of two references to: Dr. Kate C. Miller, Chair, Department of Geological Sciences, University of Texas at El Paso, El Paso, TX 79968-0555, E-mail: miller@geo.utep.edu.

We will begin reviewing applications on December 15, 2001, and will accept applications until the position is filled.

The University does not discriminate on the basis of race, color, national origin, sex, religion, age, disability, or sexual orientation in employment of the provision of services.

TENURED OR TENURE-TRACK POSITION
CAVE AND KARST STUDIES

New Mexico Institute of Mining and Technology invites applications for a new tenure-track position in cave and karst studies in the Department of Earth and Environmental Science (www.ees.nmt.edu), starting summer or fall semester 2002. New Mexico Tech is the academic partner in the newly established federal National Cave and Karst Research Institute (NCKRI), located near Carlsbad Caverns National Park, and the position will serve as the link between activities at New Mexico Tech and NCKRI. The position will be on New Mexico Tech's campus in Socorro. We seek an individual specializing in an earth-science oriented aspect of cave and karst research such as karst hazards, paleoclimatology based on cave deposits, or cave biogeochemistry. Applicants must have a Ph.D. in one of the earth sciences, or a related field, at the time of appointment. Demonstrated excellence in research, potential for future growth, broad expertise in national cave/karst issues, and ability to coordinate New Mexico Tech's activities within NCKRI are the most important qualifications. Responsibilities will include developing an active program of extramurally funded research, supervising and supporting graduate students, and teaching two graduate or undergraduate courses per year. The successful candidate will join a department of 21 full-time faculty, 26 adjunct faculty, 100 graduate, and 80 undergraduate students. The Department has strong programs in hydrology, geophysics, and geology/geochemistry. The New Mexico Bureau of Geology and Mineral Resources, with 35 other earth-science professionals, is also located on campus. The position may be filled at any level, commensurate with qualifications. Salary is negotiable and competitive. For further information on this position see http://www.ees.nmt.edu/cavekarst.html. Applicants should submit a letter of interest, resume, college transcripts, and the names and contact information of three references to New Mexico Institute of Mining and Technology, 801 Leroy Place, Human Resources, Wells Hall Box 116B, Socorro NM 87801. E-mail applications are not accepted. To receive full consideration, all materials must be received by January 15, 2002. New Mexico Tech is an Equal Opportunity/Affirmative Action employer.

MULTIPLE FACULTY POSITIONS
DEPARTMENT OF GEOLOGICAL SCIENCES
INDIANA UNIVERSITY

The Department of Geological Sciences at Indiana University invites applications for two endowed, tenured positions at the full or associate professor level and one tenure-track position at the level of assistant professor. The two endowed positions supplement two endowed professorships that were filled in the past year.

We seek individuals with a solid record of scholarly achievement and demonstrated success in obtaining, or the potential to obtain, external research support. Priority will be given to candidates who can enhance our existing research strengths and expand our collaborative analytical facilities. All positions will include teaching across the curriculum and supervision of student research.

Murray Chair in Applied Clay Mineralogy: We seek a clay mineralogist with high visibility in some area of applied clay mineralogy, which could include: novel industrial uses of clays, clay minerals as biohazards, and environmental or biomedical applications of clay minerals.

Mead Professorship in Geophysics: We seek a geophysicist with expertise in applied and exploration geophysics. Applicants should demonstrate an ability and interest in fostering interdisciplinary study in geophysics, tectonics, and basin analysis.

Geochemistry: We seek a metal-isotope geochemist or microbial biogeochemist working on ICP-MS instrumentation to investigate metal-isotope systematics in hydrothermal mineralization, extremophile metabolism, cosmic reactions or other processes where partitioning of metals occurs.

The Department of Geological Sciences currently has 16 full-time and 5 part-time faculty shared with other I.U. units and the Indiana Geological Survey, which is located in the same building as the department. The department's outstanding existing laboratory infrastructure and Field Station in Montana are expected to be augmented in the near future with the completion of a new multi-disciplinary science building housing state-of-the-art analytical equipment. More information about the department can be found at http://www.indiana.edu/~geosci.

Applications should include a personal statement of teaching and research interests, a detailed curriculum vitae, and names and addresses (including email) of five referees. They should be sent to the appropriate person listed below at the Dept. of Geosciences, Indiana University, Bloomington, IN 47405. Review of applicants will

begin on December 20, and will continue until the positions are filled. Indiana University, as an equal opportunity/affirmative action employer, encourages the candidacies of women and minorities.

Dr. Mark Person, Chair, Clay Mineralogy Search Com., (812) 855-4404, maperson@indiana.edu; Dr. Lee Suttner, Chair, Geophysics Search Com., (812) 855-4957, suttner@indiana.edu; Dr. Lisa Pratt, Chair, Geochemistry Search Com., (812) 855-9203, prattl@indiana.edu.

ASSISTANT PROFESSOR, STRUCTURAL GEOLOGY
LOUISIANA STATE UNIVERSITY

The Department of Geology and Geophysics at Louisiana State University invites applications for a tenure-track assistant professor position to begin fall semester of 2002. A position at the associate professor level may be considered for an exceptional candidate. Required Qualifications: Ph.D. in geology or related field at the time of appointment. Additional Qualifications Desired: postdoctoral experience; outstanding, quantitative geoscientist with demonstrated expertise in the areas of structural geology.

The successful candidate is expected to contribute to our undergraduate and graduate teaching programs and develop courses in his or her area of specialization. Responsibilities: develops a strong research program; supervises graduate student research; active publication in national or international highly ranked journals; generates external funding.

The department consists of 20, tenure-track faculty members covering a wide range of expertise. In support of our faculty and students, we have many well-equipped analytical and computational laboratories. Geology and geophysics has strong support from the LSU administration as evidenced in our selection as one of the 12 priority departments at the university. For more information about our department, see our Web site at http://www.geol.lsu.edu.

The review process will begin December 15, 2001. The search will be continued until a suitable candidate is found. Interested persons should send a copy of their vita, a statement of their research and teaching interests, and the names, addresses, and phone numbers of at least three references to: Chair, Structure Search Committee, Department of Geology and Geophysics, Louisiana State University, Ref. Log #0468 Baton Rouge, LA 70803.

LSU IS AN EQUAL OPPORTUNITY/EQUAL ACCESS EMPLOYER

UNIVERSITY OF TORONTO, DEPT. OF GEOLOGY
EARTH AND PLANETARY MATERIALS

The Department of Geology is readvertising its vacant tenure stream position on the downtown (St. George) campus in the field of earth and planetary materials at the assistant professor level. We are particularly interested in, but not limited to, candidates with research interests in quantitative aspects of planetary studies, igneous and metamorphic petrology, mineralogy and high-temperature geochemistry. Candidates must have a Ph.D. degree at the time of appointment and be able to demonstrate both their ability for independent research and a potential to complement existing research programs described on our Web site, www.geology.utoronto.ca. In addition to establishing an internationally recognized independent research program, the successful candidate will have a strong commitment to teaching at all levels. Salary will be commensurate with the candidate's qualifications and experience. The position is available from July 1, 2002.

The Department of Geology is well equipped with analytical and experimental facilities to support earth and planetary materials research. More information on facilities and programs is available on our Web site.

Applicants should send their complete curriculum vitae, including a list of publications, and a short statement describing their research program. They should also arrange to have at least three letters of reference sent directly to: Chair, Department of Geology, University of Toronto, 22 Russell Street, Room 1066, Toronto, Ontario, Canada M5S 3B1.

To ensure full consideration, all information should be received by January 15, 2002. Applications after this date will be considered until the position has been filled.

The University of Toronto is strongly committed to diversity within its community. The University especially welcomes applications from visible minority group members, women, Aboriginal persons, persons with disabilities, members of sexual minority groups, and others who may add to the diversity of ideas.

UNIVERSITY OF ARKANSAS
DEPARTMENT OF GEOSCIENCES

The University of Arkansas, Fayetteville invites applications for a tenure track position in the Department of Geosciences in the area of igneous petrology and volcanology at the rank of associate professor commencing August 2002. Minimum qualifications are a Ph. D. in the earth sciences. The candidate should have expertise and research interests in igneous and metamorphic petrology and volcanology. The application of GPS and geodesy to problems in volcanology and plate movement would be an asset.

The successful candidate will be expected to develop a rigorous, externally funded research program, supervise graduate students and teach undergraduate and graduate courses. Collaboration with existing faculty who have research interests in plate movement and structural geology will be strongly encouraged.

The University of Arkansas is committed to equity and diversity in the workplace and welcomes applications from persons with disabilities and members of minorities. Applications from women are particularly encouraged.

Applications should include: a letter of application; a detailed curriculum vita; a research plan; a statement of teaching interests; teaching evaluations or evidence of effective teaching if available; and three current letters of reference forwarded by the referees. To insure full consideration, complete applications and letters of reference should be submitted by January 4, 2002, to: Doy Zachry, Search Committee Chair, Department of Geosciences, Ozark Hall 113, University of Arkansas, Fayetteville, AR 72701; e-mail dzachry@uark.edu; phone (501) 575-2785; fax (501) 575-3469.

ENVIRONMENTAL GEOLOGIST
GEORGE MASON UNIVERSITY

The Environmental Science and Policy Program invites applications for a tenure-track assistant professor position in environmental geology for fall 2002. We seek a dynamic person with research expertise in one or more of the following: geochemistry, soil science, hydrology, geologic hazards, and global change. Special consideration will be given to candidates with expertise in remote sensing, GIS, and/or environmental modeling. The successful candidate will be expected to pursue an active externally funded

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Department of Geosciences
PRINCETON UNIVERSITY

HARRY HESS FELLOWS PROGRAM

The Department of Geosciences at Princeton University announces competition for the 2001-2002 Harry Hess Fellows Program. This honorific postdoctoral fellowship program has been established to provide opportunities for outstanding young geoscientists to work in the field of their choice. Research may be carried out independently or in collaboration with members of the Geosciences Department. One or more Hess fellows are usually appointed each year. Applicants must have obtained a Ph.D. at the time of the start of the fellowship, but not more than five years before. Current areas of research include:

Geochemistry	Petrology
Biogeochemical Cycles	Structural Geology
Paleontology	Geophysics
Mineral Physics	Seismology
Tectonics	Geomicrobiology

Candidates should send a letter of application and the supporting materials listed below to the HESS FELLOWS COMMITTEE, c/o Professor F. A. Dahlen, Department of Geosciences, Guyot Hall, Princeton University, Princeton, NJ 08544. Applications will continue to be accepted until the available positions are filled, but no later than December 31, 2001.

- Curriculum vitae
- List of publications and preprints
- Brief statement of research interests and goals
- Name, address and email address of three referees familiar with the candidate's work

Hess fellowships provide a competitive annual stipend, depending upon experience, along with an allowance for travel to meetings and research support. Initial awards are for one year, with a starting date that must be before January 1, 2003. Extensions for an additional year are generally granted depending upon satisfactory performance. Applications will continue to be accepted until the available positions are filled, but no later than December 31, 2001. Hess fellowship applicants will also be considered for other available postdoctoral positions in the Geosciences Department.

Princeton University is an Affirmative Action/Equal Opportunity employer and particularly welcomes applications from women and members of minority groups.

Information about the research activities of the Department of Geosciences may be viewed at http://www.geoweb.princeton.edu.

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research program, aspire to teaching excellence, and engage in interdisciplinary collaboration. Teaching duties will include undergraduate courses as well as graduate courses in area of expertise. A Ph.D. is required.

The program offers undergraduate degrees in geology/earth science and M.S./Ph.D. in environmental science and policy. Our faculty includes ecologists, microbiologists, geologists, earth scientists, oceanographers, and sociologists. Additional information about the program and university may be found at www.mason.gmu.edu/~espp and www.gmu.edu, respectively.

Candidates should submit CV, letter of intent including statements of research and teaching interests, examples of published work, teaching evaluations (if available), and contact information (with e-mail addresses) of three references to Randy McBride, Search Committee Chair, Environmental Science and Policy Program, Mail Stop 5F2, George Mason University, Fairfax, VA 22030-4444. Application deadline is 31 December 2001. George Mason University is an Affirmative Action/Equal Opportunity Employer. We strongly encourage women and minority candidates to apply.

UNIVERSITY OF NEW HAMPSHIRE
SOLID EARTH GEOCHEMISTRY

The Department of Earth Sciences at the University of New Hampshire invites applications for a tenure-track position in solid earth geochemistry at the assistant professor level starting September 2002, or as soon as possible thereafter. The successful candidate will be expected to teach geochemistry, an introductory earth sciences course as part of the core curriculum in geology, graduate course(s) in his/her specialty, and to develop a strong research program involving graduate and undergraduate students. Research specialization is open (e.g., stable isotopes, high-temperature geochemistry, geochronology) but should be complementary to current departmental and college efforts. UNH offers bachelor's degrees in the areas of geology, hydrology, oceanography and earth sciences; five M.Sc. options; and the Ph.D. in earth sciences. The department (http://www.unh.edu/esci) has strong ties to the Institute for the Study of Earth, Oceans, and Space, and the Center for Coastal and Ocean Mapping. A Ph.D. at the time of appointment is expected.

Review of applications begins December 17, 2001. Please send complete CV, statement of research and teaching interests, and names and addresses of three references to Geochemistry Search Committee, UNH Department of Earth Sciences, 56 College Road, Durham, NH 03824. UNH is committed to excellence through diversity in its faculty and strongly encourages women and minorities to apply.

UNIVERSITY OF MINNESOTA
SOLID-EARTH GEOPHYSICS

The Department of Geology and Geophysics at the University of Minnesota invites applications for a tenure-track faculty position in solid-earth geophysics. The appointment will be made at the assistant professor or, under exceptional circumstances, at a higher level with faculty rank and tenure status dependent on the qualifications of the candidate.

Candidates are sought with interests in one or more of the following areas: geodynamics, geomagnetism, mineral and/or rock physics, and seismology. Outstanding candidates in other areas of geophysics will also be considered. Potential areas of focus include the crust, mantle and/or core of the Earth or other planetary bodies.

The appointee will be expected to develop a vigorous research program, attract external funding, and complement existing research activities. Teaching duties will reflect the expertise of the candidate and include both undergraduate and graduate courses. This position is enhanced by potential interactions with colleagues at research centers throughout the university including the Minnesota Supercomputer Institute, the Institute for Rock Magnetism, the geophysical fluid dynamics program at St. Anthony Falls Hydraulic Laboratory, the Limnological Research Center, the Minnesota Geological Survey, and the Institute of Technology Characterization Facility. Information concerning collaborative research and related instrumentation is available at http://www.geo.umn.edu/dept/positions/geophysics.html.

A Ph.D. degree must be earned by the time of the appointment in August 2002. The review of completed applications will begin **January 11, 2002,** and continue until an appointment is made. Application requirements are (1) curriculum vitae, (2) complete list of publications, (3) statement of research interests, (4) statement of teaching interests, and (5) at least three letters of recommendation. Send application to Chair, Geophysics Search Committee, Department of Geology and Geophysics, University of Minnesota, 310 Pillsbury Dr. S.E., Minneapolis, MN 55455 USA. Questions may be addressed to Professor David Kohlstedt at dlkohl@umn.edu.

The University of Minnesota is an equal opportunity educator and employer.

TEXAS A&M UNIVERSITY

The Department of Geology and Geophysics at Texas A&M University invites applications for two entry-level, tenure-track faculty positions beginning fall of 2002.

Environmental/Engineering Geology. We seek a researcher interested in fundamental questions concerning societal interactions with geologic systems, such as water resources; biogeochemistry and ecosystem functioning; fluvial geomorphology; or urban development. The candidate will join a dynamic program with expertise in hydrogeology, biogeochemistry, near-surface geophysics, engineering geology, and neotectonics, as well as many other geoscience areas. This position is funded through a major, campus-wide, interdisciplinary research program, The Sustainable Coastal Margins Program (SCMP, http://scmp.gerg.tamu.edu).

Responsibilities for this position include the development of an outstanding, externally funded, research program, involvement in the SCMP program, and a commitment to undergraduate and graduate teaching. Submit a curriculum vita, reprints, a summary of research and teaching interests, and the names, postal and e-mail addresses of three or more references to: Dr. Bruce Herbert, Environmental/Engineering Search Committee Chair, Geology and Geophysics, Texas A&M University, College Station, TX 77843-3115. Review of applications will start on Dec. 1, 2001.

Paleobiology, Biotic response to global change. We seek an individual to develop an outstanding research and teaching program that will complement interdisciplinary research in paleoecology, paleoclimatology, and paleoceanography within the College of Geosciences, including the Depts. of Geology and Geophysics, Oceanography and the Ocean Drilling Program. Research areas of particular interest include, but are not restricted to: paleoecology, taphonomy, paleoceanography and paleoclimatology, paleoproductivity, molecular paleobiology and the biogeochemistry of ancient environments, paleoproductivity, and evolutionary theory.

Applicants must hold a Ph.D. in geology or related field, and demonstrate research productivity in the form of publications and current or potential external funding. Submit a curriculum vitae, reprints, statement of research interests, and the names, postal, and e-mail addresses of three references to: Dr. Anne Raymond (raymond@geo.tamu.edu), Paleobiology Search Committee Chair, Dept. of Geology & Geophysics, Texas A&M University, College Station, TX 77843-3115 USA. Review of applications will begin on Jan. 10, 2002, and continue until the position is filled.

Texas A&M University, a land-, sea- and space-grant institution, is located in College Station, Texas, a dynamic community of 140,000 people. Texas A&M University is an affirmative action/equal opportunity employer committed to excellence through diversity and compliance with the Americans with Disabilities Act. Departmental facilities and programs can be reviewed at our Web site (http://geoweb.tamu.edu/).

UNIVERSITY OF WEST FLORIDA
ASSISTANT PROFESSOR
HYDROGEOLOGY/HYDROGEOMORPHOLOGY

The Department of Environmental Studies, University of West Florida, invites applications for a tenure-track position in hydrogeology/hydrogeomorphology, beginning August 2002. We seek candidates with expertise in applied groundwater hydrology or water/land surface interactions. Interest in environmental issues is highly desirable. Applicants should have an appreciation for undergraduate education and will be expected to teach classes in geology, geomorphology, and hydrology. Applicants are expected to develop an active research program and should be committed to peer-reviewed publication. A Ph.D. in geology or geography at the time of appointment is required. Salary commensurate with qualifications and experience.

The Department of Environmental Studies offers a major in environmental studies and minors in geography and environmental studies. Over 135 majors specialize in natural science and environmental policy tracks. A geography track is being developed. The department is housed in a renovated building with new research and teaching facilities. The department maintains the university-wide Geodata Center, which has extensive GIS capabilities. For more information on the department see http://uwf.edu/environmental/.

Candidates are requested to submit a statement of research and teaching interests and experience, a curriculum vitae, and three letters of reference by December 17, 2001. Inquires may be made at liebens@uwf.edu or at phone (850) 474-2065.

Apply: Dr. Johan Liebens, Department of Environmental Studies, University of West Florida, 11000 University Parkway, Pensacola, FL 32514.

The University of West Florida is an Equal Opportunity/Access/Affirmative Action Employer.

GEOCHEMISTRY/PETROLOGY OF THE LITHOSPHERE
BOSTON UNIVERSITY

The Department of Earth Sciences at Boston University invites applications for a tenure-track faculty position at the assistant professor level, to begin September 1, 2002.

We seek a scientist to build a vibrant research and teaching program emphasizing geochemical and petrologic approaches to solving tectonics problems, with interests in the composition and evolution of the continental and/or oceanic lithosphere. The scientist may utilize methods based on one or more of the following: (1) isotope geochemistry and/or geochronology, (2) igneous and/or metamorphic petrology and geochemistry, (3) experimental petrology or geochemistry, and (4) field geology. The new faculty member will complement existing strengths in lithosphere deformation and geochemistry, tectonics, geophysics, low-temperature geochemistry, and marine and surface processes.

The successful applicant will be expected to supervise graduate thesis work in M.A. and Ph.D. programs, maintain an externally funded research program, and teach at all levels in the earth sciences curriculum. Interaction is encouraged with the Departments of Geography, Chemistry, and Physics, the Center for Remote Sensing the Center for Energy and Environmental Studies, and the B.U. Marine Program. For more information about the department, see http://www.bu.edu/ES.

A Ph.D. at the time of appointment is required. Applicants should send a curriculum vitae, a statement of research and teaching interests, and the names and addresses of at least three referees to: Search Committee Chair, Department of Earth Sciences, Boston University, 685 Commonwealth Ave., Boston MA 02215 USA; e-mail: earth@bu.edu. Review of applications will begin on December 1, 2001. Boston University is an equal opportunity/affirmative action employer.

FACULTY POSITION
STRATIGRAPHY/SEDIMENTOLOGY
WASHINGTON UNIVERSITY, ST. LOUIS

Washington University in St. Louis announces a tenure-track position at the assistant professor level in the fields of stratigraphy and sedimentology to begin in fall 2002. Under special circumstances, an outstanding candidate may be considered for appointment at a higher level. The successful candidate will be a creative individual who uses field, laboratory, and analytical techniques to investigate modern and ancient sedimentary rocks and processes. Areas of interest might include, but are not limited to: sequence stratigraphy and its relationship to tectonic subsidence, eustasy, and sediment flux; sedimentary rocks as recorders of climate change; environmental geology as deduced from sedimentary strata. Candidates should demonstrate promise of excellence in both teaching and research and must have been awarded a Ph.D. at time of appointment. Send resume, statement of future research interest, and names and contact information for at least three references to: Robert Tucker, Search Committee Co-Chair, Department of Earth and Planetary Sciences, Washington University, Campus Box 1169, One Brookings Dr., St. Louis, MO 63130, or via e-mail: SS-FacSearch@levee.wustl.edu. EO/AA employer. Employment eligibility verification required upon employment. Consideration of applicants will begin on December 31, 2001, and continue until the position is filled.

GEOLOGY INSTRUCTOR

The Grossmont-Cuyamaca Community College District, located in El Cajon, CA, is currently accepting applications for a full-time, tenure track geology instructor beginning fall 2002. Applications are required and may be obtained at www.gcccd.net/hr/academic.htm. Applications must be received by 01/18/02. AA/EEO/Title IX Employer

TENURE-TRACK POSITION IN GEOMORPHOLOGY
MIAMI UNIVERSITY

The Department of Geology at Miami University invites applications for a tenure-track faculty position at the assistant professor level, beginning August 2002. Applicants must have a Ph.D. degree at the time of appointment. The successful applicant will be expected to teach effectively at the undergraduate and graduate levels, supervise student research at the undergraduate, M.S. and Ph.D. levels, and initiate and maintain a vigorous, externally funded research program.

We are seeking an outstanding candidate who is undertaking significant field and/or laboratory based research. The particular research emphasis should complement current program strengths. Thus, areas of emphasis may include, but are not limited to active tectonics, remote sensing, Quaternary geology, and climate change.

The successful applicant will join an active department that consists of 10 faculty members, two technical staff members, 50 undergraduate majors and 20 graduate students. The department maintains active research programs in environmental geology, hydrogeology, low-temperature geochemistry, geomicrobiology, sedimentology and stratigraphy, mineralogy, igneous petrology, volcanology, isotope geochemistry, structural geology, and tectonics. Included among departmental instrumentation are: DC plasma spectrometer, thermal ionization mass spectrometers (new multi-collector to arrive spring 2002), HPLC ion chromatograph, atomic force/scanning tunneling microscope, single-crystal and powder x-ray diffractometers (including a new CCD diffractometer), single-crystal x-ray cameras, electrophoretic mobility analyzer, and cathode lumniscope. The department also owns a truck-mounted hollow-stem auger drilling rig. Please visit www.muohio.edu/geology/ for additional information.

Miami University, with 16,000 students, is located in a small-town setting within a one-hour drive of Cincinnati and Dayton. Interested candidates should submit a packet containing a letter of application, curriculum vitae, statement of teaching and research objectives and accomplishments, transcripts, and arrange three letters of reference to be sent to: Geomorphology Search Committee, Department of Geology, Miami University, 114 Shideler Hall, Oxford, OH 45056 (fax: 513-529-1542). Applications will be accepted until January 11, 2002, or until the position is filled.

We encourage applications from women, members of ethnic minorities, and individuals with disabilities. Miami University offers equal opportunity in employment and education.

FACULTY POSITION
REMOTE SENSING GEOSCIENTIST
UNIVERSITY AT BUFFALO
THE STATE UNIVERSITY OF NEW YORK

The Department of Geology at the University at Buffalo, a Research I University, invites applications for a tenure-track faculty position in remote-sensing geoscience, starting in August 2002 at the rank of assistant or associate professor. The successful candidate will demonstrate a potential for research and teaching that will complement and integrate with our existing programs in volcanology and environmental geology. Existing research in the department includes studies of volcanoes, surficial processes, neotectonics, fractured rock systems, ground water, and basin analysis, including oil and gas exploration. All these research programs presently involve remote sensing. The successful candidate may also wish to collaborate with the National Center for Geographic Information and Analysis and the Center for Computational Research at the University at Buffalo. Teaching duties will involve undergraduate and graduate level courses in the candidate's specialties, and will include introductory structural geology. Successful candidates must have a Ph.D. degree at the time of appointment. Apply with a statement of teaching and research goals and a curriculum vitae, including published research, grant support, and names of at least three references to: Chair, Search Committee, Department of Geology, 876 Natural Science Complex, University at Buffalo, The State University of New York, Buffalo, NY 14260-3050. More information about our department can be found at: http://www.geology.buffalo.edu. We will begin evaluating applicants December 15, 2001. The University at Buffalo is an Equal Opportunity Employer/Recruiter.

UTAH STATE UNIVERSITY
DEAN—COLLEGE OF SCIENCE

Utah State University seeks a successful scholar to provide leadership and administration to a dynamic faculty in biology, chemistry/biochemistry, computer science, geology, mathematics/statistics, and physics. A full position description is available at: http://personnel.usu.edu/W1-104-01.htm. Send letter of application, resume and contact information for five references to: Dr. Noelle E. Cockett, Vice Provost for Academic Affairs, Utah State University, 1435 Old Main Hill, Logan, UT 84322-1435, ph: (435) 797-0979, e-mail: fanoelle@cc.usu.edu. Review begins January 3, 2002; open until filled. AA/EOE.

SEDIMENTARY GEOLOGY
CALIFORNIA STATE UNIVERSITY, FULLERTON

The Department of Geological Sciences, California State University, Fullerton, invites applications for a tenure-track position starting August 2002. We anticipate filling this position at the rank of assistant professor, however, candidates with exceptional qualifications may be considered for appointment at a higher rank. The successful applicant will have the following credentials and capabilities: a Ph.D. in geology; a primary interest in teaching and achieving excellence in teaching; a vigorous, field-based research program in sedimentary geology that can involve undergraduate and graduate students.

Teaching responsibilities will include some of the following: physical geology, historical geology, sedimentation and stratigraphy, paleontology, advanced sedimentology/stratigraphy, and field geology, as well as upper division and graduate courses in the new faculty member's area of expertise. Research activities must result in publications in refereed journals.

CSU Fullerton is a large urban university dedicated to the preeminence of learning. Located 22 miles southeast of metropolitan Los Angeles, the city of Fullerton is renowned for its unique mix of residential, commercial and industrial, educational, and cultural environments that provide residents with an outstanding quality of life. The department has 10 full-time faculty with expertise in traditional and applied areas of geology. The nearby geological provinces provide abundant opportunities for field-based research, which the department emphasizes in its curriculum. We have about 50 undergraduate majors and a growing M.S. graduate program. Additional information is available from our Web page at http://geology.fullerton.edu/.

To apply, please send the following: a detailed curriculum vita; a letter of application that explains how you meet the qualifications outlined above; a statement about teaching that includes a discussion of relevant course work and/or experience in preparation for teaching, a list of courses you would feel comfortable teaching, and a statement of your teaching philosophy; a statement of your future research plans and goals; letters of recommendation from at least three references familiar with your teaching and research activities and potential—referees must send their letters directly to the address below.

Send application to: Dr Brady P. Rhodes, Chair, Search Committee, Department of Geological Sciences, California State University, P.O. Box 6850, Fullerton, California 92834-6850. Applications will be accepted until January 31, 2002. Applications received after this date will be reviewed only if the position is not filled from the original pool of applicants.

California State University, Fullerton is an Affirmative Action/Equal Opportunity Employer. All personnel policies conform to the requirements of Executive Order 11246, the Americans with Disabilities Act (ADA) of 1990, Title IX of the Higher Education Amendments of 1972 and other federal regulations regarding nondiscrimination.

COLORADO SCHOOL OF MINES
DEPARTMENT OF CHEMISTRY AND GEOCHEMISTRY
ASSISTANT PROFESSOR

The Department of Chemistry and Geochemistry (CG) at the Colorado School of Mines (CSM) invites applications for an anticipated tenure-track position in organic geochemistry, at the rank assistant professor.

A Ph.D., received prior to August 2002, in chemistry, geochemistry, or a closely related field is required. Postdoctoral experience is desirable. The department will consider all individuals with educational and research experi-

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The University of Texas at Austin

Two Faculty Positions

The Department of Geological Sciences at the University of Texas at Austin seeks to fill two faculty positions. Whereas appointments at the tenure-track assistant professor levels are anticipated, candidates at all ranks will be considered.

Hydrogeology. This position is in the general area of hydrology to complement our growing program in physical, biological, and chemical hydrogeology. The specific area of research is open, but we are interested in a scientist with a research background in (1) groundwater/surface water interactions or (2) reaction-transport modeling on a variety of scales. The successful candidate will be expected to teach an undergraduate course in surface water hydrology and to help with the hydrogeology field methods course, as well as courses in his/her own specialty.

Remote Sensing. This position is the second of three faculty positions in Global Change/Earth System Science. We are seeking an individual who uses remotely sensed observations to study surface processes linked to the hydrological cycle and relationships with global change. Examples of research areas include surface water hydrology, soil moisture, groundwater, sedimentation and erosion, biosphere-atmosphere interaction, and ice sheet processes.

These new faculty will join the newly formed Jackson School of Geosciences with a large and diverse community of geoscientists and superb research facilities and support. The successful candidates will be enthusiastic teachers, direct the research of M.S. and Ph.D. students, and conduct vigorous externally funded research programs. The anticipated starting date is August 2002; a Ph.D. is required at the time of appointment. Please see http://www.geo.utexas.edu for additional information. To apply, please send a curriculum vitae, statements of research and teaching interests, and the names and contact information for four references to: Faculty Searches, (Designate Hydrogeology or Remote Sensing Search), Department of Geological Sciences, The University of Texas at Austin, Austin, Texas 78712. Review of applications will begin December 1, 2001, and will continue until positions are filled. The University of Texas at Austin is an Equal Opportunity/Affirmative Action employer.

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ence in the broad field of organic chemistry. However, we are particularly interested in individuals with experience in gas-chromatographic-isotope-ratio mass spectrometry (GC-irMS) and its applications to topics such as environmental chemistry and geochemistry, compound-specific biomarker analyses, and petroleum geochemistry.

The successful candidate will be expected to develop a viable research program as well as teach undergraduate and graduate courses within the CG department.

CSM offers M.S. degrees in chemistry and geochemistry and Ph.D. degrees in applied chemistry and geochemistry. Applicants should submit a letter of application, undergraduate and graduate transcripts, curriculum vitae, statement of teaching philosophy, statement of research interests, and the names and complete contact information (including e-mail) of three references. Review of application will begin January 11, 2002, and the anticipated position will remain open until filled. Interested individuals should submit their applications to: Colorado School of Mines, Office of Human Resources, Search # 01-031420, 1500 Illinois Street, Golden, CO 80401. EEO/AA Employer.

FACULTY POSITION
CARBONATE SEDIMENTOLOGY/
SEISMIC STRATIGRAPHY
UNIVERSITY OF ALABAMA
DEPARTMENT OF GEOLOGICAL SCIENCES

The Department of Geological Sciences invites applications for a tenure-track faculty position in carbonate sedimentology/seismic stratigraphy beginning August 2002. The position will be filled at the assistant professor level. Candidates must have a strong record of research and a Ph.D. in geology, geophysics or a related field. The candidate will be expected to teach graduate courses in carbonate sedimentology and multichannel seismic methods, to attract and supervise master's and doctoral students, and to obtain external research funding. Experience with geologic and geophysical software used to construct 3-D earth models and geographic information systems is desired. This position compliments programs in basin analysis, geophysics, tectonics, coastal geology and petroleum systems. Equipment available includes a seismic data acquisition system and a state-of-the-art computing facility supporting seismic data processing, interpretation, and subsurface mapping. Applicants should send a vita, statements of research and teaching interests, copies of transcripts, and contact information for five referees to Dr. Ernest Mancini, Carbonate/Seismic Search Committee Chair, The University of Alabama, Department of Geological Sciences, Box 870338, Tuscaloosa, AL 35487-0338. Further information is available on our Web site at http://www.geo.ua.edu. Review of applications will begin on January 15, 2002, and continue until the position is filled.

The University of Alabama is an Equal-Opportunity, Affirmative-Action Employer. Applications are solicited from women and minority candidates.

THREE FACULTY POSITIONS,
UNIVERSITY OF HOUSTON
STRUCTURE AND TECTONICS,
PETROLOGY/GEOCHEMISTRY, SEISMOLOGY

The Department of Geosciences at the University of Houston is seeking applicants for three tenure-track faculty positions. Appointments will be at the rank of assistant professor and begin in September 2002. Successful candidates are expected to demonstrate outstanding research and teaching potential. Teaching duties will reflect the expertise of the candidate and include both undergraduate and graduate courses. Appointees will be expected to develop vigorous research programs, attract external funding, and supervise masters and doctoral research projects. A Ph.D. in geology or geophysics is required at the time of appointment. Candidates will be considered from the following three fields.

Structure and Tectonics We are seeking a geologist with a background in field-based regional structural geology and tectonics. Candidates are sought to complement or extend existing research programs in global plate tectonics, continental tectonics, marine tectonics, earthquake and reflection seismology, thermochronology, geochemistry, paleomagnetism, and fluid-rock interactions. Candidates should be capable of originating, leading and directing breakthrough research projects in structural geology and/or tectonics. Allied strengths in neotectonics, structural interpretation of 2-D and 3-D seismic reflection data, geochronology, petrology, basin analysis, remote sensing, and/or GIS are advantageous.

Geochemistry/Petrology We are seeking a geologist with a strong background in geochemistry and petrology and knowledge of advanced analytical approaches in solving problems related to the composition and evolution of continental and/or oceanic lithosphere. Candidates with experience in ICP-MS analytical techniques that can participate in a planned MC-ICP-MS laboratory with laser ablation capabilities will be strongly considered. Candidates who also complement one or more existing research areas, including continental and/or marine igneous petrology, high-temperature geochemistry, isotope geochemistry, geochronology, mineralogy, planetary geology, or fluid-rock interactions, will be strongly considered. In support of geochemistry and petrology, the department and university maintain instruments for analytical work, including an ICP-OES, electron microprobe, SEM, rare gas mass spectrometer, stable isotope mass spectrometers, as well as facilities and instrumentation for organic geochemistry (GCs and GC-MS), hydrochemistry, microscopy, rock preparation and mineral separation.

Seismology We are seeking an outstanding researcher and teacher in geophysics capable of originating, leading and directing research projects in seismology. Specialization areas may include earthquake seismology, mantle and core seismology, reflection seismology, 3-D seismic interpretation, multi-component seismology, seismic physical or numerical modeling, seismic acquisition, continental and/or marine seismology, and applied reflection, reservoir or borehole seismology. In support of seismology, the department maintains a seismic physical modeling facility, high-performance Sun and Beowulf cluster computer facilities, Sun and SGI workstation teaching and research facilities, and a full suite of commercial seismic processing and interpretive software packages.

The department currently has 17 tenure-track faculty and seven research faculty in geology and geophysics. For more information about the department, candidates are encouraged to visit our Web page: http://www.geosc.uh.edu.

Review of complete applications will begin January 10, 2002, and continue until appointment is made. To apply, please send (1) a letter describing research and teaching interests, (2) a curriculum vita, (3) transcripts from degree-granting institutions, and (4) at least three letters of reference. Application materials and letters should be sent to: Faculty Search Committee, Department of Geosciences, University of Houston, 312 Science & Research I, Houston, TX 77204-5007.

The University of Houston is an Equal Opportunity Employer. Minorities, women, and veterans are encouraged to apply.

FACULTY POSITION, HYDROGEOLOGY
UNIVERSITY OF ALABAMA
DEPARTMENT OF GEOLOGICAL SCIENCES

The Department of Geological Sciences invites applications for a tenure-track position in hydrogeology beginning August 2002. The position will be filled at the assistant professor level. We seek an outstanding individual who combines field-based research with theoretical studies. The successful applicant will be expected to establish a rigorous, externally funded research program in one or more of the following areas: groundwater microbiology, vadose zone hydrology, basin-scale fluid flow, and reactive transport modeling, and to teach introductory geology and graduate-level courses in specialized topics. The position will build on the Environmental Geology Program's existing strengths in contaminant transport modeling, environmental geochemistry, and global climate change. Applicants must hold a Ph.D. degree in hydrogeology or a related field at the time of appointment. Please send a curriculum vitae, statements of research and teaching interests, and contact information for 5 referees to Dr. Chunmiao Zheng, Hydrogeology Search Committee Chair, The University of Alabama, Department of Geological Sciences, Box 870338, Tuscaloosa, AL 35487-0338. The Department of Geological Sciences is housed in a modern research facility that provides laboratory space as well as state-of-the-art analytical instrumentation and computing equipment. Further information is available on our Web site at http://www.geo.ua.edu. Review of applications will begin on January 15, 2002, and continue until the position is filled.

The University of Alabama is an Equal-Opportunity, Affirmative-Action Employer. Applications are solicited from women and minority candidates.

Services and Supplies

MINERAL SPECIMENS FOR RESEARCH, EDUCATION, AND FOR MINERAL COLLECTIONS. Our Web site at www.mineralminers.com is a virtual gallery displaying thousands of photographic images of unique mineral specimens from mining locations around the world. Also displayed are rare gemstones, mineral spheres, large decorator minerals, lapidary rough, and a variety of handcrafted mineral gift ideas. www.mineralminers.com—Collector Quality at Miner's Prices!™

Opportunities for Students

Jonathan O. Davis Scholarship, administered by the Division of Earth and Ecosystem Sciences, Desert Research Institute. The family and friends of Jonathan O. Davis, a prominent geologist and geoarchaeologist, have established an endowment, which provides an annual scholarship of $3,750. Jonathan was tragically killed in an automobile accident in December 1990. It is the wish of his family and friends to support graduate students working on the Quaternary geology of the Great Basin and surrounding areas. The scholarship is open to graduate students enrolled in an M.S. or Ph.D. program at any university in the United States. Quaternary geology encompasses a wide range of topics normally considered as part of the Quaternary sciences. The research, however, must have a substantial geologic component or demonstrate a strong reliance on geological techniques and must be focused on the Great Basin and immediately adjacent areas.

Applications should include: (1) a cover letter explaining how the individual qualifies for the award (please include your social security number); (2) a current résumé or vitae; (3) a two-page, single spaced description of the thesis/dissertation research, which also clearly documents the geological orientation and research significance; (4) a letter of recommendation from the thesis/dissertation supervisor, which emphasizes the student's ability and potential as a Quaternary scientist. Applications must be postmarked by February 2, 2002. Applications should be addressed to: Executive Director, Division of Earth and Ecosystem Sciences, Desert Research Institute, 2215 Raggio Parkway, Reno, NV 89512. Contact: Mary Ann Moran, (775) 673-7458; or email mmoran@dri.edu.

Ph.D. Position on the Tectonics of Mars, University of Colorado. The geology department at CU-Boulder has support for a PhD student to study fault-related folds and reactivated thrust fault systems on Mars. The applicant must have an interest in structural geology and analysis of digital terrain models with GIS. The position carries a living allowance, tuition and other support for three years. Applications should send a letter outlining their research interests and experience, a CV and names and email addresses of three references to Karl Mueller, Dept of Geological Sci., Univ. of Colorado, Boulder CO 80309-0399.

Kottlowski/Bureau Fellowship, New Mexico Bureau Of Geology & Mineral Resources, New Mexico Tech. The New Mexico Bureau of Geology & Mineral Resources (a division of New Mexico Tech) is seeking candidates for the newly established Kottlowski/Bureau Fellowship. The fellowship, for an incoming PhD candidate in the earth sciences at NMTech, offers a 12-month, $18,000 salary plus actual tuition costs (guaranteed for 1 year, renewable for 3 years). Additional funding is available to cover some field and laboratory expenses. Applicants can have interests in any earth or environmental science specialty, but will be expected to do a project that is either within the state or of particular interest to the state in conjunction with advisors from both the bureau and the department. Application deadline is February 1, 2002. Applicants will automatically be considered for other forms of support through the Department. NMTech is a highly rated science and engineering school, located in Socorro, NM, with 1,600 students and more than 60 professional earth-science faculty and staff shared between the academic division and the Bureau.

A more complete description of the fellowship, NMTech and the Bureau is available on departmental and bureau Web pages (http://www.ees.nmt.edu and http://geoinfo.nmt.edu). In addition to applying for graduate admission to the department, a letter indicating your interest in this fellowship should be addressed to: Director, Bureau of Geology & Mineral Resources, New Mexico Tech, 801 Leroy Place, Socorro, NM 87801.

Graduate Student Opportunity in Sedimentology/ Stratigraphy at Washington State University. The Department of Geology at Washington State University is pleased to offer an NSF-funded Ph.D graduate assistantship to study how eustasy and/or climate fluctuations influenced the early evolution of metazoans in Early Cambrian carbonate and siliciclastic rocks. The field area, in the Northwest Territories, Canada, is rugged and remote so the successful candidate must be in good physical shape and enjoy working in small groups in such areas.

The WSU Geology Department offers expertise in sedimentology/stratigraphy/paleoclimatology, hydrogeology, volcanology, economic geology, structural geology and mineralogy. The Geoanalytical Laboratory (http://www.wsu.edu/~geology/Pages/Services/ Geolab.html) housed in our department is well equipped for quantitative analysis of sediments.

For more information about this opportunity, contact Dr. Mike Pope, Dept. of Geology, Washington State University, Pullman, WA 99164-2812, (509) 335-5989, mcpope@wsu.edu.

2000 Presidential Address:

Grand Challenges in Earth and Environmental Sciences: Science, Stewardship, and Service for the Twenty-First Century

Mary Lou Zoback, *U.S. Geological Survey, MS 977, 345 Middlefield Road, Menlo Park, CA 94025, USA*

INTRODUCTION

A measure of our future success as earth scientists will depend on our ability to help our global society find and implement effective solutions to environmental problems. In its most inclusive sense, environmental science could be considered to be "the" earth science. As used here, environmental science is defined to be a broadly integrative study of processes occurring at or near the surface of Earth and involving interactions between the uppermost lithosphere, the atmosphere, the hydrosphere, and the biosphere (which includes mankind). It encompasses a broad range of traditional disciplines including biology, ecology, meteorology, atmospheric sciences, hydrology, oceanography, geology, and geophysics.

Broad agreement exists within the scientific community that we must employ an integrated systems approach to solving complex environmental problems. Our long-term goal for environmental science should be to understand natural and perturbed systems well enough to predict outcomes, consequences, and impacts.

The effects of a number of important drivers of environmental science must be factored into our approaches to solving environmental problems: population growth, concentration of population into huge urban centers (many of which are situated in areas subject to natural hazards), an accelerating need for resources, mankind as a significant agent of change in the earth system, and unrealistic expectations for absolute guarantees from science. This final driver is a purely sociopolitical factor, but a critical one in seeking societally acceptable solutions to environmental problems.

Rapid technological developments in information science, telecommunications, and sensor development in the past few decades have greatly increased our ability to tackle complex environmental problems. In the earth sciences, we are only beginning to harness the power of broad bandwidth observational systems and real-time data delivery to probe active natural systems and processes on spatial scales and time scales never before possible. For example, we now have the capability to globally monitor physical properties daily (e.g., see www.ssec.wisc.edu/data/sst.html for daily sea surface temperature maps). Fifty years ago, the concept of having daily global snapshots of direct measurements of a variety of earth properties freely available on home computers was unthinkable. These advances will enable increasingly sophisticated numerical modeling of natural systems, but in many cases our scientific understanding of the interconnected physics, geology, chemistry, and biology of these natural systems is still at the infancy stage.

GRAND CHALLENGES IN EARTH AND ENVIRONMENTAL SCIENCE

So what are the big environmental problems, the grand challenges of the coming decades? Here are six, characterized on a process level rather than a discipline or theme basis:

- Recognizing the signal within the natural variability
- Defining mass flux and energy balance in natural systems
- Identifying feedback between natural and perturbed systems
- Determining proxies for biodiversity and ecosystem health
- Quantifying consequences, impacts, and effects
- Effectively communicating uncertainty and relative risk

Each of these challenges will require creative attacks involving integration of efforts in all the disciplines mentioned above. For an alternative view of grand challenges in environmental science from a topical perspective, see National Research Council (2001).

Recognizing the Signal Within the Natural Variability

This first challenge is, of course, at the crux of the global warming conundrum. Are steady increases in global temperature (and accompanying climate changes) in the past 150 years simply an expression of natural variability, or are they a direct result of mankind's activities that have resulted in an increase in greenhouse gases? The weight of the scientific evidence suggests the latter, however the debate on global warming has turned into a high-stakes, international issue with potentially multibillion-dollar implications.

Documenting and understanding natural variability is a vexing topic in almost every environmental problem: How do we recognize and understand changes in natural systems if we don't understand the range of baseline levels? Our geologic perspective allows us to view the short interval of historical records with a healthy skepticism. Figure 1 shows a 350 year record of precipitation in California (1600–1950), determined using 52 tree-ring chronologies as proxies for precipitation (Fritts, 1984). I have added two important historical dates to this chronology: 1769, the founding of the first of the Spanish missions in California and the inception of written records; and 1849, the beginning of the California gold rush that within years increased the number and

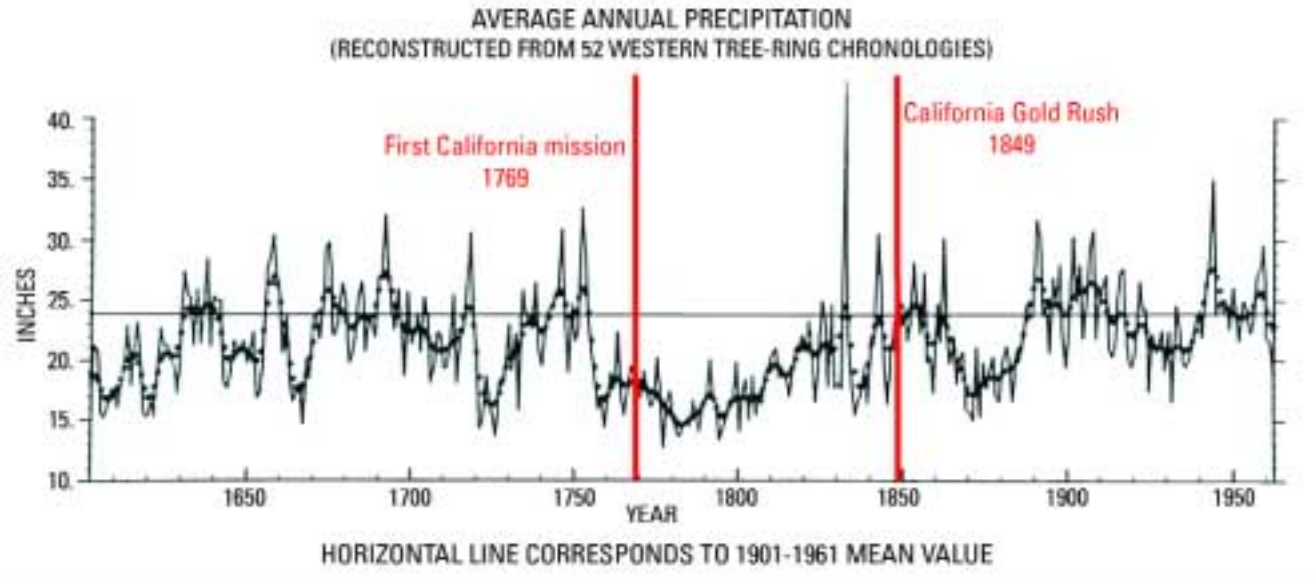

Figure 1. Average annual precipitation in California for 1600–1950 as determined using tree-ring chronology from 52 trees as a proxy for precipitation (Fritts, 1984). Horizontal line represents 1901–1961 average precipitation value from instrumental records.

distribution of population manyfold throughout the state. These two dates roughly bracket a significant 80–90 year interval of apparent drought relative to the 1901–1961 average precipitation value. While this extended dry period occurred during a period of historical records, it was probably not noteworthy since the mission padres had no baseline against which to judge the climate. Clearly, a repeat of a similar extended dry period in California today due to natural variability would be devastating to the vast agricultural enterprise that provides ~50% of the vegetables, fruits, and nuts for the entire nation (California Agriculture Statistics Service, 1999) and feeds a thirsty population with one of the fastest growth rates in the country.

Natural variability is important on both spatial and temporal scales. In an attempt to establish natural geochemical background baselines to monitor environmental change, Davenport et al. (1993) analyzed samples of organic sediment in more than 40,000 lakes in Newfoundland and Labrador. They concluded that compared to the regional background, there was no evidence of enrichment of arsenic levels in the vicinity of the major urban center of St. John's. In contrast, the lead levels they measured near St. John's were above the ninety-ninth percentile of values found in all Newfoundland, including areas of lead mineralization, suggesting an anthropogenic source near St. John's. The regional baseline data thus provide the range of natural variability to assess the geochemical signals within the urban areas.

Defining Mass Flux and Energy Balance in Natural Systems

This second challenge requires a thorough quantitative understanding of the physics, chemistry, geology, and biology of natural systems. Understanding biogeochemical cycles such as the carbon or nitrogen cycle is fundamental to understanding how larger natural systems, such as the global climate system, function. The name itself—biogeochemical cycles—implies complex, interconnected processes, which involve water, air, soil, biological, and sometimes human pathways (Fig. 2).

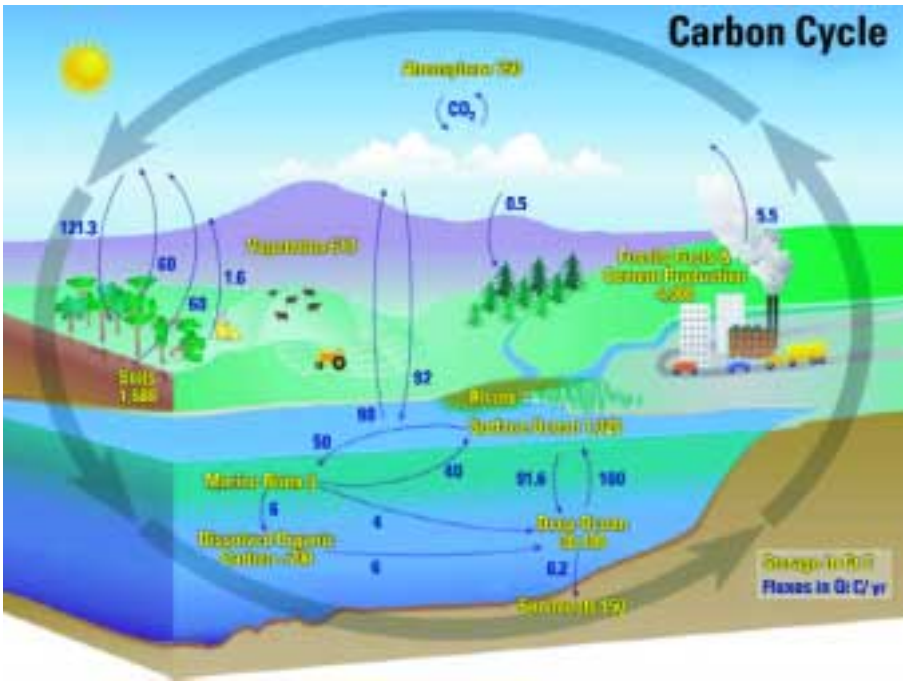

Figure 2. Major fluxes and storage associated with carbon cycle. Image courtesy of NASA Ecology Program. Fluxes and storages from Intergovernmental Panel on Climate Change, 1995 Special Assessment Report on Climate Change. See www.unep.ch/ipcc/pub/sarsum1.htm.

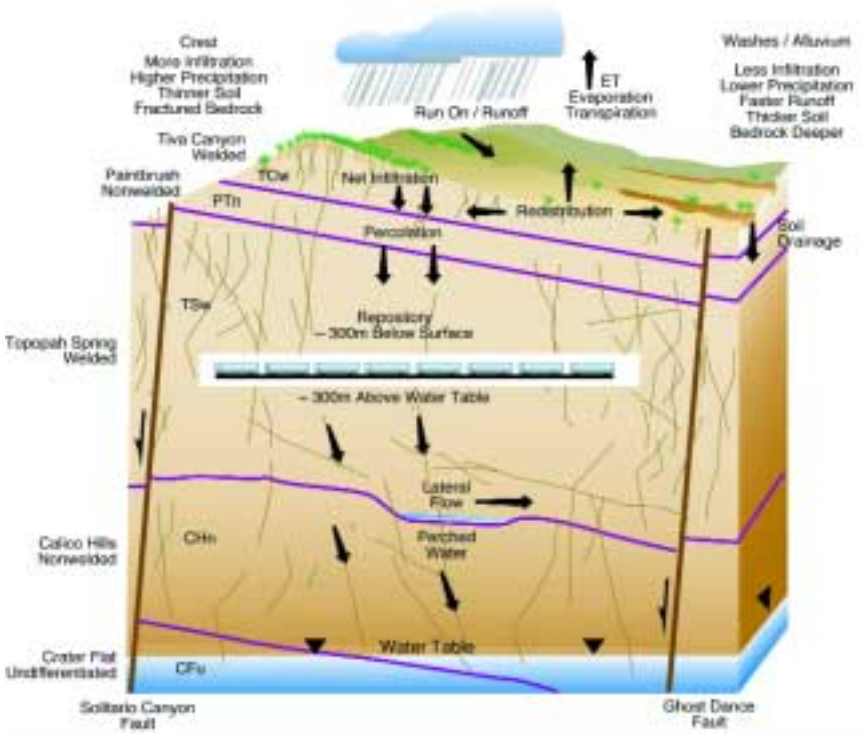

Figure 3. Block diagram showing processes acting within proposed vadose (unsaturated) zone repository at Yucca Mountain (Office of Civilian Radioactive Waste Management, 1998).

A practical example of a natural system that we have a critical need to understand is the vadose or unsaturated zone: the near-surface zone in Earth where water exists but does not fill interconnected pore space. As indicated in Figure 3, interaction of climate, rock properties, hydrology, and biology through evapotranspiration are essential in producing the net upward flux of moisture within the near surface to assure that the zone remains unsaturated. The vadose zone in fractured rock in the arid west is where we plan to store (and in fact are already inadvertently storing) high-level radioactive waste (e.g., the proposed repository at Yucca Mountain, Nevada, and the Hanford Reserve, a former nuclear weapons facility located along the Columbia River in southeastern Washington). However, quantitative understanding of the myriad of critical interconnected atmospheric, hydrologic, geochemical, and biological processes acting on and within this zone remains elusive. As indicated by former under-secretary of energy, Ernest Moniz, in a *New York Times* article on the myriad of problems with tanks leaking high-level waste at the Hanford Reserve ("Admitting Error at a Weapons Plant," March 23, 1998), "There has not been enough science for vadose zone assessment. …The vadose zone is intellectually virgin territory." Moniz, a former chair of the Physics Department at the Massachusetts Institute of Technology, recognized the need to understand the entire system in order to be able to assess human impacts upon it.

A lack of understanding of this natural system has led to solutions that could exacerbate existing environmental problems at the Hanford Reserve, which is currently under U.S. Department of Energy (DOE) control for maintenance and cleanup. On the central plateau of the Hanford site, ~55 million gallons of liquid, high-level radioactive waste is stored in 177 below-ground tanks. The tanks, 148 of which are single walled, were filled with the waste beginning in the 1940s. Not surprisingly, at least one-third of the tanks are believed to have leaked, and more than one million gallons of the liquid waste (with an estimated more than 1.8 million curies) is now in the subsurface (National Research Council, 2000). DOE engineers initially believed that the unsaturated zone would act as a barrier to contaminant migration, and that transit times to deep aquifers below the vadose zone would be on the order of tens of thousands of years. However, large plumes of radioactive and chemical contaminants have already been detected in the aquifer underlying Hanford and indicate transit times through the vadose zone of some contaminants of tens of years, not tens of thousands of years (National Research Council, 2000).

To protect workers from possible hazards associated with the leaking tanks, site engineers decided to cover the ground surface above the tanks with gravel to prevent the spread of contamination by wind, rooting vegetation, and burrowing animals. This solution, of course, reduced the risk of surface contaminant transport as well as fire hazards, but may have increased infiltration, thereby providing a potential driving force to carry already leaked contamination to the groundwater. In addition, by destroying the vegetation, a critical biological pathway for upward flux of water through evapotranspiration in the vadose zone was destroyed.

Identifying Feedback Between Natural and Perturbed Systems

As the vadose zone example demonstrates, this third challenge is linked to the previous challenge but includes the recognition that actions of man have deliberately or inadvertently perturbed natural systems. A dramatic example of such feedback affecting local urban weather has been suggested near Atlanta, Georgia. A comparison of satellite infrared imagery taken over a 19 year period indicates the extensive urban sprawl in the vicinity of that city over the past two decades (Fig. 4). The imagery indicates the ground is actually hotter and emitting more heat at night even though evening air temperatures are cooler (Quattrochi et al., 2000). Bornstein and Lin (2000) have suggested that evening thunderstorms southwest of Atlanta are caused by the effects of an urban heat island created by the urban sprawl.

Probably nowhere has mankind had a bigger impact than on the water cycle. In addition to the natural components of this cycle, we must also understand the effects of irrigation, flood control, pollution, reclamation, urban use, and agricultural use, among others. For millennia, mankind has been a victim of the water cycle. Today, while we fundamentally control a great deal of the water cycle, we have only a nascent understanding of the full impact of our control on this system. The water cycle is, of course, just one component of the global climate cycle, the one natural system for which we are furthest along in developing complex computer models that incorporate not only the significant physics and chemistry

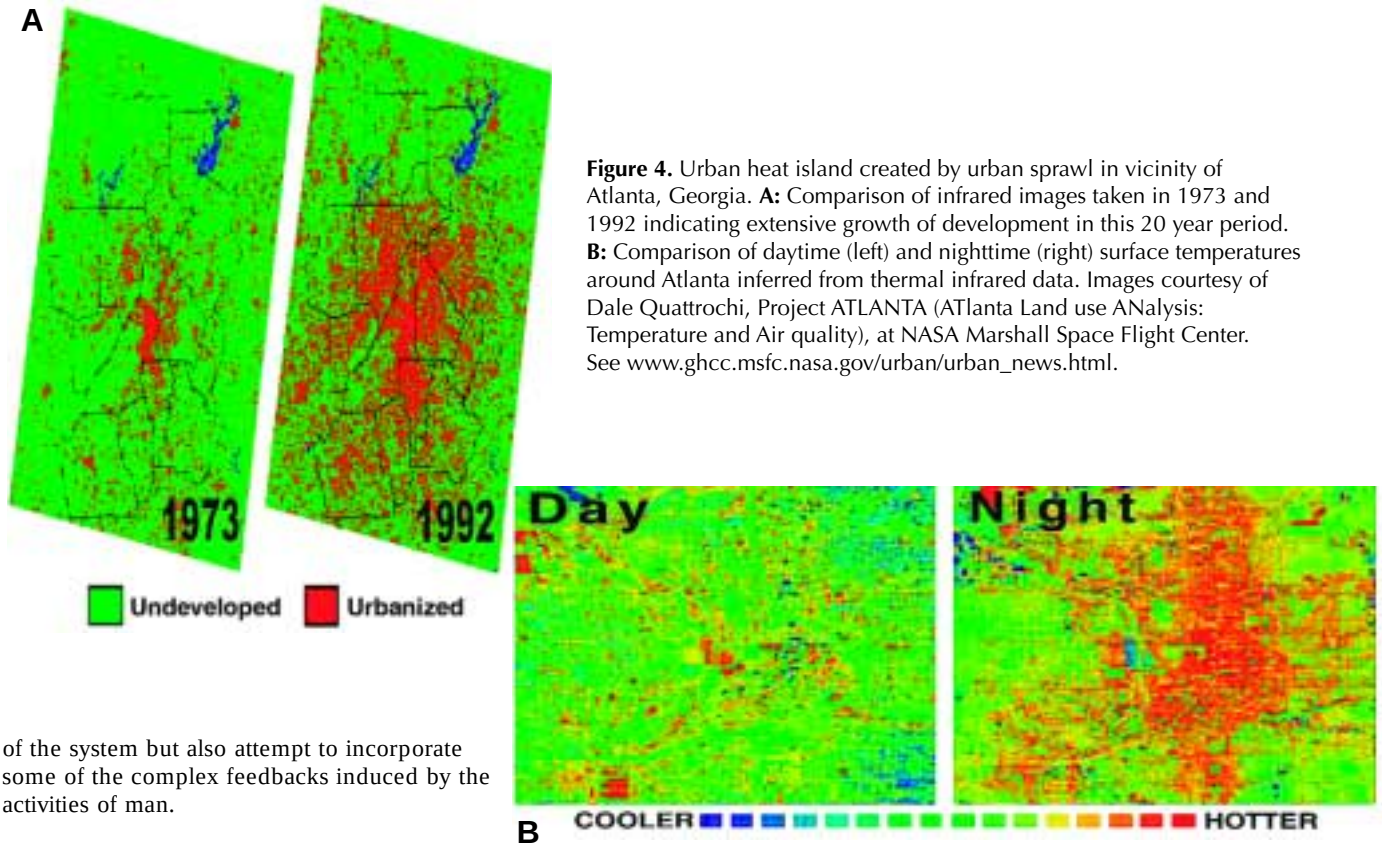

Figure 4. Urban heat island created by urban sprawl in vicinity of Atlanta, Georgia. **A:** Comparison of infrared images taken in 1973 and 1992 indicating extensive growth of development in this 20 year period. **B:** Comparison of daytime (left) and nighttime (right) surface temperatures around Atlanta inferred from thermal infrared data. Images courtesy of Dale Quattrochi, Project ATLANTA (ATlanta Land use ANalysis: Temperature and Air quality), at NASA Marshall Space Flight Center. See www.ghcc.msfc.nasa.gov/urban/urban_news.html.

of the system but also attempt to incorporate some of the complex feedbacks induced by the activities of man.

Identifying Proxies for Biodiversity or Ecosystem Health

Identifying geologic, chemical, or biologic parameters or a suite of parameters that can indicate the health or biodiversity of an ecosystem represents a substantial challenge for all practitioners of environmental science. This challenge gets at the crux of solving environmental problems. Once we think we have found solutions for environmental problems, how do we monitor or measure (one hopes remotely) parameters that indicate the effectiveness of our corrective actions or efforts at restoration or remediation?

Some tools for remote monitoring of ecosystem health already exist. A National Aeronautics and Space Administration (NASA) sensor currently being tested, the Vegetation Canopy LIDAR (light detection and ranging), or VCL tool, can measure the density and structure of forest vegetation (NASA, no date). By analyzing multiple bounces within the reflecting radar signal, this sensor is able to map the areal distribution of tree height, the vertical structure within the forest, and the subcanopy topography at very high resolution. NASA plans to launch a satellite-based VCL system to do forest biomass monitoring on a global scale in 2003. Interestingly, geologists in the U.S. Geological Survey (USGS) Earthquake Program have used LIDAR obtained from aircraft to map the topography under the dense tree cover and discover young thrust fault scarps in the Seattle, Washington, region (Haugerud et al., 2001; Blakely et al., 2002). In this case, the vegetation canopy information is simply noise!

We also need to explore new types of land-based monitoring techniques and capabilities to measure the health of natural or perturbed systems. Restoration of wetlands is an issue currently receiving a great deal of political and economic attention. Ecologically, wetlands provide numerous critical functions, including: filtering sediments and chemicals from water washed through them, providing flood control, helping regulate atmospheric gases, and providing habitat and food that attract and support abundant fish and wildlife (Constanza et al., 1997). The state of California alone has lost 90%–95% of its wetlands since the middle of the nineteenth century (Natural Resources Conservation Service, 1999; California Habitat Protection Division, Wetlands, no date). Louisiana has requested federal funding for a $14 billion plan to restore its coastal wetlands, which are disappearing at a record pace (Bourne, 2000). How can we monitor the progress of such a massive restoration effort? Perhaps by deploying millions of low-cost, low-power sensors to monitor and report back in real-time critical parameters such as temperature, humidity, salinity, and water chemistry, which are then continuously processed and analyzed. Of course, to do useful monitoring, we need to understand the system being monitored. Maybe it is time for a grand experiment to make a big step forward.

Quantifying Consequences, Impacts, and Effects

This fifth challenge is directly related to the long-term goal of understanding natural systems well enough to quantify their consequences and impacts in response to changes in natural or anthropogenic forcings. We need to build complex computer models of natural systems that can forecast impending disasters and predict their likely effects or can predict the consequences of a given societal decision or the trend or change in a natural system.

Figure 5 illustrates such a prediction for the change in Douglas fir growth range corresponding to a doubling in CO_2 over pre-industrial levels, a level we might experience sometime this century if current emission rates of greenhouse gases continue. Thompson et al. (1998) used knowledge of the factors controlling Douglas fir growth and the results of climate modeling to predict a significant contraction of the range of Douglas fir in western North America in a $2 \times CO_2$ climate.

For most systems, however, we will not be able to predict absolutely, but must forecast probabilistically. We can predict the most likely outcome and assign a level of certainty to that prediction—or give a range of the most likely outcomes at a given confidence level. Probabilistic forecasting is widely applied in my own field, the study of earthquakes and earthquake hazards. We are currently unable to scientifically predict earthquakes, and even if we could, that would not prevent the damage to buildings and infrastructure. A recent study led by the USGS in the San Francisco Bay area assigned a 70% likelihood of a damaging earthquake (≥6.7 M) striking the region during the next 30 years (Working Group for Northern California Earthquake Probabilities, 1999). The 30 year time frame of this forecast was selected as large enough to represent a significant fraction of the earthquake cycle for major events on any given fault (typically several hundreds of years) and short enough to have some societal reference (e.g., the length of a typical home mortgage). The high likelihood indicates mitigation measures might be cost effective.

This forecast gives only a likelihood of the occurrence of a future earthquake and not its likely effects. The forecast information can be combined with theoretical models of earthquake ruptures and seismic wave propagation to give annual likelihoods of exceeding a given level of ground motion. The USGS National Seismic Hazards maps (http://geohazards.cr.usgs.gov/eq/) are probabilistic maps of annual exceedance of ground-motion levels over different time periods. Exceedance maps are used to develop and upgrade seismic design criteria in the Unified Building Codes.

Effectively Communicating Uncertainty and Relative Risk

Perhaps our biggest challenge as earth scientists is to refocus society's desire for absolute guarantees from science and replace it with an acceptance that most solutions are uncertain and will carry some level of risk and also some level of environmental consequences. We must frame the questions and explain the choices so that decision makers can make better-informed decisions. Forcing one correct, "ultimate" solution will rarely be socially acceptable.

Safe, long-term containment of high-level radioactive waste is an excellent example of the dilemmas faced in finding acceptable solutions to environmental problems. Spent nuclear fuel and other high-level radioactive waste is currently stored at 72 commercial reactors in 33 U.S. states as well as at an additional 86 government sites around the country (Office of Civilian Radioactive Waste Management, 1998; Fig. 6). Many of the nuclear reactors are along coastlines or in river valleys. Typically, the spent fuel rods are stored in cooling ponds located at the surface of these sites. If we don't come up with a long-term solution for radioactive waste storage, we are opting for the default solution of continued storage at the widely dispersed sites, many of which were never designed for very long-term storage (>100 years, 30–50 years of which have already passed) and are exposed to multiple hazards.

The nation is near the end of site characterization for a potential high-level radioactive waste underground storage repository at Yucca Mountain, Nevada. Many of the geologic, geochemical, and hydrologic processes affecting the site have been carefully examined and quantified. However, the long-term suitability of this site for a geologic repository cannot be guaranteed absolutely; only statements about the likelihood of migration of radioactive contaminants away from the site and traveling through the aquifer can be made. The "default" solution I mentioned and the risks associated with it have not been factored into our public discussion and dialogue on the suitability of Yucca Mountain or any other site as the nation's geologic repository for high-level radioactive waste, nor have the policy choices between Yucca Mountain and continued existing storage been properly framed for decision makers.

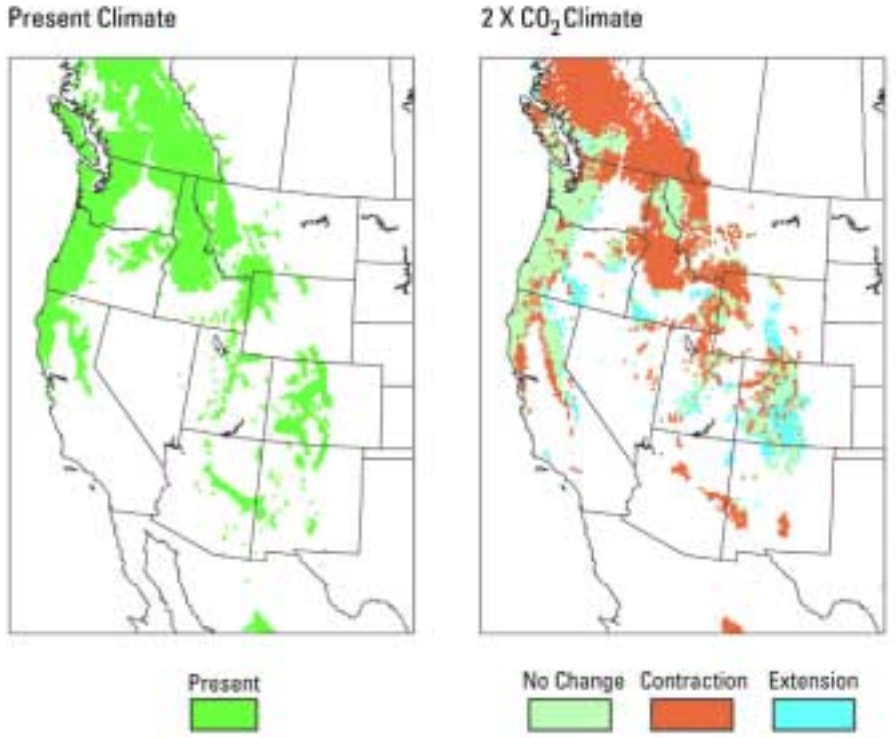

Figure 5. Distribution of Douglas fir in western North America at present and anticipated changes in range in 2 × CO_2 environment (from Thompson et al., 1998).

WHAT CAN WE DO TO MEET THESE CHALLENGES?

We, as earth scientists, can do a great deal to meet these grand challenges in environmental science. First, we need to learn some biology and ecology. We need to aggressively exploit technological advances in the area of monitoring active processes, both in situ and remotely from space or aircraft. We need to work with information technology experts to develop the means to process huge amounts of data generated by these monitoring sensors in real time and assimilate this information into self-learning complex numerical models of

natural systems that incorporate feedback and evolve in real time.

However, finding workable solutions to large-scale environmental problems will require more than first-rate integrative physical and biological science. Implicit in its definition, environmental science has a human and social aspect. Environmental scientists must work with social scientists and economists to gain societal acceptance of proposed solutions that utilize the best scientific and engineering judgment, but that will undeniably be associated with considerable uncertainty. Solutions for environmental problems will represent a delicate balancing act in which society must weigh the level of risk they are willing to live with as well as the level of environmental consequences.

WHAT SHOULD WE DO?

We should begin now to design grand, bold, process-level experiments that fully exploit modern technology to tackle these challenges. We should acknowledge that solving these problems is every bit as difficult and complex as building the atomic bomb that started the radioactive waste problem.

For example, we should tackle safe, long-term isolation of high-level radioactive waste as one of the grandest scientific, technological experiments of the twenty-first century. Globally, our lack of solutions to this problem will continue to affect our world's energy future. DOE is now considering a staged approach to repository design, development, and operation that recognizes that we do not yet understand many of the important processes involved. In a 1999 letter to the National Research Council, DOE requested a study on such an option, stating that they were interested in an approach in which "decisions must be made in a step-wise and reversible fashion." This is exactly the approach the scientific community has been advocating for more than a decade (National Research Council, 1990). We, the earth science community, should become active participants in such a grand experiment.

The challenges I've outlined are daunting, but I think earth scientists are extremely well equipped and positioned to address them. I'm proud to be part of a science and a scientific society that can help the nation and the world address these challenges.

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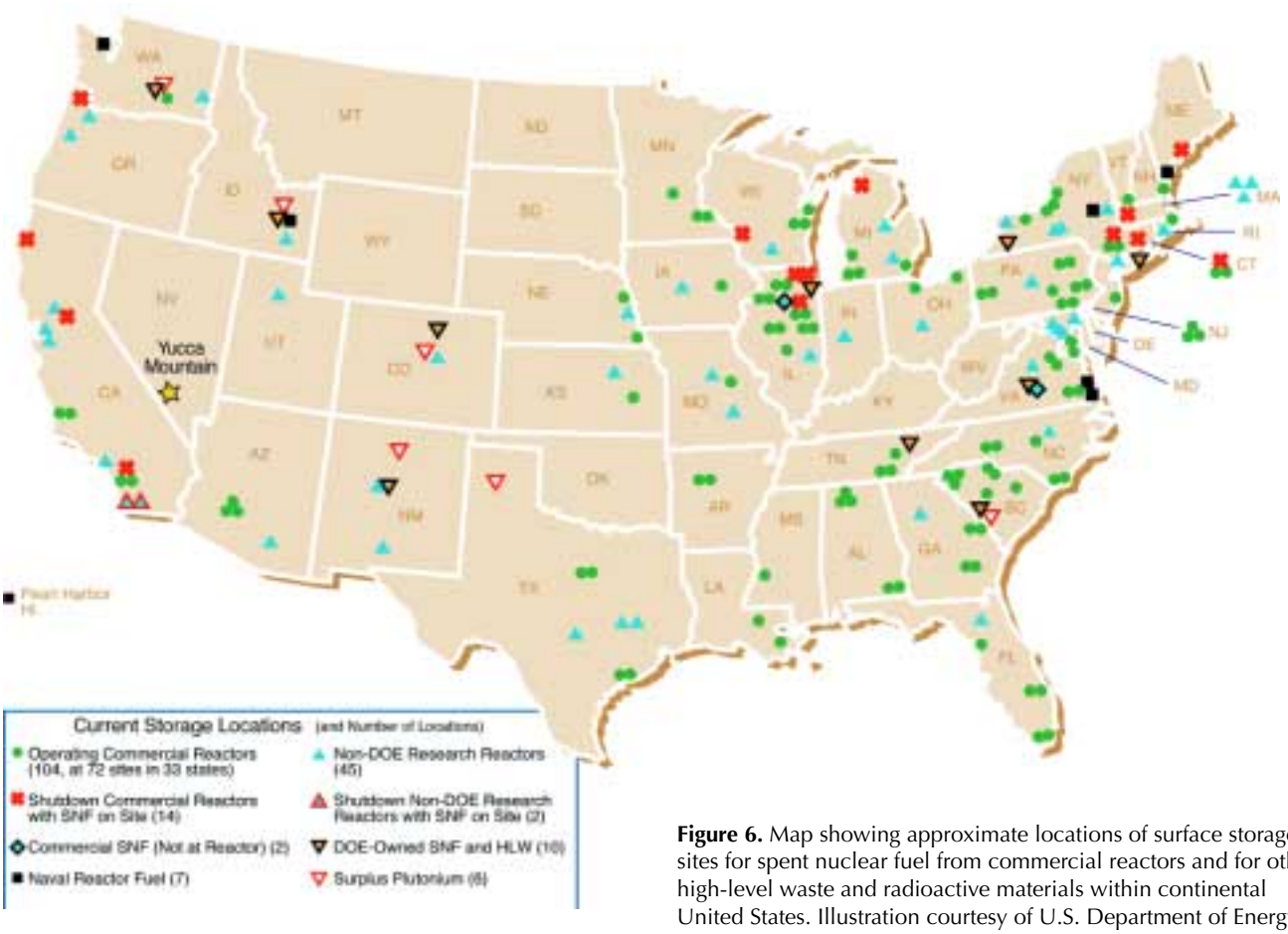

Figure 6. Map showing approximate locations of surface storage sites for spent nuclear fuel from commercial reactors and for other high-level waste and radioactive materials within continental United States. Illustration courtesy of U.S. Department of Energy.

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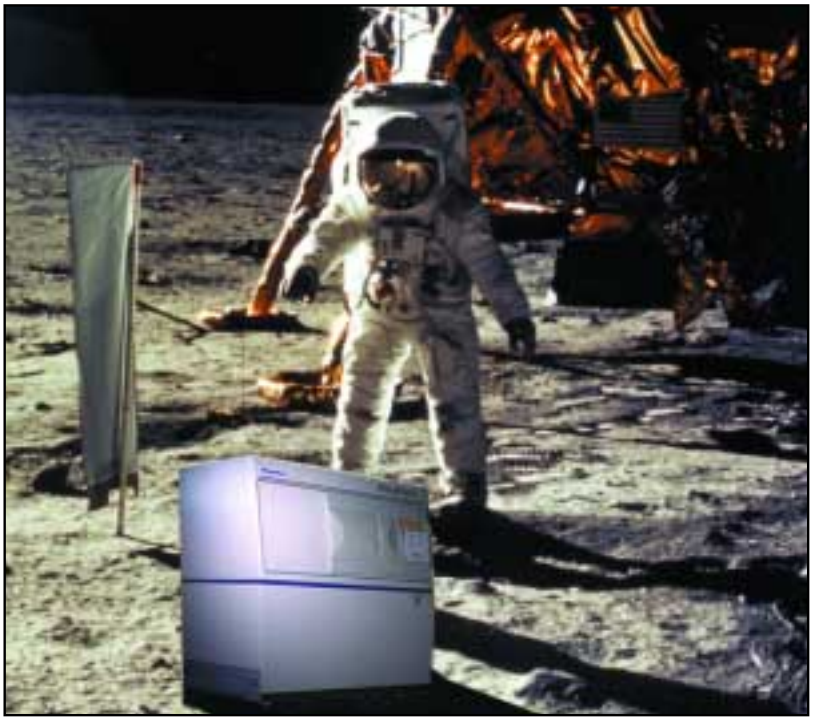

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