

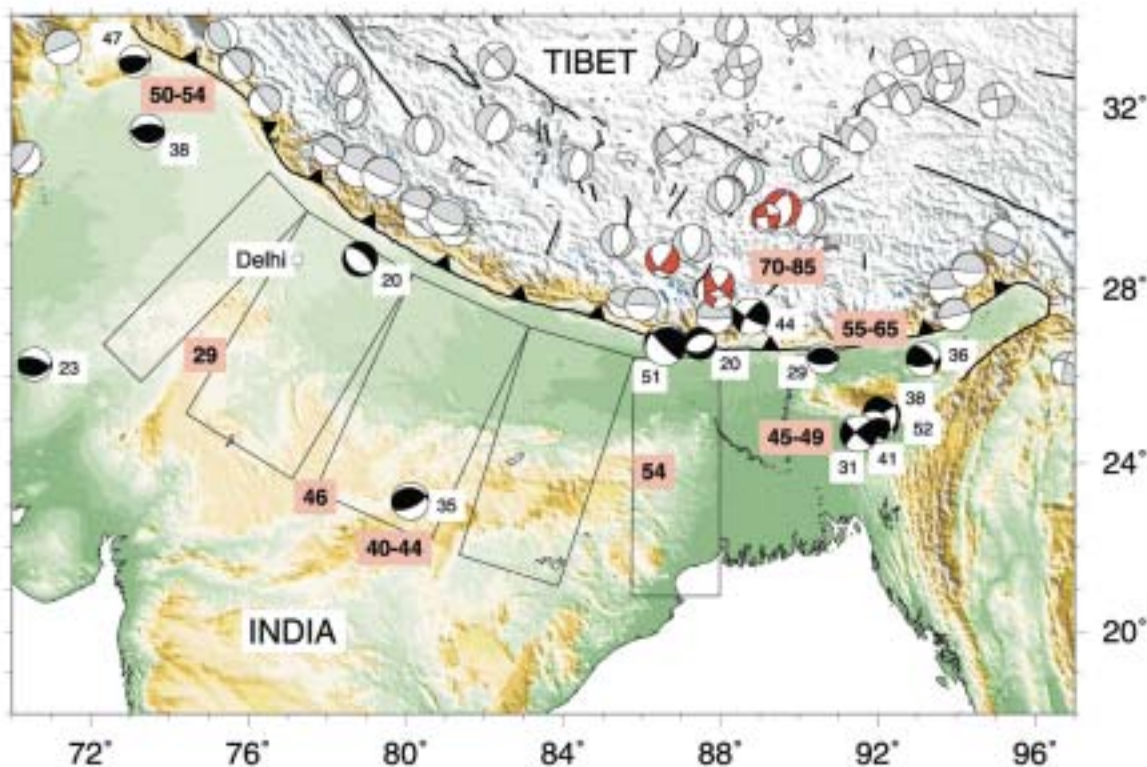
# GSA TODAY

Vol. 12, No. 9

A Publication of the Geological Society of America

September 2002

## Strength of the continental lithosphere: Time to abandon the jelly sandwich?



### Inside:

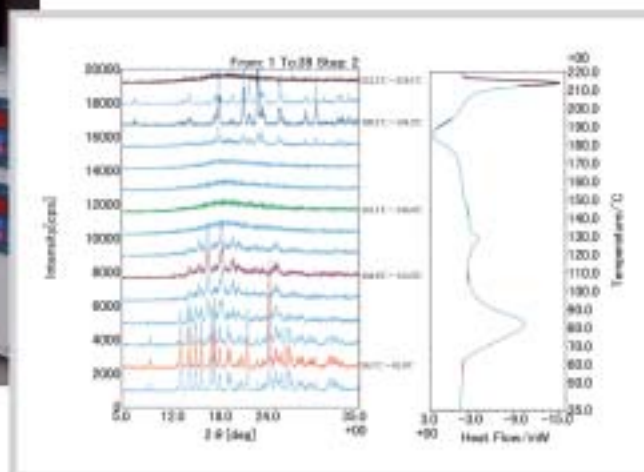
Strength of the continental lithosphere: Time to abandon the jelly sandwich?  
James Jackson, p. 4

Section Meetings:  
Joint South-Central & Southeastern, p.14  
North-Central, p.16

# Simultaneous XRD

and DSC

for Pharmaceutical  
Applications



- Combines X-ray diffraction (XRD) and differential scanning calorimetry (DSC) into a single instrument
- Eliminates uncertainties comparing XRD and DSC data obtained separately
- Enables simultaneous characterization of dehydration, polymorphic phase transitions, melting, crystallization, and decomposition of pharmaceuticals
- Distinguishes exothermic and endothermic reactions and provides their enthalpies and temperatures
- Probes the effects of temperature history and heat treatment on structural and thermal properties
- Requires only milligrams of sample

**Rigaku**  
**MSC**

www.RigakuMSC.com  
phone: 281-363-1033  
fax: 281-364-3628  
e-mail: info@RigakuMSC.com

# GSATODAY

*GSA TODAY* publishes news and information for more than 17,000 GSA members and subscribing libraries. *GSA Today* lead science articles should present the results of exciting new research or summarize and synthesize important problems or issues, and they must be understandable to all in the earth science community. Submit manuscripts to science editor Karl Karlstrom, kek1@unm.edu.

*GSA TODAY* (ISSN 1052-5173) is published monthly by The Geological Society of America, Inc., with offices at 3300 Penrose Place, Boulder, Colorado. Mailing address: P.O. Box 9140, Boulder, CO 80301-9140, U.S.A. Periodicals postage paid at Boulder, Colorado, and at additional mailing offices. Postmaster: Send address changes to *GSA Today*, Member Services, P.O. Box 9140, Boulder, CO 80301-9140.

Copyright © 2002, The Geological Society of America, Inc. (GSA). All rights reserved. Copyright not claimed on content prepared wholly by U.S. government employees within scope of their employment. Individual scientists are hereby granted permission, without fees or further requests to GSA, to use a single figure, a single table, and/or a brief paragraph of text in other subsequent works and to make unlimited photocopies of items in this journal for noncommercial use in classrooms to further education and science. For any other use, contact Copyright Permissions, GSA, P.O. Box 9140, Boulder, CO 80301-9140, USA, fax 303-357-1073, editing@geosociety.org; reference *GSA Today*, ISSN 1052-5173. Permission is granted to authors to post the abstracts only of their articles on their own or their organization's Web site providing the posting includes this reference: "The full paper was published in the Geological Society of America's journal *GSA Today*, [include year, month, and page numbers if known, where the article will appear]." GSA provides this and other forums for the presentation of diverse opinions and positions by scientists worldwide, regardless of their race, citizenship, gender, religion, or political viewpoint. Opinions presented in this publication do not reflect official positions of the Society.

**SUBSCRIPTIONS** for 2002 calendar year: Society Members: *GSA Today* is provided as part of membership dues. Contact Member Services at 1-888-443-4472, (303) 447-2020, or member@geosociety.org for membership information. Nonmembers & Institutions: Free with paid subscription to both *GSA Bulletin* and *Geology*, otherwise \$65 for U.S., Canada, and Mexico; \$75 elsewhere. Contact Subscription Services at (800) 627-0629 or gsa@allenpress.com. Also available on an annual CD-ROM (together with *GSA Bulletin*, *Geology*, GSA Data Repository, and an Electronic Retrospective Index to journal articles from 1972): \$94 to GSA Members, others call GSA Subscription Services for prices and details. Claims: For nonreceipt or for damaged copies, members contact Member Services; all others contact Subscription Services. Claims are honored for one year; please allow sufficient delivery time for overseas copies, up to six months.

## STAFF

**Executive Director:** John W. Hess  
**Science Editor:** Karl E. Karlstrom, Department of Earth and Planetary Science, University of New Mexico, Albuquerque, NM 87131-1116, kek1@unm.edu  
**Director of Publications:** Jon Olsen  
**Managing Editor:** Jeanette Hammann, jhammann@geosociety.org  
**Editorial Assistant:** Matt Hanauer  
**Production Manager:** Diane C. Lorenz  
**Production Coordinator:** Margo Y. Good  
**Graphics Production:** Margo Y. Good

## ADVERTISING

Classifieds and display: Contact Ann Crawford, 1-800-472-1988, ext. 1053, (303) 357-1053, fax 303-357-1073; acrawford@geosociety.org  
GSA ONLINE: www.geosociety.org  
Printed in U.S.A. using pure soy inks.

THE GEOLOGICAL SOCIETY  
OF AMERICA



50% Total  
Recovered Fiber  
10% Postconsumer

# CONTENTS

Vol. 12, No. 9

September 2002

Fossilized Eocene-Oligocene Sequoia stumps, Florissant Fossil Beds National Monument. Photo by Martin Miller.

<b>Strength of the Continental Lithosphere: Time to Abandon the Jelly Sandwich?</b> James Jackson	4
<b>Dialogue: Geology and Public Policy Committee</b> Activities and Goals	10
<b>Notice of Council Meeting</b>	10
<b>New Society Division Proposed</b>	11
<b>Call for Geological Papers: 2003 GSA Section Meetings</b>	12
<b>GSA Foundation Update</b>	13
<b>Preliminary Announcement and Call for Papers:</b> Joint Meeting, South-Central and Southeastern Sections	14
<b>Preliminary Announcement and Call for Papers:</b> North-Central Section Meeting	16
<b>Student Volunteer Program Helps Pay Your Bills</b>	17
<b>Memorial Preprints Now Available</b>	18
<b>Call for Applications: 2003–2004 Congressional</b> Science Fellowship	18
<b>GSA Announces 2002 Research Grant Recipients</b>	20
<b>Cole Awards for Postdoctoral Research Announced</b>	22
<b>Earth Science Week is October 13–19</b>	22
<b>GSA Employment Service: Now Online</b>	23
<b>Announcements</b>	24
<b>2002–2003 Congressional Science Fellow Appointed</b>	25
<b>Journal Highlights</b>	26
<b>GSA Thanks Long-Time Members</b>	26
<b>Classified Advertising</b>	27

**On the cover:** Earthquake focal mechanisms in India and southern Tibet. See "Strength of the continental lithosphere: Time to abandon the jelly sandwich?" by James Jackson, p. 4–10.

**Reminder:** The preregistration deadline for the 2002 GSA Annual Meeting is September 20. Register online at [www.geosociety.org](http://www.geosociety.org).

# Strength of the continental lithosphere: Time to abandon the jelly sandwich?

James Jackson, University of Cambridge, Department of Earth Sciences, Bullard Laboratories, Madingley Road, Cambridge CB3 0EZ, UK, [jackson@esc.cam.ac.uk](mailto:jackson@esc.cam.ac.uk)

## ABSTRACT

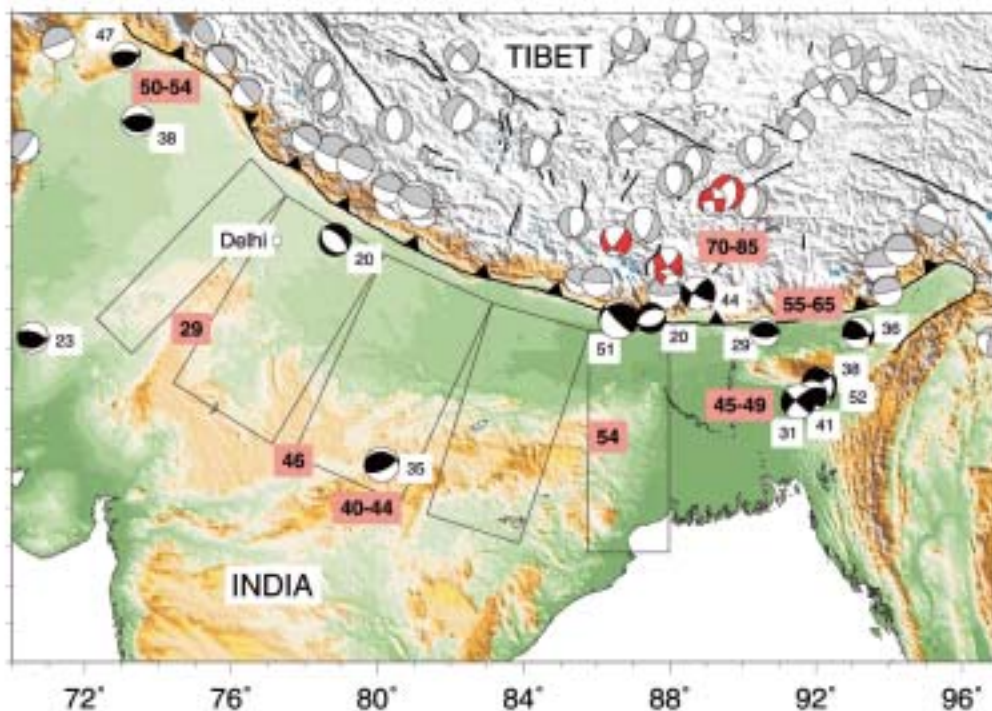
For the past two decades, many people (including me) have embraced the view that the continental lithosphere is like a jelly sandwich, with a weak lower crust lying between a strong upper crust and a strong uppermost mantle. A recent reassessment of earthquake depth distributions and gravity anomalies on the continents makes it difficult to maintain this view, suggesting instead that the seismogenic layer may be the only significant source of strength in the continental lithosphere, and that the upper mantle beneath the continents is relatively weak. This change of view, if it is correct, has several implications for continental geodynamics: (1) patterns of surface faulting on the scale of a few hundred kilometers are likely to be controlled by the anisotropic strength of

crustal blocks and their intervening faults; (2) flexure of the Indian shield is likely to be a major support of the topography in the Himalaya and southern Tibet; and (3) transient lower-crustal flow, of the type associated with metamorphic core complexes, is likely to be controlled by the input of igneous melts and fluid into the lower crust. Overall, this new view suggests that continental tectonics and mechanics are controlled by strength that resides mainly in the crust, rather than in the mantle.

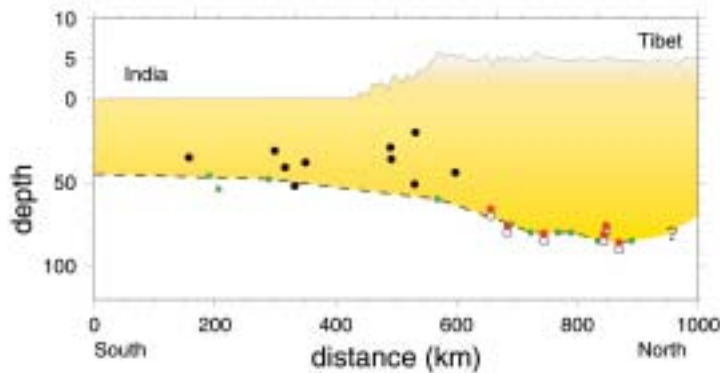
## INTRODUCTION

For almost 20 years, the prevailing view has been that the continental lithosphere generally consists of a weak lower crust sandwiched between a relatively strong upper crust and uppermost mantle (e.g., Chen and

Molnar, 1983). This view arose from studying the depth distribution of earthquakes, combined with an extrapolation of laboratory rock mechanics experiments to geological conditions (e.g., Brace and Kohlstedt, 1980). An important corollary is the conclusion that the largest contribution to the integrated vertical strength of the lithosphere comes from the upper mantle (e.g., Sonder and England, 1986; Molnar, 1992). This conclusion, in turn, has greatly influenced numerical models of continental deformation and implicitly supports the view that the behavior of the continental lithosphere as a whole is controlled by the strength of its creeping mantle component. I now believe that this popular “jelly sandwich” conception of the continental lithosphere and its corollary that the mantle is the strongest part of the lithosphere are both generally incorrect. Indeed, I now suspect that the opposite point of view, in which the behavior of the continental lithosphere is dominated by the strength of its upper seismogenic layer, is more likely to be correct. This article summarizes the reasons for this change in interpretation and outlines some of its implications for continental tectonics.



**Figure 1.** Earthquake focal mechanisms in India and southern Tibet. Focal spheres in black are those whose depth and location place them within the material of the Indian shield. Numbers next to those spheres are centroid depths (in km) determined by body wave modeling or direct observations of pP and sP phases. Red focal spheres are earthquakes at depths of 70–90 km beneath Tibet, discussed in the text. Light-gray spheres are shallow earthquakes in the Himalaya and Tibet, with centroid depths typically in the 10–15 km range. Boldface numbers in pink boxes are estimates of Moho depths in kilometers, from receiver functions (Yuan et al., 1997; Maggi et al., 2000a; Kumar et al., 2001), from refraction surveys (Murty et al., 1998), or from local seismic networks (Rai et al., 1999). Rectangular boxes in the foreland are those used for stacking the gravity profiles to produce Fig. 3B.



**Figure 2.** A cross section through Figure 1 along 90°E (note the different vertical exaggeration above and below sea level), with earthquakes and Moho depths projected onto the profile from up to 400 km on either side (in addition, the event at 35 km depth at 24°N 80°E has been included). Black and red symbols correspond to the same colored earthquakes in Figure 1. The red earthquakes have had their depths reduced by 4 km from their published depths (open circles) to allow for the overlying crustal velocities (see text). Green squares are Moho depth determinations, joined by a dotted line separating crust (yellow) from mantle.

## EARTHQUAKES AND GRAVITY

It has been known for a long time that, in most places, earthquakes on the continents are confined to the upper half of the crust. But an important influence on the formulation of the jelly sandwich view was the occurrence of rare earthquakes in the uppermost mantle in a few areas, which were thought to indicate a strength contrast between the upper mantle and the generally aseismic lower crust (e.g., Chen and Molnar, 1983). Maggi et al. (2000a, 2000b) reexamined the evidence for these upper mantle earthquakes and concluded that they were instead in the lower crust. The pattern found by Maggi et al. is that earthquakes on the continents are restricted to a single layer (the seismogenic thickness,  $T_s$ ), usually the upper crust, but in some cases the whole crust, and that there is no convincing evidence for significant seismicity in the continental mantle. The main reason for this reevaluation was an improvement in the data quality since the study of Chen and Molnar (1983). More abundant seismic refraction and receiver function studies have led to better seismologically defined Moho depths, and more earthquakes, combined with improved body-waveform inversion programs, have led to clearer patterns of well-determined centroid depths.

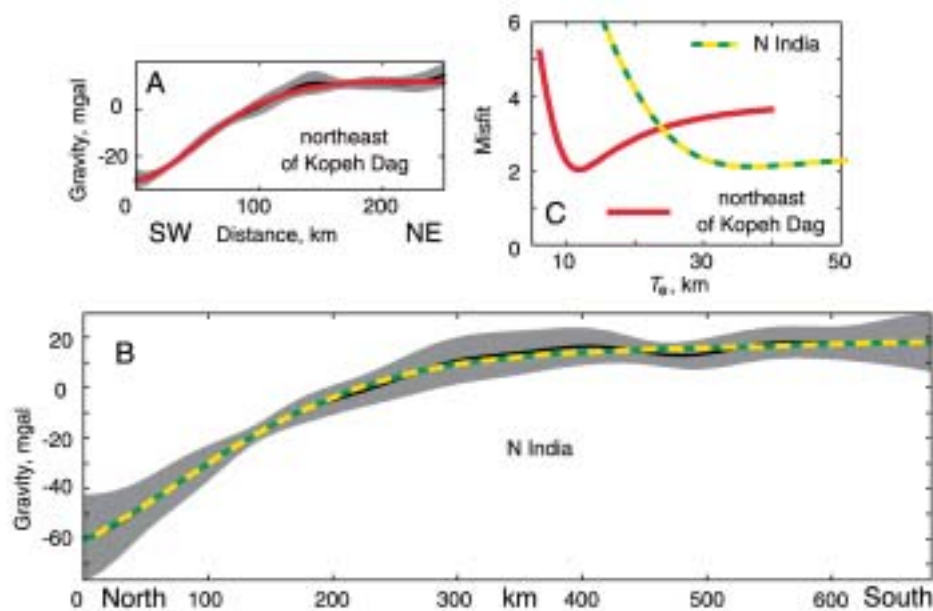
An important example is given in Figure 1, in an area once thought to be a type example of continental mantle seismicity. Black focal mechanisms are earthquakes in the foreland of the Himalaya and therefore within the underthrusting Indian shield. The depths of all these earthquakes have been determined by waveform modeling or by direct identification of the surface reflection phases pP and sP, and all lie at or above the estimates of the Moho depth in their epicentral regions (Fig. 2). They are nearly all in the lower half of the Indian continental crust in this case. Most of these earthquakes are relatively small, with  $M_w \sim 5.5$  and source dimensions of order 5 km, so that even allowing for uncertainties in Moho and centroid depths, they are unequivocally in the lower crust.

For others, it might be argued that such uncertainties could just allow some of them to be in the uppermost mantle, but because we know the lower crust is seismically active, we suspect they are all above the Moho. An additional argument for a single seismogenic layer comes from the focal mechanisms themselves. The shallowest events (at  $\sim 20$  km) show normal faulting, consistent with bending of the shield beneath the foreland basin. The deeper ones are mostly thrusts or strike-slip mechanisms with the P axis directed north, consistent with shortening in the lower part of the bending layer, as seen beneath the outer rises seaward of oceanic trenches (Chapple and Forsyth, 1979). If the deeper earthquakes were at the top of a separate strong upper mantle layer, they should show extension, not shortening. The single, thick seismogenic layer is partly responsible for the large fault areas and moments of the biggest earthquakes in the Indian shield, such as the 1897 earthquake beneath the Shillong plateau, whose fault plane ruptured between 9 and 45 km depth (Bilham and England, 2001), and the 2001 Bhuj earthquake in Gujarat (Withers, 2001).

The red focal mechanisms in Figure 1 are earthquakes in southern Tibet with confirmed depths between 70 and 90 km, which are often cited as evidence of mantle seismicity (e.g., Chen and Molnar, 1983; Zhu and Helmberger, 1996). However, various new data have emerged about this area. First, it is now known from receiver functions in the very area of these earthquakes, that the Moho is between 70 and 85 km, and deepest in the north (Yuan et al., 1997). Second, the depths of these events were estimated from pP-P and sP-P times assuming a crustal thickness of 60–70 km, whereas if the crust were thicker, their depths would decrease by  $\sim 4$  km. Third, Zhu and Helmberger (1996) concluded that the events were sub-Moho because various expected multiple S-wave reflections were apparently missing, cut out by the Moho discontinuity. However, we now know that the crust itself contains at least two sharp discontinuities that would have the same effect (Yuan et al., 1997), so this conclusion is not secure. Finally, these earthquakes are in a very special place—precisely where an extrapolation of the Indian shield beneath Tibet would lead to near-Moho earthquakes if it were seismically active in the lowermost crust, as it is beneath the Himalayan foreland.

These data are summarized in the cross section in Figure 2. It takes little imagination to believe the earthquakes are all in the lower part of the Indian shield crust as it underthrusts Tibet to a latitude of  $\sim 30^\circ\text{N}$ . Thus, this region is not a secure peg on which to hang a belief in mantle seismicity beneath the continents.

As well as examining the focal depth distribution on the continents, Maggi et al. (2000b) also reexamined the distribution of effective elastic thickness ( $T_e$ ) estimates on the continents, building on the study of McKenzie and Fairhead (1997).  $T_e$  is the conceptual thickness of an elastic beam that supports gravity anomalies of up to a few hundred kilometers in wavelength produced by loading. Maggi et al. (2000b) concluded that  $T_e$  was everywhere slightly less than the seismogenic thickness ( $T_s$ ) and that the two tracked each other. Thus, in places where earthquakes occurred down to



**Figure 3.** Stacked free-air gravity profiles across (A) the Kopeh Dag and (B) the Himalayan foreland basins, at the same scale. The solid black lines are the averages ( $g_m$ ) of stacked profiles taken at 2 km spacing in the boxes shown in Figures 1 and 4 and the gray band shows the  $\pm 1 \sigma$  range. The actual free-air gravity maps are shown in McKenzie and Fairhead (1997) and Maggi et al. (2000b). Colored lines are the modeled gravity profiles ( $g_c$ ) matched by bending an elastic plate of thickness  $T_e$ . (C) The misfit:

$$H^2 = \frac{1}{N} \sum_{n=1}^N [(g_m - g_c) / \sigma]^2$$

as a function of  $T_e$  for both regions. The greater wavelength of the Himalaya flexural signal is clear, requiring a  $T_e$  of  $\sim 36$  km, compared with only 12 km for the Kopeh Dag (see also McKenzie and Fairhead 1997).

the Moho (e.g., North India, northern Tien Shan) both  $T_e$  and  $T_s$  values were greater than in other places where earthquakes were confined to the upper crust alone. McKenzie and Fairhead (1997) and Maggi et al. (2000b) used two techniques to estimate  $T_e$ , an analysis of the correlation between free-air gravity and topography in the frequency domain, and modeling of the flexural free-air gravity signal in foreland basins. The second technique is less controversial and is illustrated in Figure 3. It ignores topography altogether and makes only one important assumption, which is that the plate is bent only by loads and couples on its end.

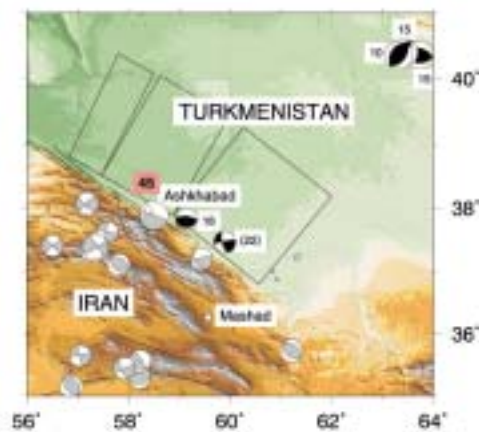
Figure 3B shows a free-air gravity profile across the Himalayan foreland, in which the broad gravity low of the Ganges Basin is evident. The colored line shows the expected profile from the bending of an elastic plate of thickness 36.5 km, the formal best-fitting value of  $T_e$ . The value of the misfit between observed and calculated gravity profiles as a function of  $T_e$  has a quite broad and shallow minimum (Fig. 3C). The point is, however, that the  $T_e$  estimate for north India is clearly in the 30–50 km range, and quite different from the estimate obtained using the same technique for the foreland of the Kopeh Dag Mountains on the Iran-Turkmenistan border (Fig. 4), where earthquakes in the foreland are no deeper than  $\sim 20$  km.

The  $T_e$  estimate for the Kopeh Dag foreland is 12 km, with a much better defined minimum (Fig. 3C). The difference in  $T_e$  in the two forelands is directly reflected in the difference in width of the two gravity signals (Fig. 3A and 3B), which are drawn at the same scale.

Other  $T_e$  estimates, and their comparison with  $T_s$  observations, are reported by Maggi et al. (2000b). They concluded that: (a) the continental lithosphere has only one seismogenic layer (typically the upper crust, but in some cases the whole crust); (b) there is no convincing evidence for significant seismicity in the continental mantle, and (c),  $T_e$  values are similar to, but a little less than, the thickness of the seismogenic layer.

### STRENGTH OF THE CONTINENTAL LITHOSPHERE

The most obvious explanation for the observations summarized above is that the strength of the continental lithosphere resides in a single layer, which is the layer within which there are earthquakes. It would then be no surprise that the effective elastic thickness is somewhat smaller than the seismogenic thickness, for two reasons. First, the top few kilometers, especially in sediment-thick foreland basins, are unlikely to contribute much to the elastic strength. Second,  $T_e$  reflects the



**Figure 4.** Earthquake focal mechanisms in the foreland region of the Kopeh Dag, with notation as in Figure 1. Earthquakes in the Turkmen shield have black focal spheres, with numbers indicating centroid depths in km determined by waveform modeling. The earthquake with its depth (22 km) in brackets was too small for long-period body wave modeling. Its depth of 22 km is from the relocated catalogue of Engdahl et al. (1998) and its depth determined by the Harvard Centroid Moment Tensor Project was 24 km. Light focal spheres are earthquakes in the thickened crust of the Kopeh Dag, with centroids all shallower than 15 km (Jackson et al., 2002). The Moho depth of 45 km near Ashkhabad is from a receiver function analysis by Mangino and Priestley (1998). Rectangular boxes in the foreland are those used for stacking the gravity profiles to produce Figure 3A.

ability of the lithosphere to support loads over several million years, whereas the loading and unloading associated with the earthquake cycle happens on a much shorter time scale, over which the lithosphere might appear to be stronger. A corollary of this interpretation is that the continental mantle has no significant long-term strength.

However, all the analyses of gravity yield only an estimate of an elastic thickness, not the depth at which that elastic strength occurs. An alternative interpretation of the gravity could be that all or most of that strength lies in the mantle, rather than in the crust. It could also be argued that earthquakes are an indicator of frictional stability rather than strength, and that the continental mantle could still be strong despite being aseismic. The problem then is that, because  $T_e < T_s$ , it is also necessary to argue that the seismically active layer has long-term weakness, whereas the aseismic part has long-term strength. While this is possible in principle, it seems improbable and unnecessarily complicated. Nor are such complications needed in the oceans (see following section). The simpler explanation is that long-term strength resides in the seismogenic layer.

In the case of north India, it is also possible to say something about the creep strength of the mantle lithosphere. The Indian shield is bent under the Ganges Basin, and from the elastic thickness (40 km) and the amount of deflection (~10 km over 400 km) we can estimate the strain necessary in the shortening mantle beneath the flexed lid to be about  $2 \times 10^{-3}$ . This happens over a time period of ~10 Ma needed to move the shield through the bending region, giving a strain rate of about  $10^{-17} \text{ s}^{-1}$ . At this strain rate, the stresses in the mantle must be much less than those generated in the seismogenic elastic layer above. If that were not true, we would not see the change in focal mechanisms from shallow normal faulting to deeper thrusts *within the crust*. So at this strain rate, the creep strength of the mantle is much weaker than the elastic strength of the seismogenic layer.

The new view, in which the continental lithosphere contains a single

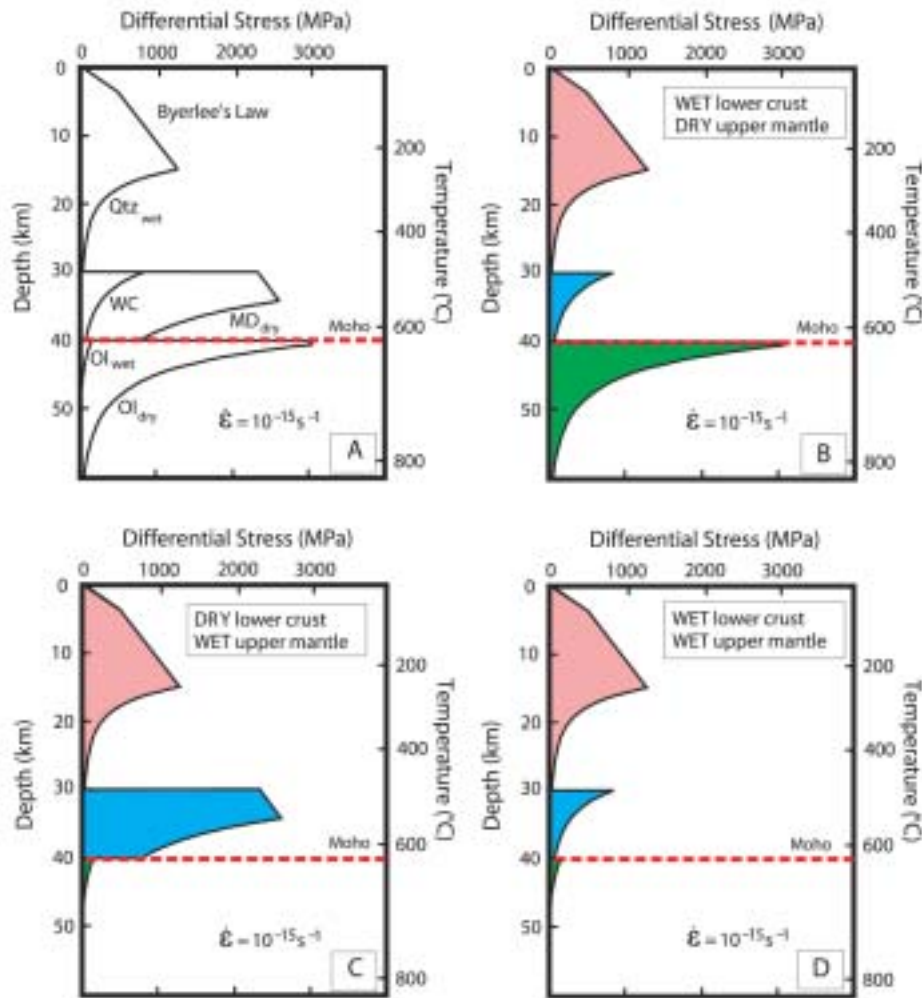
strong layer, is similar to the long-accepted view of the oceanic lithosphere. Intraplate oceanic earthquakes occur to depths that correspond to 600–800 °C, whereas oceanic elastic thicknesses correspond approximately to the shallower depth of the 450 °C isotherm, and thus  $T_e < T_s$  (e.g., Wiens and Stein, 1983; Chen and Molnar, 1983; Watts et al., 1980). The main difference is that earthquakes and significant long-term strength certainly occur in the oceanic mantle, whereas they do not on the continents.

If this new view of the continents is correct, it is worth thinking why we were misled for so long. One reason was almost certainly the very success of the simple oceanic picture, in which elastic and seismogenic limits correspond to entirely reasonable values of homologous temperature (the ratio of actual temperature to melting temperature) in dry peridotite. It seemed reasonable to transfer this expectation of the mantle to the continents, using laboratory experiments on dry olivine as a proxy for dry mantle, in which case a strong uppermost mantle beneath the Moho would be expected (e.g., Brace and Kohlstedt, 1980; Chen and Molnar, 1983). It also seemed reasonable to interpret the few continental earthquakes near the Moho to be in the mantle rather than the crust, as Moho depths were generally poorly known, and a wet Si-rich lower crust was not expected to be seismically active. To be fair, the early papers that tried to relate laboratory creep and friction experiments to earthquake depths were aware of various other possibilities and urged caution (Brace and Kohlstedt, 1980; Chen and Molnar, 1983). But the extreme effect of temperature in activating creep mechanisms was well appreciated at the time, nothing else seemed necessary, and the simplicity of the laminated continental lithosphere model with the strong mantle was enthusiastically embraced by many of us.

Unease with that laminated model started to appear when some analyses of gravity and topography in the frequency domain began to yield  $T_e$  values of 100–130 km in some shield areas. If correct, these values required significant strength at depths corresponding to ~1000 °C (McKenzie and Fairhead,

1997), far above the homologous temperatures at which such strength is expected, and far deeper than the deepest continental earthquakes. To argue that in a laminated system, the effective elastic thickness is only an abstract notion is no help here. A laminated system in which layer-parallel slip is permitted will always respond with an apparent elastic thickness that is *smaller* than its true thickness, requiring actual strength to a depth even greater than  $T_e$ . McKenzie and Fairhead (1997) argued that the method used to obtain these large values of  $T_e$  yielded upper bounds only, and that the true  $T_e$  values were probably much smaller, being always less than  $T_s$ .

If all the strength in the continental lithosphere resides in the crustal seismogenic layer, some other effect, in addition to temperature, must be important to distinguish continental and oceanic mantle and to allow the lower continental crust to be seismic in some areas and not in others. This is particularly clear in continental shields, where Moho temperatures can be as low as 300–500 °C (Artemieva and Mooney, 2001), so that the uppermost mantle is certainly cold enough to produce earthquakes, if that is the only relevant criterion (recall that earthquakes occur in the oceanic mantle to temperatures of at least 600 °C). Maggi et al. (2000b) suggested that the additional important effect is provided by water, which is known to reduce creep strength dramatically, even if present as only a few parts per million in nominally anhydrous minerals (Hirth and Kohlstedt, 1996; Mackwell et al., 1998). They suggested that, in the oceanic mantle lithosphere, dry Si-poor rheologies are appropriate because any water that was present was lost during the melting beneath ridges. But the continental mantle may well have small amounts of water, either from a long-term percolation of metasomatic fluids or from episodes of subduction. Loss of water from the lower crust, to leave anhydrous granulite-facies assemblages, may also be responsible for the strength of the lower crust in some ancient shield areas, with the Moho acting as a permeability barrier to the long-term percolation of fluids from below. The



**Figure 5.** Strength envelopes of differential stress (essentially rock strength) versus depth for various continental conditions, to illustrate the potential effects of water (adapted from Mackwell et al., 1998). The Moho is at 40 km and the temperature variation with depth corresponds to a surface heat flow of  $60 \text{ mW m}^{-2}$ . In all cases, the upper crust is represented by wet quartz (Qtz) and frictional strength by Byerlee's law. **A.** A summary of experimental results, in which the lower crust is represented by dry diabase (MD) or undried granulite (WC), and the mantle by dry or wet olivine (Ol). **B.** Wet lower crust and dry upper mantle, showing the popular conception of the continental lithosphere for the past 20 years, involving a weak lower crust and strong upper mantle. **C.** Dry lower crust and wet upper mantle, showing a strong lower crust over a mantle that has no strength, which may represent conditions under some continental shields, such as north India. **D.** Wet lower crust and wet upper mantle, neither of which have significant strength. In this case, nearly all strength resides in the seismogenic upper crust, which may represent conditions in most continental areas.

detailed suggestions of Maggi et al. (2000b) depend on petrological and melting inferences that have not yet been tested. In this respect, the observations of Austrheim and Boundy (1994) and Austrheim et al. (1997) from the Norwegian Caledonides are particularly interesting. They describe pseudotachylites (friction-generated melts) that formed under eclogite conditions at depths of 60 km or more,

with the transformation to eclogite facies assemblages occurring during shear failure in metastable dry granulites only when hydrous fluids are present. These circumstances may well be relevant to the deep earthquakes beneath southern Tibet.

It is clear that water has the potential to influence lithosphere strength dramatically. Figure 5 shows a series of theoretical profiles based on laboratory

experiments, contrasting the expected behaviors of representative dry and wet lower crust and mantle combinations (adapted from Mackwell et al., 1998). This figure is included not because such profiles should be taken literally, but to illustrate the effect of small amounts of water on creep strength.

## IMPLICATIONS

If significant strength resides only in the seismogenic layer of the continental lithosphere, it would not be surprising if regional patterns of active faulting at the surface were dominated by the strength of the crustal blocks and the interactions between them. The strength of the faults themselves is then presumably a limiting factor in crustal behavior, but remains very uncertain (e.g., Scholz, 2000). Maggi et al. (2000b) suggested that the heights of mountains and plateaus correlate with the strength of their bounding forelands, with higher mountains requiring greater support. The large buoyancy force needed to support Tibet is equivalent to average deviatoric stresses of  $\sim 120 \text{ MPa}$  if contained within the 40-km-thick elastic layer of India, greatly exceeding the average stress drops observed in earthquakes of 1–10 MPa. But the faults in the Himalayan foreland are not required to sustain 100 MPa stresses if most of the seismogenic layer in the Indian shield is intact. In places where the seismogenic layer is pervasively ruptured by faulting, such as in regions of distributed extension on parallel normal faults, topographic contrasts and the stresses required to maintain them are much less, and approach the levels of the stress drops seen in earthquakes (e.g., Jackson and White, 1989).

In the studies summarized here, it is perhaps the contrast between the shields and the deforming regions that is most dramatic. The earthquakes in Figures 1 and 2 suggest the Indian shield underthrusts Tibet at least as far as  $30^\circ \text{N}$ . Huang et al. (2000) traced the lack of shear wave anisotropy that is characteristic of the Indian shield even farther, to  $32^\circ \text{N}$ , and the gravity in Figure 3B suggests that the shield is strong. If these interpretations are correct, the strong Indian shield underlies most of the region of active normal faulting in southern Tibet (see Fig. 1), making it



improbable that there is a link between the surface extension and any convective downwelling in the mantle, as is often envisaged. Instead, it is perhaps more likely that the high elevations in this region are supported by the flexure of the Indian shield, with the entire overlying region 300–400 km north of the Himalayan front falling towards India, causing arc-normal slip vectors on the thrusts and arc-parallel extension behind.

If, at least in some places, the lower crust is stronger than the upper mantle, it is also necessary to reexamine the conditions under which the lower crust can flow to even out crustal thickness contrasts, as it has done in some areas, particularly in extensional metamorphic core complexes (e.g., Kruse et al., 1991; McKenzie et al., 2000). On the scale of 100–200 km, most of the interesting characteristics of lower crustal flow, such as the extreme dependence of relaxation time on wavelength and the generation of topographic fronts, occur because there are strong vertical shear gradients within the flowing channel. Such gradients require a viscosity contrast in which the mantle is more viscous than the lower crust, not less. It is probable that special circumstances are needed to reduce the viscosity of the lower crust to make it flow on this scale, such as the intrusion of igneous melts or the addition of water-rich fluids. In both cases, the important features of the flow arise from the limited time over which the viscosity is reduced, controlled either by conductive cooling of intrusions or by the separation of melt from its matrix, which removes water (McKenzie and Jackson, 2002). Lower-crustal flow on much larger scales, such as that envisaged over >1000 km around parts of Tibet (Clark and Royden, 2000), is only likely to happen in reasonable time scales if the viscosities of both the lower crust and the mantle are low, when flow can occur quickly by pure shear.

## CONCLUSIONS

The view of the continental lithosphere presented here, in which strength resides only in a single seismogenic layer, is easy to reconcile with the new earthquake and gravity interpretations, and is likely to involve processes in rock mechanics and

petrology that are understood in principle, even if they remain to be tested in detail. By contrast, the jelly sandwich model, which includes significant strength in the continental mantle, requires an obscure relationship between  $T_s$  and  $T_e$  and, if the large values of  $T_e$  are still believed, substantial long-term strength at temperatures where rocks are expected to be very weak. At the moment, our views of continental tectonics are confused by not knowing what really controls the patterns of deformation we see at the surface. At length scales much larger than the lithosphere thickness, it is probable that deforming velocity fields are related to forces on the edges of the lithosphere that arise from plate motions or within the lithosphere that arise from crustal thickness contrasts (e.g., England and Molnar, 1997; Flesch et al., 2000). If the new views proposed here are correct, the detailed patterns of faulting on the scales of interest to most tectonic and structural geologists (say, 100–400 km) are likely to be controlled predominantly by the strength of the crustal blocks and the faults that bound them.

## ACKNOWLEDGMENTS

It is a pleasure to acknowledge that I have been greatly influenced by discussions with my colleagues Dan McKenzie and Keith Priestley, as well as with Philip England, Peter Molnar, and David Kohlstedt, though they may not agree with all the interpretations expressed here, and I alone am responsible for any errors or misconceptions. I thank Dan McKenzie for help in producing Figure 3. Cambridge Earth Sciences contribution ES 7077.

## REFERENCES CITED

Artemieva, I.M., and Mooney, W.D., 2001, Thermal thickness and evolution of Precambrian lithosphere: A global study: *Journal of Geophysical Research*, v. 106, p. 16,387–16,414.

Austrheim, H., and Boundy, T.M., 1994, Psuedotachylites generated during seismic faulting and eclogitization of the deep crust: *Science*, v. 265, p. 82–83.

Austrheim, H., Erambert, M., and Engvik, A.K., 1997, Processing of crust in the root of the Caledonian continental collision zone: The role of eclogitization: *Tectonophysics*, v. 273, p. 129–153.

Bilham, R., and England, P., 2001, Plateau “pop-up” in the great 1897 Assam earthquake: *Nature*, v. 410, p. 806–808.

Brace, W.F., and Kohlstedt, D.L., 1980, Limits on lithostatic stress imposed by laboratory experiments: *Journal of Geophysical Research*, v. 85, p. 6248–6252.

Chapple, W.M., and Forsyth, D.W., 1979, Earthquakes and the bending of plates at trenches: *Journal of Geophysical Research*, v. 84, p. 6729–6749.

Chen, W-P., and Molnar, P., 1983, Focal depths of intra-continental and intraplate earthquakes and their implications for the thermal and mechanical properties of the lithosphere: *Journal of Geophysical Research*, v. 88, p. 4183–4214.

Clark, M.K., and Royden, L.H., 2000, Topographic ooze: building the eastern margin of Tibet by lower crustal flow: *Geology*, v. 28, p. 703–706.

Engdahl, E.R., van der Hilst, R., and Buland, R., 1998, Global teleseismic earthquake relocation with improved travel times and procedures for depth determination: *Bulletin of the Seismological Society of America*, v. 88, p. 722–743.

England, P., and Molnar, P., 1997, Active deformation of Asia: From kinematics to dynamics: *Science*, v. 278, p. 647–650.

Flesch, L.M., Holt, W.E., Haines, A.J., and Shen-Tu, B., 2000, Dynamics of the Pacific–North American plate boundary in the western United States: *Science*, v. 287, p. 834–836.

Hirth, G., and Kohlstedt, D.L., 1996, Water in the oceanic upper mantle: Implications for rheology, melt extraction and the evolution of the lithosphere: *Earth and Planetary Science Letters*, v. 144, p. 93–108.

Huang, W.C., Ni, J.F., Tilman, F., Nelson, D., Guo, J., Zhao, W., Mechie, J., Kind, R., Saul, J., Rapine, R., and Hearn, T., 2000, Seismic polarization anisotropy beneath the central Tibetan Plateau: *Journal of Geophysical Research*, v. 105, p. 27,979–27,989.

Jackson, J.A., and White, N.J., 1989, Normal faulting in the upper continental crust: Observations from regions of active extension: *Journal of Structural Geology*, v. 11, p. 15–36.

Jackson J., Priestley, K., Allen, M., and Berberian, M., 2002, Active tectonics of the South Caspian Basin: *Geophysical Journal International*, v. 148, p. 214–245.

Kruse, S., McNutt, M., Phipps-Morgan, J., Royden, L., and Wernicke, B., 1991, Lithospheric extension near Lake Mead, Nevada: A model for ductile flow in the lower crust: *Journal of Geophysical Research*, v. 96, p. 4435–4456.

Kumar, M.R., Saul, J., Sarkar, D., Kind, R., and Shukla, A.K., 2001, Crustal structure of the Indian shield: New constraints from teleseismic receiver functions: *Geophysical Research Letters*, v. 28, p. 1339–1342.

Mackwell, S.J., Zimmerman, M.E., and Kohlstedt, D.L., 1998, High-temperature deformation of dry diabase with application to tectonics on Venus: *Journal of Geophysical Research*, v. 103, p. 975–984.

Maggi, A., Jackson, J.A., Priestley, K., and Baker, C., 2000a, A reassessment of focal depth distributions in southern Iran, the Tien Shan and northern India: Do earthquakes really occur in the continental mantle?: *Geophysical Journal International*, v. 143, p. 629–661.

Maggi, A., Jackson, J.A., McKenzie, D., and Priestley, K., 2000b, Earthquake focal depths, effective elastic thickness, and the strength of the continental lithosphere: *Geology*, v. 28, p. 495–498.

Mangino, S., and Priestley, K., 1998, The crustal structure of the southern Caspian region: *Geophysical Journal International*, v. 133, p. 630–648.

McKenzie, D., and Fairhead, D., 1997, Estimates of the effective elastic thickness of the continental lithosphere from Bouguer and free air gravity anomalies: *Journal of Geophysical Research*, v. 102, p. 27,523–27,552.

McKenzie, D., and Jackson, J.A., 2002, Conditions for flow in the crust: *Tectonics* (in press).

McKenzie, D., Nimmo, F., Jackson, J., Gans, P., and Miller, E., 2000, Characteristics and consequences of flow in the crust: *Journal of Geophysical Research*, v. 105, p. 11,029–11,046.

Molnar, P., 1992, Brace-Goetze strength profiles, the partitioning of strike-slip and thrust faulting at zones of oblique convergence, and the stress-heat flow paradox of the San Andreas fault, in Evans, B., and Wong, T-F., eds., *Fault mechanics and transport properties of rocks: San Diego, California, Academic Press*, p. 461–473.

Murty, A.S.N., Mall, D.M., Murty, P.R.K., and Reddy, P.R., 1998, Two-dimensional crustal velocity structure along Hirasur-Mandla profile from seismic refraction and wide-angle reflection data: *Pure and Applied Geophysics*, v. 152, p. 247–266.

Rai, S.S., Prakasam, K.S., and Agrawal, N., 1999, Pn wave velocity and Moho geometry in north eastern India: Proceedings of the Indian Academy of Sciences: Earth and Planetary Sciences, v. 108, p. 297–304.

Scholz, C.H., 2000, Evidence for a strong San Andreas fault: *Geology*, v. 28, p. 163–166.

Sonder, L.J., and England, P., 1986, Vertical averages of rheology of the continental lithosphere: relation to thin sheet parameters: *Earth and Planetary Science Letters*, v. 77, p. 81–90.

Watts, A.B., Bodine, J.H., and Ribe, N., 1980, Observations of flexure and the geological evolution of the Pacific Ocean basin: *Nature*, v. 283, p. 532–537.

Wiens, D.A., and Stein, S., 1983, Age dependence of intraplate seismicity and implications for lithospheric evolution: *Journal of Geophysical Research*, v. 88, p. 6455–6468.

Withers, P., 2001, Gujarat aftershock epicenters and temporary station locations: [www.ceri.memphis.edu/~withers/Gujarat/](http://www.ceri.memphis.edu/~withers/Gujarat/) (December 2001).

Yuan, X., Ni, J., Kind, R., Mechie, J., and Sandvol, E., 1997, Lithospheric and upper mantle structure of southern Tibet from a seismological passive source experiment, *Journal of Geophysical Research*, v. 102, p. 27,491–27,500.

Zhu, L., and Helmberger, D.V., 1996, Intermediate depth earthquakes beneath the India-Tibet collision: *Geophysics Research Letters*, v. 23, p. 435–438.

*Manuscript received March 22, 2002; accepted July 4, 2002. \**

## Notice of Council Meeting



Meetings of the GSA Council are open to Fellows, Members, and Associates of the Society, who may attend as observers, except during executive sessions. Only councilors and officers may speak to agenda items, except by invitation of the chair. Because of space and seating limitations, you will need to notify the Executive Director prior to the meeting if you plan to attend.

The next meeting of the Council will be at 1 p.m., Saturday, October 26, and at 1 p.m., Tuesday, October 29, at the GSA Annual Meeting in Denver.

# DIALOGUE

## Geology and Public Policy Committee Activities and Goals

*Lou Gilpin, Chair, Geology and Public Policy Committee, [lgilpin@gilpingeosciences.com](mailto:lgilpin@gilpingeosciences.com)*

**“In order to secure adequate funding for geological research and credibility and respect for our profession, we must learn to promote the value of our work.”**

—Rachel Sours-Page, 2000–2001 GSA–U.S. Geological Survey Congressional Science Fellow (*GSA Today*, January 2002).

This succinct and insightful quote from a former congressional fellow provides an appropriate mission statement for the Geology and Public Policy (G&PP) Committee.

Our profession is diverse, yet it impacts people in their daily lives in many ways—from a child’s education of natural processes and the availability of clean water to preparation for natural hazards that may affect safety and livelihood of entire communities. GSA members contribute in all the fields of geology that ultimately benefit communities. My background is in applied engineering geology. I have experienced the responses from local officials and business people that view geological information as a research tool that adds color to the local natural history. Furthermore, they perceive this information to have little impact on planning and development guidelines that serve to protect human lives, property, and the environment.

The geological community can learn from our more service-oriented geotechnical and civil engineering partners who are continually reminding individuals, communities, and government agencies of the need to maintain and upgrade our infrastructure. For example, the American Society of Civil Engineers 2001 Report Card for America’s Infrastructure is provided to Congress on an annual basis. The 2001 Report Card gave an overall grade of D+ to the nation’s infrastructure.

What would a Report Card of Natural Hazard Preparedness look like? GSA members as a group are certainly capable of producing such an assessment. The public perception of the need for the geological sciences is not as accurate as their perception of the need for engineering. Engineers design buildings and roads and build bridges; it is up to us to point out our con-

tributions to the identification and management of natural hazards. Geologists regularly develop groundwater and mineral resources, assess vulnerability of structures and property to geologic hazards, and judge the appropriate scale of community development in areas subject to natural hazards. In addition, geologists have a special responsibility in the field of education to ensure dissemination of accurate and appropriate earth science information to students, communities, and policy makers.

As the new chair of the committee on which I have served since 1999, I hope to continue the numerous relationships and new projects that my predecessors (most recently, Geoff Feiss) have fostered. Such projects include:

- Actively servicing a G&PP list server with congressional updates and announcements of policy decisions that affect the earth sciences community.
- Funding for a Public Policy Speakers Tour new in 2002–2003. This tour will provide a venue for public policy topics to be presented at Section meetings and at local universities. Information will be forthcoming in *GSA Today*.
- Developing several position statements (Need for Geological Mapping and Natural Hazards Assessment) that we plan to complete and publish in *GSA Today* for your comments.

We continue the Congressional Science Fellow program, in partnership with the USGS, with a new appointee for 2002–2003, Raphael Sagarin, who has been active in climatic and biological systems research on the West Coast. (See page 25 for more information on Sagarin.) This program has provided an extraordinary team of geologists who now have advanced their careers, and our profession, in the public light since their involvement in the program. My interaction with these exceptional individuals over the past three years has certainly been one of the highlights of serving on the G&PP committee.

Most of all I look forward to discussing the policy issues with you, the membership, and to working with the committee and GSA to “market” the great value that geologists provide to communities across the nation and the world today.

# Crystal Clear.

## The Meiji EM Series of Modular Stereo Microscopes.

If you are looking for precision, durability, quality and value in a Stereo Microscope, we invite you to take a closer look at Meiji's EM Series of Stereo Microscopes.

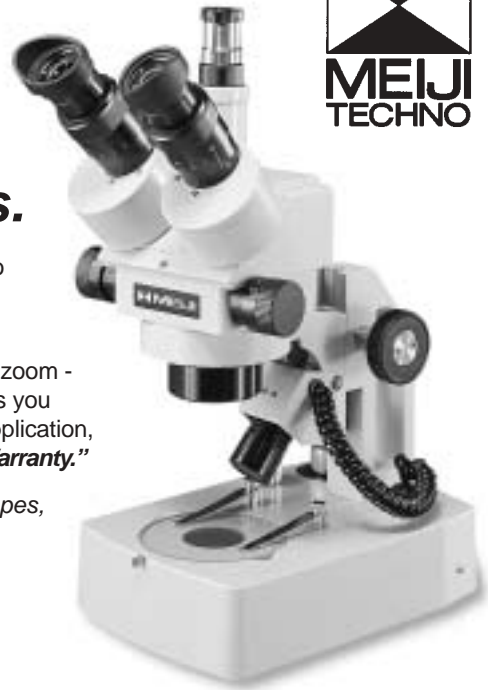
The modular design (A wide variety of bodies, single magnification or zoom - rotatable 360°, auxiliary lenses, eyepieces, stands, holders, etc.) gives you the freedom to create the ideal instrument for your specific need or application, and Meiji stands behind every instrument with its **"Limited Lifetime Warranty."**

For more information on these economically priced Stereo Microscopes, please call, FAX, write us or log on to our website today.

## MEIJI TECHNO AMERICA

2186 Bering Drive, San Jose, CA 95131,  
Tel: 408.428.9654, FAX: 408.428.0472

**Toll Free Telephone: 800.832.0060 or visit our website at [www.meijitechno.com](http://www.meijitechno.com)**



## New Society Division Proposed

*Thomas J. Evans, North-Central Section Representative,  
Geology and Public Policy Committee*

Interest has been expressed in creating a new interdisciplinary division in GSA to further enhance the Society's activities that promote geoscience in the service of society. Tentatively called the Geology and Society Division, the purpose of the proposed division would be to:

- ⊙ stimulate research, teaching, and active participation of GSA members in understanding how geoscience is engaged in the public and private discourse to learn about and to actively address some of the complex issues confronting society in today's world;
- ⊙ provide a forum for the presentation of scholarly papers and discussions relevant to understanding the diverse perspectives that may be engaged in addressing these issues;
- ⊙ provide a forum for professional support and recognition for members and colleagues engaged in the examination of these issues;
- ⊙ encourage undergraduate and graduate students to become active in the application of the geosciences to

address societal concerns, to maintain their involvement throughout their careers, and to support them in related educational opportunities; and

- ⊙ actively promote within GSA "the application of geoscience knowledge and insight to human needs and aspirations and to stewardship of the Earth."

It is envisioned that the proposed Geology and Society Division can become a means to promote and enhance the work of various groups and committees within the society, such as the Geology and Public Policy Committee and the Education Committee, among others, and to promote the application of geoscience information to societal issues, wherever appropriate.

At the Denver 2002—Science at the Highest Level meeting, please stop by the Geology and Public Policy Committee booth, located in the Headquarters Services area of the Exhibit Hall, to learn more about the proposed division and to sign petitions expressing your interest in the creation of this new, interdisciplinary Geology and Society Division.



**THE POKESCOPE™ FOLDING 3D VIEWER**  
 for viewing stereo images of all sizes  
**COMPACT** FOLDS TO 2" SQ. **EASY TO USE**  
 FOR: DIGITAL STEREO IMAGES • UNMOUNTED STEREO PRINTS  
 USGS AERIAL PHOTOGRAPHS • FIELD USE



**\$49.95** +\$4.95 P&H  
 INCLUDES  
 PokeScope™  
 Image Manager  
 SOFTWARE

Graphic Media  
 Research  
 211 Ridgecrest Dr.  
 Cannon Falls, MN  
 55009 USA  
**507-263-4611**

[www.pokescope.com](http://www.pokescope.com)


[www.terraplus.com](http://www.terraplus.com)

**Geophysical Instruments**  
*that meet your needs*



Littleton, Colorado, 303 799-4140 [info@terraplus.com](mailto:info@terraplus.com)

*Call for Geological Papers:* **2003 GSA Section Meetings**

<p>South-Central–Southeastern          Sections Joint Meeting          March 12–14, 2003          University of Memphis, Memphis, Tennessee  <b>Abstract deadline: December 10, 2002</b>  <b>Information:</b> Dan Larsen, Dept. of Earth Sciences,          University of Memphis, 421 J.M. Smith Bldg., Memphis,          TN 38152, (901) 678-4358, <a href="mailto:dlarsen@memphis.edu">dlarsen@memphis.edu</a>.</p>	<p>Northeastern Section          March 27–29, 2003          Westin Hotel, Halifax, Nova Scotia  <b>Abstract deadline: December 18, 2002</b>  <b>Information:</b> Jane Barrett, Dept. of Earth Sciences,          Dalhousie University, Halifax, NS B3H 3J5, Canada,          (902) 494-1473, <a href="mailto:jmbarret@is.dal.ca">jmbarret@is.dal.ca</a>.</p>	<p>Cordilleran Section          April 1–3, 2003          Hotel NH Krystal, Puerto Vallarta, Mexico  <b>Abstract deadline: December 16, 2002</b>  <b>Information:</b> Elena Centeno-García, Instituto de          Geología, Universidad Nacional Autónoma de México,          (National Autonomous University of Mexico), Ciudad          Universitaria, México, D.F. 04510, México,  <a href="mailto:centeno@servidor.unam.mx">centeno@servidor.unam.mx</a>.</p>
<p>North-Central Section          March 24–25, 2003          Kansas City Airport Hilton, Kansas City, Missouri  <b>Abstract deadline: December 10, 2002</b>  <b>Information:</b> Raymond M. Coveney Jr., Dept. of          Geosciences, 420 Flarsheim Hall, University of Missouri,          5110 Rockhill Rd., Kansas City, MO 64110-2499,          (816) 235-2980, <a href="mailto:coveneyr@umkc.edu">coveneyr@umkc.edu</a>.</p>		<p>Rocky Mountain Section          May 7–9, 2003          Fort Lewis College, Durango, Colorado  <b>Abstract deadline: January 30, 2003</b>  <b>Information:</b> James Collier, Dept. of Geosciences,          Fort Lewis College, 1000 Rim Dr., Durango, CO 81301-          3999, (970) 247-7129, <a href="mailto:collier_j@fortlewis.edu">collier_j@fortlewis.edu</a>.</p>
<p>1. Cordilleran Section          2. Rocky Mountain Section</p>		<p>3. North-Central Section          4. South-Central Section</p>

**Students:**  
**Section Meetings Have Workshops Just for You!**

If you're interested in pursuing a career in applied geoscience, you'll find the Roy J. Shlemon Mentor Programs valuable, informative, fun, and filling (lunch is included).

The programs extend the mentoring reach of individual professionals from applied geology to advanced undergraduate and graduate students attending GSA Section Meetings. Mentors interact with student members, discussing the opportunities and realities of employment outside academia.





## Foundation Trustees Meet in Boulder

The Foundation's Board of Trustees held its annual spring meeting in Boulder during April. Chair Lee Suttner welcomed three new trustees to the meeting: David Dunn, James Kahn, and George Sharp.

Foundation President Tom Fouch reported on the progress of his corporate contact and proposals. Fouch discussed GSA's most recent list of funding needs as endorsed by the Society's Executive Committee and Council. He presented to the Board the Foundation's strategy plan for funding each of these needs. Trustee subcommittees have been formed for each specific GSA need and are charged with raising sufficient funds to insure that the Foundation achieves the targeted goal for that specific need.

Catherine Skinner, Chair of the Foundation's Ad Hoc Strategic Planning Committee, led an energetic discussion on the draft strategic plan prepared by the committee. The plan outlines the Foundation's vision for the future.

GSA President Tony Naldrett and GSA Executive Director Jack Hess reported on the Society's recent activities, including the reductions taken by the Society to bring its Fiscal Year 2003 budget in line. Hess also announced his plan to

form an ad hoc committee to explore where the Society would like to be five to ten years in the future.

The Board reviewed the extensive direct expense reduction in the Foundation's Fiscal Year 2003 Operating Budget. Foundation staff had labored long and hard to reduce expenses as far as possible.

Fouch announced successful negotiations to hold the Senior Fellows Reception at the famous Navarre Building in Denver. This is an invitation-only, ticketed event, and reservations will be made on a first-come, first-served basis.

The next Board of Trustees' meeting will be held during the GSA Annual Meeting in Denver.

### Have You Named the GSA Foundation in Your Will?

If you are in the process of planning and/or preparing your will, the Foundation has the appropriate language needed in order to leave a bequest to the Foundation. For further information, please contact Donna Russell, drussell@geosociety.org, (303) 357-1054. The Foundation is a 501(c)(3) not-for-profit corporation.



#### Most memorable early geologic experience

Ojo Caliente, New Mexico, 1947. Mapping with Dick Jahns and Clay Smith (pros), both Gene Shoemaker and I (undergrads) broke our barometers by the fourth day. Elevation control degraded to vertical angles with our Bruntons. Not cool!

—William R. Muehlberger



## GSA Foundation

3300 Penrose Place, P.O. Box 9140  
Boulder, CO 80301-9140 • (303) 357-1054  
drussell@geosociety.org

Enclosed is my contribution in the amount of \$\_\_\_\_\_.

Please credit my contribution for the:

- Greatest need
- Other: \_\_\_\_\_ Fund
- I have named GSA Foundation in my will.

PLEASE PRINT

Name \_\_\_\_\_

Address \_\_\_\_\_

City/State/ZIP \_\_\_\_\_

Phone \_\_\_\_\_

# JOINT MEETING

**37th Annual Meeting of the South-Central Section, GSA,  
and 52nd Annual Meeting of the Southeastern Section, GSA  
Memphis, Tennessee • March 12–14, 2003**



THE  
GEOLOGICAL  
SOCIETY  
OF AMERICA

## HEADQUARTERS, ACCOMMODATIONS, AND REGISTRATION

**Preregistration deadline: January 31, 2003**

**Cancellation deadline: February 7, 2003**

**Register online at [www.geosociety.org](http://www.geosociety.org).**

Located along the Mississippi River and the boundary between the South-Central and South-eastern Sections, Memphis, Tennessee, is the perfect site for a joint meeting. Centered in the Mississippi Embayment, the Memphis area has many field locations pertinent to Quaternary geology, neotectonic processes, geologic hazards, and fluvial geomorphology. Field trip destinations in the Ouachita Mountains, Ozark Plateau, St. Francis Mountains, and central Tennessee are all within a few hours of the site by car. The meeting will be held at the University of Memphis Conference Center, located on the northwest side of the campus. The conference center includes the Fogelman Executive Center and Wilson School of Hospitality and Resort Management.

A block of rooms has been reserved at the University of Memphis Conference Center for meeting attendees; room options range from \$85 to \$105 per room per night. Meeting attendees are responsible for making their own housing arrangements. Please call the University of Memphis Conference Center for reservations at (901) 678-8200, and refer to the Geological Society of America room block. For more information on registration, lodging, and schedules, please visit the meeting Web site at: [www.geosociety.org/sectdiv/southc/03sc-semtg.htm](http://www.geosociety.org/sectdiv/southc/03sc-semtg.htm). Information can also be found at [cas.memphis.edu/geology/2003gsa/2003SCSEGSA.htm](http://cas.memphis.edu/geology/2003gsa/2003SCSEGSA.htm).

## ABSTRACTS

**Abstract deadline: December 10, 2002**

Papers are invited for symposia, theme sessions, and general sessions, in both oral and poster formats. Abstracts not included in symposia will be scheduled for theme or general sessions, as appropriate. All abstracts must be submitted online at [www.geosociety.org](http://www.geosociety.org). An abstract submission fee of \$10 will be charged. 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 other papers.

## SYMPOSIA AND THEME SESSIONS

The proposed symposia and theme sessions follow. Additional symposia and theme session topics may still be accommodated. For more information, contact the technical program co-chairs: Gregg Davidson, (662) 915-5824, [davidson@olemiss.edu](mailto:davidson@olemiss.edu), or Roy Dokka (225) 578-2975, [rdokka@c4g.lsu.edu](mailto:rdokka@c4g.lsu.edu). For more details, consult the meeting Web site, [www.geosociety.org/sectdiv/southc/03sc-semtg.htm](http://www.geosociety.org/sectdiv/southc/03sc-semtg.htm).

### Symposia

1. **History of Geologic Investigation of Crystalline Rocks of Alabama, with Emphasis on the Past 40 Years: How We Saw it Then; How We See it Now.** Robert Deininger, University of Memphis, (901) 682-4324, [mdeinin100@aol.com](mailto:mdeinin100@aol.com); Thornton L. Neathery, [tneathery@prodigy.net](mailto:tneathery@prodigy.net).
2. **A 21st Century Look at the Cretaceous Coon Creek Formation.** Stan Dunagan, (731) 587-7430, [dunagans@charter.net](mailto:dunagans@charter.net), and Michael Gibson, (731) 587-7435, [mjgibson@utm.edu](mailto:mjgibson@utm.edu), both at University of Tennessee at Martin.
3. **Cenozoic Paleodrainage in the Southeastern United States.** Robert Self, University of Tennessee at Martin, (731) 587-7444, [rself@utm.edu](mailto:rself@utm.edu).
4. **Environmental Research and Remediation at Department of Energy's Savannah River Site.** Mary Harris, Savannah River Technology Center, (803) 725-4184, [mary.harris@srs.gov](mailto:mary.harris@srs.gov); Chris Romanek, Savannah River Ecology Laboratory, (803) 725-5883, [romanek@srel.edu](mailto:romanek@srel.edu).

### Theme Sessions

1. **Petrotectonic History of the Blue Ridge Belt: Faults, Fault Blocks, Terrains, and Ophiolites.** Loren Raymond, Appalachian State University, (828) 262-2749, [raymondla@appstate.edu](mailto:raymondla@appstate.edu); Calvin Miller, Vanderbilt University, (615) 322-2232, [millercf@ctrvx.vanderbilt.edu](mailto:millercf@ctrvx.vanderbilt.edu).
2. **Post-Mesozoic Tectonics of the Southern Mid-Continent.** Paul A. Washington, University of Louisiana at Monroe, (318) 342-1898, [gewashington@ulm.edu](mailto:gewashington@ulm.edu).

3. **Seismicity and Neotectonics in the Southern United States.** Terry Panhorst, University of Mississippi, (662) 915-5825, [panhorst@olemiss.edu](mailto:panhorst@olemiss.edu); James Harris, Millsaps College, (601) 974-1343, [harrijb@okra.millsaps.edu](mailto:harrijb@okra.millsaps.edu).
4. **Connections and Timing in the Appalachian-Ouachita Orogen.** Kent C. Nielsen, University of Texas at Dallas, (972) 883-6837, [knielsen@utdallas.edu](mailto:knielsen@utdallas.edu); and William A. Thomas, University of Kentucky, (859) 257-6222, [geowat@pop.uky.edu](mailto:geowat@pop.uky.edu).
5. **Late Paleozoic Intraplate Deformation of Central North America.** Randy Cox, University of Memphis, (901) 678-4361, [randycox@memphis.edu](mailto:randycox@memphis.edu); and Mark Hudson, U.S. Geological Survey, (303) 236-7446, [mhudson@usgs.gov](mailto:mhudson@usgs.gov).
6. **Oh Southern Stars! Planetary Geology in the South.** Keith A. Milam, (865) 974-2789, [kmilam@utk.edu](mailto:kmilam@utk.edu), and Karen R. Stockstill, (865) 974-5324, [kstockst@utk.edu](mailto:kstockst@utk.edu), both at University of Tennessee at Knoxville.
7. **Earth Science and Earthquake Education Resources for K–12 Science Teachers in the Central and Eastern United States.** *Sponsored by National Association of Geoscience Teachers.* Michelle Dry, (901) 678-1723, [mdry@memphis.edu](mailto:mdry@memphis.edu), and Gary Patterson, (901) 678-5264, [patterson@ceri.memphis.edu](mailto:patterson@ceri.memphis.edu), both at University of Memphis.
8. **Innovative Initiatives in Geoscience Education.** Shelley Miller, Saint Mary's School, Raleigh, N.C., (919) 424-4050, [samiller@saint-marys.edu](mailto:samiller@saint-marys.edu).
9. **Geologic Maps and Digital Geologic Maps.** (Poster Session.) Ralph F. Crawford, The Geologic Mapping Institute, (404) 373-6780, [crawford@sprintmail.com](mailto:crawford@sprintmail.com); Michael W. Higgins, Roswell, Ga., (770) 641-1268, [mhiggins@mindspring.com](mailto:mhiggins@mindspring.com).
10. **Coastal Plain Stratigraphy of the Southeastern United States.** Charles Swann, University of Mississippi, (662) 915-7320, [cts@mmri.olemiss.edu](mailto:cts@mmri.olemiss.edu).
11. **Hydrostratigraphy and Hydrology of Cenozoic Aquifer Systems of the Southeastern Coastal Plain, Gulf Coast, and Mississippi Embayment.** Randy Gentry, University of Tennessee at Knoxville;

Dan Larsen, University of Memphis, (901) 678-4358, dlarsen@memphis.edu.

12. **The Role of Fieldwork in the Study of Carbonate Rock Aquifer/Landscape Systems.** Chris Groves, Western Kentucky University, (270) 745-4169, chris.groves@wku.edu; Joe Meiman, Mammoth Cave National Park, (270) 758-2137, joe\_meiman@nps.gov.
13. **Recharge Mechanisms and Estimation.** Brian Waldron, University of Memphis, (901) 678-3913, bwaldron@memphis.edu.
14. **Groundwater-Surface Water Interactions.** Gregg Davidson, University of Mississippi, (662) 915-5824, davidson@olemiss.edu.
15. **Water Rock Life: Interactions Between Hydrology and Biology.** Nate Bickford, (870) 972-3087, nbickfor@mail.astate.edu, and Robyn Hannigan, (870) 972-3086, hannigan@mail.astate.edu, both at Arkansas State University.
16. **Advances in Environmental Biogeochemistry.** Dibendu Sarkar, University of Texas at San Antonio, (210) 458-5453, dsarkar@utsa.edu.
17. **Radioisotopes as Tracers of Sedimentary and Pore Water Processes in the Coastal Zone.** Sam Bentley, Louisiana State University, (225) 578-2954, sjb@lsu.edu; John Jaeger, University of Florida, (352) 846-1381, jaeger@geology.ufl.edu; Jaye Cable, Louisiana State University, (225) 578-9402, jcable@lsu.edu.

## WORKSHOPS

Workshops will be held before and after the meeting on March 11 and 15. Registration for some workshops is limited. For additional information, please check the meeting Web site, [www.geosociety.org/sectdiv/southc/03sc-semtg.htm](http://www.geosociety.org/sectdiv/southc/03sc-semtg.htm), or contact the workshop chair, Roy Van Arsdale, [rvanrsdl@memphis.edu](mailto:rvanrsdl@memphis.edu), (901) 678-2177, or the workshop conveners.

1. **Introduction to ArcGIS with Geohydrology Applications (ESRI's ArcGIS 8.2).** Brian Waldron, (901) 678-3913, [bwaldron@memphis.edu](mailto:bwaldron@memphis.edu), and Pin-Shou (Ben) Liu, both at University of Memphis.
2. **Three-Dimensional Geological Visualization and Volumetrics: A Hands-On, One-Day Short Course Using RockWorks2002.** Jim Reed, RockWare Inc., (303) 278-3534, [jim@rockware.com](mailto:jim@rockware.com).

## ROY J. SHLEMON MENTOR PROGRAM IN APPLIED GEOLOGY

Thurs. and Fri., March 13 and 14, 11:30 a.m.–1 p.m. *Sponsored by GSA Foundation.* Karlon Blythe, GSA, (303) 357-1036, [kblythe@geosociety.org](mailto:kblythe@geosociety.org). Cost: free (includes lunch).

This workshop for undergraduate and graduate students will be led by practicing geoscientists. Plan to attend both free luncheons to hear different presenters each day. These interactive and informal workshops will cover real-life issues such as the professional opportunities and challenges that await students after graduation. Preregistration is encouraged to secure a seat; however, meeting registration is not required to attend only these workshops.

## FIELD TRIPS

Both premeeting and postmeeting field trips are planned. Registration for some trips is limited. For more information, please visit the meeting Web site, [www.geosociety.org/sectdiv/southc/03sc-semtg.htm](http://www.geosociety.org/sectdiv/southc/03sc-semtg.htm), the field trip chair, Randy Cox, (901) 678-4361, [randycox@memphis.edu](mailto:randycox@memphis.edu), or the field trip leader.

## Premeeting

1. **Cretaceous to Late Tertiary Gravel Deposits in the Western Tennessee River Valley.** Robert Self, University of Tennessee at Martin, [rself@utm.edu](mailto:rself@utm.edu).
2. **Late Paleozoic Tectonics of the Southern Ozark Dome.** (Overnight.) Mark Hudson, U.S. Geological Survey, [mhudson@usgs.gov](mailto:mhudson@usgs.gov); Randy Cox, University of Memphis, [randycox@memphis.edu](mailto:randycox@memphis.edu).
3. **Sedimentology, Stratigraphy, Paleontology, and History of Cretaceous Coon Creek Formation of Western Tennessee.** *Sponsored by the Southeastern Section of the Paleontological Society.* (Overnight.) Michael A. Gibson, University of Tennessee at Martin, [mjgibson@utm.edu](mailto:mjgibson@utm.edu).
4. **Mississippian-Pennsylvanian Deep Water Depositional Systems and Related Structure of the Ouachita Orogen.** (Overnight.) Arnold Bouma and Roy Dokka, Louisiana State University, [rkdokka@c4g.lsu.edu](mailto:rkdokka@c4g.lsu.edu).

## Postmeeting

5. **Hands-On Earth Science at the Coon Creek Science Center.** *Sponsored by the Southeastern Section of National Association of Geoscience Teachers.* (Overnight.) Pam Riddick, Pink Palace Museum, [pam.riddick@cityofmemphis.org](mailto:pam.riddick@cityofmemphis.org); Michael A. Gibson, University of Tennessee at Martin, [mjgibson@utm.edu](mailto:mjgibson@utm.edu).
6. **Waulsortian-like Bioherms of the Maury and Fort Payne Formations, Tennessee.** Frank Stapor, [fstapor@tntech.edu](mailto:fstapor@tntech.edu), and Larry W. Knox, Tennessee Technological University.
7. **Basement-Cover Tectonic Relationships in Southeastern Missouri.** (Overnight.) Richard Harrison, U.S. Geological Survey, [rharrison@usgs.gov](mailto:rharrison@usgs.gov); Bill Clendenin, South Carolina Geological Survey; Gary Lowell,

University of Southeastern Missouri, [glowell@semovm.semo.edu](mailto:glowell@semovm.semo.edu).

8. **Loess in the Northern Mississippi Embayment.** David Lumsden, University of Memphis, [dlumsden@memphis.edu](mailto:dlumsden@memphis.edu).
9. **Paleoenvironment, Depositional Setting, and Plant Fossil Diversity Found in the Claiborne Formation (Middle Eocene) Clay Deposits of Western Tennessee.** B. Roger Moore, University of Tennessee at Martin, [brmoore@click1.net](mailto:brmoore@click1.net); David L. Dilcher, University of Florida; and Michael A. Gibson, [mjgibson@utm.edu](mailto:mjgibson@utm.edu).

## STUDENT TRAVEL GRANTS

Travel grants are available from the South-eastern and South-Central Sections and the GSA Foundation. Grants are available for GSA Student Associates who are presenting oral or poster papers. Students must be currently enrolled as GSA members to be eligible.

The application form for Southeastern Section grants can be found at [www.geology.ecu.edu/geology/segga/travel.html](http://www.geology.ecu.edu/geology/segga/travel.html). Applications must be received no later than February 15, 2003. All eligible students will receive some support, the amount depending on the number of applicants. Additional information may be obtained from Donald Neal, (252) 328-4392, [neald@mail.ecu.edu](mailto:neald@mail.ecu.edu).

For the South-Central Section, please visit the GSA Web site, [www.geosociety.org](http://www.geosociety.org), for details regarding application instructions for these grants. Applications must be received no later than February 15, 2003. For more information, please contact Elizabeth Y. Anthony, [eanthony@geo.utep.edu](mailto:eanthony@geo.utep.edu).

## EXHIBITS

Exhibit space will be available in an exhibit hall together with the poster sessions. Exhibits will be open from 6–8 p.m., Wednesday, March 12, 9 a.m.–5 p.m., Thursday, March 13, and 9 a.m.–noon, Friday, March 14. For more information on exhibit space, please contact Robyn Hannigan, (870) 972-3086, [hannigan@mail.astate.edu](mailto:hannigan@mail.astate.edu).

## DETAILED INFORMATION

For more information, please contact the meeting chairman, Dan Larsen, (901) 678-4358, [dlarsen@memphis.edu](mailto:dlarsen@memphis.edu). Additional meeting information is also available at [www.geosociety.org/sectdiv/southc/03sc-semtg.htm](http://www.geosociety.org/sectdiv/southc/03sc-semtg.htm).

GSA is committed to making all events at the 2003 meeting accessible to all people interested in attending. You can indicate special requirements (wheelchair accessibility, dietary concerns, etc.) on the registration forms.

## Preliminary Announcement and Call for Papers

# North-Central Section, GSA

37th Annual Meeting • Kansas City, Missouri • March 24–25, 2003



THE  
GEOLOGICAL  
SOCIETY  
OF AMERICA

Please see the full announcement

of this meeting at

[www.geosociety.org/sectdiv/](http://www.geosociety.org/sectdiv/)

[Northc/03ncmtg.htm](http://Northc/03ncmtg.htm).

(E-mail: [geosciences@umkc.edu](mailto:geosciences@umkc.edu).)

## KANSAS CITY

Pennsylvanian shales and limestones underlie Kansas City, which is noted for secondary use of underground space in room and pillar limestone mines. Kansas City straddles the confluence of the Missouri and Kansas Rivers and the terminus of Pleistocene glaciation, both of which have heavily influenced land usage. Floods occur in upland valleys such as Brush Creek, channels cut during the Pleistocene such as Turkey Creek, and along the Missouri and Kansas Rivers.

## REGISTRATION

Preregistration and hotel accommodations deadline: February 14, 2003.

Register online at [www.geosociety.org](http://www.geosociety.org).

The local committee strongly encourages you to preregister to qualify for lower registration fees. Field trip participants must preregister for the meeting. Preregistration by mail will be handled by the GSA Registration Coordinator, P.O. Box 9140, Boulder, CO 80301-9140. Preregistration forms will be printed in the November 2002 issue of *GSA Today*.

## ACCOMMODATIONS

The entire meeting will take place at the Kansas City Airport Hilton, near exit 12 of I-29, 8801 NW 112th Street, Kansas City, MO 64153. Free parking and airport shuttle. The conference room rate is \$82 (single or sharing, with up to four to a room permissible). Go to [www.kansascityairport.hilton.com](http://www.kansascityairport.hilton.com), and click on "Book a Room." When you reach the question "What rate type do you want to see?" click "Packages/Promotions/Special Offers." Type "GSA" for the group code, and click on "Rates & Availability." Or, call 1-800-HILTONS for reservations. All meeting rooms are ADA accessible.

## ABSTRACTS

Abstract deadline: December 10, 2002

Use the online electronic abstract form from the GSA Web site. An abstract submission fee of

\$10 will be charged. If you cannot submit your abstract electronically, contact Nancy Carlson at [ncarlson@geosociety.org](mailto:ncarlson@geosociety.org), (303) 357-1061. For information on technical sessions and symposia, please contact the symposium organizer listed below or the technical program chair, Syed E. Hasan, at [hasans@umkc.edu](mailto:hasans@umkc.edu), (816) 235-2976.

## FIELD TRIPS

For inquiries concerning field trips and suggestions of additional trips please contact field trip coordinator, Tina M. Niemi, at [niemit@umkc.edu](mailto:niemit@umkc.edu), (816) 235-5342. A preliminary listing of trips follows.

1. **The Geology of Kansas City—From the Pennsylvanian to the Recent.** (2 days.) Richard J. Gentile, University of Missouri—Kansas City, [gentiler@umkc.edu](mailto:gentiler@umkc.edu).
2. **Latest Pennsylvanian and Earliest Permian Cyclic Sedimentation and Paleocology in Southeastern Nebraska.** (1 day.) Roger Pabian, Nebraska Geological Survey, University of Nebraska—Lincoln, [rpabian1@ul.edu](mailto:rpabian1@ul.edu).
3. **Classic Pennsylvanian Conodont Localities in Black Shales of Western Missouri** *Cosponsored by the Pander Society.* (1 day.) Philip Heckel, University of Iowa, [philipheckel@uiowa.edu](mailto:philipheckel@uiowa.edu).
4. **Tri-State Zn-Pb Ores from Bonanza to Superfund.** (1 day.) Virginia Ragan, Maplewoods Community College, [raganv@maplewoods.cc.mo.us](mailto:raganv@maplewoods.cc.mo.us); Mark Doolan and David Drake, U.S. Environmental Protection Agency, Kansas City, Kans.
5. **Quaternary Geology of the Mill Creek Valley.** (1 day.) Rolfe Mandel, University of Kansas, [mandel@falcon.cc.ukans.edu](mailto:mandel@falcon.cc.ukans.edu).
6. **Metallogeny of Pennsylvanian Black Shales.** (1 day.) Raymond Coveney, University of Missouri—Kansas City, [coveneyr@umkc.edu](mailto:coveneyr@umkc.edu).
7. **Kansas City: World Leader in Underground Space Utilization.** Charles Spencer, University of Missouri—Kansas City, [spencerc@umkc.edu](mailto:spencerc@umkc.edu).

## SYMPOSIUMS AND THEME SESSIONS

For general questions concerning symposia and sessions and to suggest additional themes, please contact technical program chair, Syed E.

Hasan, [hasans@umkc.edu](mailto:hasans@umkc.edu), (816) 235-2976.

## Symposia

1. **Stratigraphic Correlation and Nomenclature of the Upper Midwest Paleozoic.** *Cosponsored by SEPM—Society for Sedimentary Geology.* Richard Gentile, University of Missouri—Kansas City, [gentiler@umkc.edu](mailto:gentiler@umkc.edu).
2. **Diversity in the Geosciences.** Virginia Ragan, Maplewoods Community College, [raganv@maplewoods.cc.mo.us](mailto:raganv@maplewoods.cc.mo.us).
3. **Tri-State Mining District: From Bonanza to Superfund.** David Drake, U.S. Environmental Protection Agency, Kansas City, Kans., [Drake.Dave@epamail.epa.gov](mailto:Drake.Dave@epamail.epa.gov).
4. **Pander Society Symposium.** Jim Barrick, Texas Tech University, [Jim.Barrick@TTU.EDU](mailto:Jim.Barrick@TTU.EDU).
5. **Midwest Intraplate Seismicity.** Tina Niemi, University of Missouri—Kansas City, [niemit@umkc.edu](mailto:niemit@umkc.edu).
6. **Engineering and Environmental Geology of Midwestern Black Shales.** Charles Spencer, University of Missouri—Kansas City, [spencerc@umkc.edu](mailto:spencerc@umkc.edu).
7. **Geological, Engineering and Environmental Problems in the Missouri River Basin.** John Moylan, [johnmoylan@att.net](mailto:johnmoylan@att.net).
8. **Climate Variability and Change: Past, Present, and Future.** Jimmy Adegoke, University of Missouri—Kansas City, [adegokej@umkc.edu](mailto:adegokej@umkc.edu).

## Theme Sessions

1. **Subduction Zones: Modern and Ancient.** Jim Walker, Northern Illinois University, [jim@geol.niu.edu](mailto:jim@geol.niu.edu).
2. **Hydrogeologic Problems and Midwestern Agriculture.** Syed Hasan, University of Missouri—Kansas City, [hasans@umkc.edu](mailto:hasans@umkc.edu).
3. **Geological and Environmental Education in the 21st Century.** *Cosponsored by National Association of Geoscience Teachers, Central Section.* Janis Treworgy, Principia College [jdt@prin.edu](mailto:jdt@prin.edu).
4. **Undergraduate and Graduate Student Research.** James Murowchick, University of Missouri—Kansas City, [murowchickj@umkc.edu](mailto:murowchickj@umkc.edu).



## EXHIBITS

Exhibitors: please contact James B. Murowchick, [murowchickj@umkc.edu](mailto:murowchickj@umkc.edu), (816) 235-2979.

## SPECIAL EVENTS

Association of Women Geoscientists Breakfast and Business Meeting.

Central Section National Association of Geoscience Teachers Breakfast and Business Meeting.

North Central Section and Pander Society Luncheon.

North Central Section Departmental Chairs Breakfast and Business Meeting.

## ROY J. SHLEMON MENTOR PROGRAM IN APPLIED GEOLOGY

Mon., March 24, 11:30 a.m.–1 p.m. *Sponsored by GSA Foundation.* Karlon Blythe, GSA, (303) 357-1036, [kblythe@geosociety.org](mailto:kblythe@geosociety.org). Cost: free

(includes lunch). This workshop for undergraduate and graduate students will be led by practicing geoscientists. This interactive and informal workshop will cover real-life issues such as the professional opportunities and challenges that await students after graduation. Preregistration is encouraged to secure a seat; however, meeting registration is not required to attend only this workshop.

## GUEST ACTIVITIES

Nongeologic local attractions include the Country Club Plaza shopping and dining district, 18th and Vine Jazz district, Nelson-Atkins Art Gallery, Kemper Museum of Modern Art, Belger Arts Center for Creative Studies, Crown Center and Hallmark Cards Visitor Center, Union City Science City, the Liberty Memorial, Linda Hall Library of Science, Technology and Engineering, the Miniature Museum, University of Missouri—Kansas City, Westport Area dining, and the Harry S. Truman Presidential Library.

## TRAVEL GRANTS AVAILABLE FROM THE NORTH-CENTRAL SECTION AND THE GSA FOUNDATION

Grants are available for GSA Student Associates who are presenting oral or poster papers. Students must be currently enrolled as GSA members to be eligible, and requests for funding should be made through North-Central Section Chair, Raymond M. Coveney Jr., [geosciences@umkc.edu](mailto:geosciences@umkc.edu), (816) 235-1334.

## OTHER

For other matters, including student awards (from GSA North-Central Section; Kansas City Section, Geotechnical Society; National Association of Geoscience Teachers, SEPM—Society for Sedimentary Geology), please contact North-Central Section Chair, Raymond M. Coveney Jr., [geosciences@umkc.edu](mailto:geosciences@umkc.edu), (816) 235-1334.

# Student Volunteer Program Helps

## Pay Your Bills *No up-front meeting registration fee required!*

As a student volunteer during the 2002 GSA Annual Meeting in Denver, you can offset some of your cost of attending the meeting.

Volunteer just 12 hours and your meeting registration is **FREE**.

Volunteer 15 or more hours and receive a **FREE** Abstracts with Programs volume in addition to **FREE** meeting registration.

PLUS, GSA will pay volunteers a stipend of \$20 per each half-day (4 hours) volunteered at the meeting.

(Stipends can only be issued to students who have a U.S. government-issued Social Security number or Green Card.)

### For more information

contact Kevin Ricker  
[kricker@geosociety.org](mailto:kricker@geosociety.org) or visit  
[www.geosociety.org/meetings/  
2002/students.htm](http://www.geosociety.org/meetings/2002/students.htm)



Science at the Highest Level: Denver 2002 Annual Meeting & Exposition  
Colorado Convention Center © October 27–30, 2002

## HOW WILL YOU SPEND YOUR SAVINGS?

*Geological Society  
of America members  
can save on auto  
insurance with  
Group Savings Plus.<sup>®</sup>*



If you're not a member of our Group Savings Plus program, then you're not taking advantage of the group buying power of the Geological Society of America. So you could be paying too much for auto insurance. Just think what you could do with that extra money.

Call now and see just how much you can save. Then start spending your money on something a bit more exciting than auto insurance!

For a free coverage evaluation and no-obligation rate quote, please call **1.800.524.9400** or visit [www.libertymutual.com/lm/geologicalsoc](http://www.libertymutual.com/lm/geologicalsoc).

GROUP SAVINGS PLUS<sup>®</sup>

Discounts and credits are available where state laws and regulations allow, and may vary by state. Certain discounts apply to specific coverages only. To the extent permitted by law, applicants are individuals and households; not all applicants may qualify. Coverage provided and underwritten by Liberty Mutual Insurance Company and its affiliates, 375 Berkeley Street, Boston, MA. California Department of Insurance license number 0C046217. © 2002 Liberty Mutual Insurance Company. All Rights Reserved.

### Call for Applications: Apply for the GSA-USGS Congressional Science Fellowship for 2003-2004

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

The Congressional Science Fellow will be selected from top competitors early in 2003. Successful candidates are **GSA members** who possess either a: Ph.D. in the earth sciences (or a related field); or a Master's degree in the earth sciences (or a related field) with at least five years of professional experience.

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

Deadline to apply: January 24, 2003.

For application information, check our Web site at [www.geosociety.org/science/csf/](http://www.geosociety.org/science/csf/) or contact

Karlton Blythe, Program Officer, GSA Headquarters, (303) 357-1036, [kblythe@geosociety.org](mailto:kblythe@geosociety.org).

# Memorial Preprints Now Available

The following memorial preprints are now available, free of charge. To order, contact GSA Member Services by e-mail at [member@geosociety.org](mailto:member@geosociety.org), by phone at 1-888-443-4472, or (303) 447-2020, option 3, by fax at 303-357-1071, or by mail to P.O. Box 9140, Boulder, CO 80301-9140, USA. The annual *Memorials* volume for 2002 (v. 32) is available for purchase.

Glen F. Brown (1911-2001)  
*by John A. Reinemund*

Alexander Rankin Cameron (1927-2000)  
*by Russell R. Dutcher and William Spackman*

Freleigh Fitz Osborne (1903-2000)  
*by J.F.V. Riva*

Steven Hesse Harris (1924-2001)  
*by Wayne Harris*

Harold Lloyd James (1912-2000)  
*by Paul B. Barton*

Robert C. McDowell (1935-2000)  
*by Randall C. Orndorff*

I. Gregory Sohn (1911-2000)  
*by Ellis L. Yochelson*

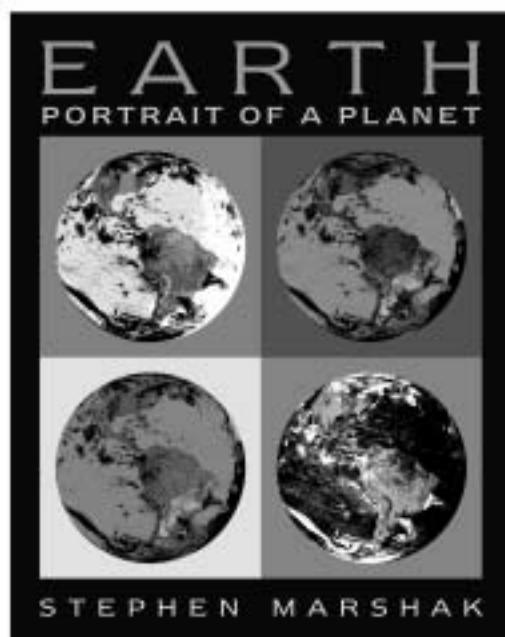
Paul Tasch (1910-2001)  
*by Daniel F. Merriam*

Marlies Teichmüller (1914-2000)  
*by Paul C. Lyons*

David J. Varnes (1919-2002)  
*by his friends at the U.S. Geological Survey,  
Denver, Colorado*

Charles J. Vitaliano (1910-2000)  
*by Donald E. Hattin*

Join the Revolution in Geology



# EARTH

PORTRAIT OF A PLANET

STEPHEN MARSHAK

Stephen Marshak's *Earth: Portrait of a Planet* has taken the Introductory Geology course by storm. Already in use at over 160 universities, colleges, and community colleges worldwide, *Earth* has become one of the market-leading texts in less than a year. A selection of the schools using *Earth* includes:

Arizona State University • Bates College • California State University, San Luis Obispo • Colorado State University • Front Range Community College • Georgia Southern University • Grand Valley State University • Kingsborough Community College • Lehigh University • Louisiana Tech University • Northern Colorado University • Penn State University • Prince George Community College • Rutgers University • State University of New York, Plattsburgh • Texas A&M University • Towson University • University of California, Davis • University of Florida • University of Michigan • University of Oregon • University of Wisconsin, Madison • University of Wyoming • Brock University • McGill University • University of Toronto

*"I loved it! I found it very complete and understandable."*

—James Woodhead, Occidental College

*"I was very happy with [Earth]. . . . I think the students liked it, too, because they were actually reading it."*

—Karl Leonard, Minnesota State University

W. W. Norton & Company, Inc.

wwnorton.com • (800) 233-4830

## GSA Announces

# 2002 Research Grant Recipients

The GSA Committee on Research Grants met at GSA headquarters in Boulder, Colorado, March 22, 2002, and awarded \$450,000 to 243 graduate students. Committee members for 2002 are John F. Bratton (chair), Daniel K. Holm, Marith Cady Reheis, Anne Raymond, Rodney V. Metcalf, Ward E. Sanford, Dennis R. Kolata, Barbara E. John, John A. Breyer, Bruce E. Broster, Janet S. Herman, Aiyun Zhang, Wanda J. Taylor, Claudia C. Johnson, Carol M. Tang, and Frank A. Corsetti. As in previous years, the committee was pleased with the high quality of the research proposals submitted to the GSA Research Grants Program.

### Student Awards

Grant proposals for 2002 numbered 557. The total number of awards, 243, was 44% of the applicant pool. The average request was \$2,535, an increase from \$2,457 in 2001. The average award this year was \$1,852, a decrease from \$1,882 last year.

The committee selected 20 alternate candidates in the event that any grantees return all or part of their funds due to a change in their research project or receipt of funds from another source.

The National Science Foundation's portion of the \$450,000 budget was \$150,000, and the GSA Foundation's portion was \$73,431, which included \$8,000 from the Research Fund, \$38,800 from the GEOSTAR and Unrestricted Funds, \$3,500 from the Lipman Research Fund, and \$2,381 from the Hydrogeology Division. The budget also included \$212,069 from the Penrose Endowment and Pardee Memorial, and \$7,300 from the Harold T. Stearns Award Fund, the Geophysics Division, the Sedimentary Geology Division, and the Structural Geology and Tectonics Division.

Recipients of student research grants awarded by GSA Divisions and Sections will be announced in an upcoming issue of *GSA Today*.

### Outstanding Mention

The committee has specially recog-

nized the following 28 proposals as being of exceptionally high merit in conception and presentation.

Andreas J. Andersson, University of Hawaii, "Calcification by Coccolithophorids as an Effect of pCO<sub>2</sub> and Nutrient Concentrations, Investigating the Effect Since the Last Glacial Maximum, Until Present and Extending into the Future."

Jason B. Barnes, University of Arizona, "Erosion Rates Determined by the In Situ Production of Cosmogenic <sup>14</sup>C in Quartz: A Case Study in the Central Andes, Bolivia."

Sid Carter, Stanford University, "Exploring the Strontium Isotopic Compositions of Geologic Sources of Ceramic Raw Materials in Northern Arizona as a Basis for Provenance Analysis of Cohonina and Anasazi Pottery."

Kevin Cooney, Columbia University, "Coral Paleorecords of El Niño During the Holocene."

Christian S. de Fontaine, Northern Arizona University, "Late Quaternary Distal Tephra in Lacustrine Sediments of the Upper Cook Inlet, Alaska: Implications for Magnetic Susceptibility, Sample-Site Selection, and Tephrochronology."

Eric Fossett, University of Nevada—Las Vegas, "Evidence and Implications of Holocene Faulting Along the Black Hills Fault, Southern Nevada."

Juan L. Gonzalez, University of Illinois at Chicago, "Reconstructing Natural Rates of Sea-Level Rise in the Western Mississippi Delta."

Tessa M. Hill, University of California at Santa Barbara, "Effects of Oceanic Disposal of Carbon Dioxide on Benthic Microfauna: Foraminifera as Indicators of Dissolution and Benthic Ecologic Change."

James M. Kaste, Dartmouth College, "Tracing Physical and Chemical Transport in Soils using <sup>241</sup>Am and <sup>137</sup>Cs."

Carrie A. Menold, University of California at Los Angeles, for "Metamorphism and Exhumation Mechanism of UHP Eclogites, North Qaidam, China."

Patrick J. Mickler, University of Texas at Austin, "Evaluation of Isotopic Equilibrium

During Precipitation of Modern Speleothem Calcite in a Tropical Setting."

Ian M. Miller, Yale University, "Paleofloral and Paleotemperature Tests for the Baja B.C. Hypothesis."

Irene C. Montero S., University of California at Berkeley, "Fast Hyperspectral Mapping and Evaluation of Environmental Problems Associated with Sulfide Oxidation at Abandoned Mines."

Mark C. Nabong, University of Michigan, "Isolation of Holocene Woolly Mammoths (*Mammuthus Primigenius*) on Wrangel Island: Evidence from Strontium Isotope Ratios."

Matthew Charles Peros, University of Toronto, "Late Holocene Environmental Change at Los Buchillones, A Coastal Archaeological Site in North Central Cuba."

Melissa A. Pfeffer, University of New Mexico, "Determination of Localized Chemistry and Atmospheric Impact of Volcanic Plumes."

Laurel E. Qualls, Syracuse University, "Isotopic Characterization of Syntectonic and Post-Tectonic Granites of the Anti-Atlas Orogen: Constraints on the Extent of the West African Craton."

Jeffrey M. Rahl, Yale University, "Does Pressure Solution Control the Location of the Brittle-Ductile Transition? A Case Study on the High-Pressure, Low-Temperature Metamorphic Rocks of Crete, Greece."

Carl A. Reese, Louisiana State University, "Pollen Dispersal and Deposition on Tropical Andean Ice Caps: Quelccaya (Peru) and Parinacota (Bolivia)."

Phillip G. Resor, Stanford University, "Deformation Associated with Continental Normal Faults, Western Grand Canyon, Arizona."

Ramya Sivaraj, Northwestern University, "Use of Stomatal Index of Fossil Plant Cuticles to Monitor Atmospheric CO<sub>2</sub> Changes During the Cenomanian-Turonian Oceanic Anoxic Event (OAE-II)."

Matthew D. Strine, University of Rochester, "Resolving Strain Patterns within a Major Salient-Recess Pair Along the Moine Thrust Zone, NW Scotland."

Alexandru M. Tomescu, Ohio University, "Earliest Evidence for Well-Developed Terrestrial Groundcover and Atmospheric Oxygen Levels that Could Support Wildfire."

John G. Van Hoesen, University of Nevada—Las Vegas, "Evaluating the Internal Structure, Ice Content, and Possible Genesis of Holocene Rock Glaciers Using Ground Penetrating Radar (GPR) in Great Basin National Park, Nevada."

Stephen F. Wathen, University of California at Davis, "A 10,000 Year History of Vegetation, Fire, and Geomorphology of an Upper Montane Watershed, Northern Sierra Nevada, California."

Andrew C. Wilcox, Colorado State University, "Velocity Structure, Turbulence, and Morphology of Steep Mountain Stream Channels."

Jane Kathryn Willenbring, Dalhousie University, "Determining Rates of Alpine Glacial Erosion Using Terrestrial In Situ Cosmogenic Be-10, Al-26, and Cl-36."

Paul H. Zehfuss, University of Washington, "Late-Holocene, Rapid Progradation of a Marine Delta and its Relation to Lahar Runout from Mount Rainier, Washington."

#### *Student Recipients of Special Awards in 2002*

The **Gretchen Louise Blechschmidt Award Fund** was established for women in the geological sciences who have an interest in achieving a Ph.D. in the fields of biostratigraphy and/or paleoceanography, sequence stratigraphy analysis, particularly in conjunction with research in deep-sea sedimentology, and a career in academic research. The 2002 recipient is Tessa M. Hill, University of California at Santa Barbara, for "Effects of Oceanic Disposal of Carbon Dioxide on Benthic Microfauna: Foraminifera as Indicators of Dissolution and Benthic Ecologic Change."

The **John T. Dillon Alaska Research Award** honors the memory of Dillon, who was particularly noted for his radiometric age-dating work in the Brooks Range, Alaska. Two areas which serve as guidelines for selection of the award are field-based studies dealing with the structural and tectonic development of Alaska, and studies which include some aspect of geochronology (either paleontologic or

radiometric) to provide new age control for significant rock units in Alaska. The recipient is Laura C. Kellogg, Bryn Mawr College, for "The Physical and Chemical Interactions of Plutons and Host Rock in the Coast Mountains Batholith."

The **Robert K. Fahnestock Award** honors the memory of Fahnestock, a former member of the Research Grants Committee, who died indirectly as a result of service on the committee. The grant is awarded for the best proposal in sediment transport or related aspects of fluvial geomorphology, Fahnestock's field. The 2002 recipient is Paul H. Zehfuss, University of Washington, for "Late-Holocene, Rapid Progradation of a Marine Delta and its Relation to Lahar Runout from Mount Rainier, Washington."

The **Lipman Research Fund** was established in 1993 and is supported by gifts from the Howard and Jean Lipman Foundation. The purpose of the fund is to promote and support student research grants in volcanology and petrology. The president of the Lipman Foundation, Peter W. Lipman, was the recipient of a GSA research grant in 1965. The committee presented the award to two candidates: Christian S. de Fontaine, Northern Arizona University, for "Late Quaternary Distal Tephra in Lacustrine Sediments of the Upper Cook Inlet, Alaska: Implications for Magnetic Susceptibility, Sample-Site Selection, and Tephrochronology," and Carrie A. Menold, University of California at Los Angeles, for "Metamorphism and Exhumation Mechanism of UHP Eclogites, North Qaidam, China."

The **Bruce L. "Biff" Reed Scholarship Fund** was established to provide research grants to graduate students pursuing studies in the tectonic and magmatic evolution of Alaska, primarily, and also can fund other geologic research. The 2002 recipient is Sara E. Bier, Pennsylvania State University, for "The Kahiltna Terrane: Evidence for Accretion of the Talkeetna Superterrane."

Family members of Alexander Sisson established a fund in his memory to promote and support research for students pursuing studies in Alaska and the Caribbean. The recipient of the **Alexander Sisson Research Award** is Matthew Charles Peros, University of Toronto, for "Late Holocene Environmental Change at Los Buchillones, a Coastal Archaeological Site in North Central Cuba."

Harold T. Stearns established the **Harold T. Stearns Fellowship Award** in 1973 for student research on aspects of the geology of the Pacific Islands and the Circum-Pacific region. The committee presented the award to two candidates: Nathan D. Sheldon, University of Oregon, for "A Paleosol-Based Quaternary Climate Record from the Hawaiian Scientific Drilling Program Core," and Kevin Cooney, Columbia University, for "Coral Paleorecords of El Niño During the Holocene."

The **John Montagne Fund** was established in 2000 to support one recipient's research in the Quaternary-geomorphology field. The 2002 recipient is Jane Kathryn Willenbring, Dalhousie University, for "Determining Rates of Alpine Glacial Erosion Using Terrestrial In Situ Cosmogenic Be-10, Al-26 and Cl-36."

The **Alexander and Geraldine Wanek Fund** was established in 2002 to support research dealing with coal and petroleum resources, mapping, and engineering geology, marine resources, petroleum economics, appraisal, and evaluation, and the geology of phosphate resources. There were two recipients in 2002: Michael R. Bruemmer, Wichita State University, for "Processes Controlling the Stratigraphic Architecture of Nonmarine and Marine Mixed Siliciclastic and Carbonate Oread Cyclothem (Upper Pennsylvanian), SE Kansas and NE Oklahoma," and Allyson K. Anderson, University of Kansas, for "Hyperspectral Remote Sensing of Hydrocarbon and Brine Seepage in Hutchinson, Kansas."

The **Charles A. and June R.P. Ross Research Fund** was established in 2002 to support research in the fields of biostratigraphy, stratigraphy and stratigraphic correlation, paleogeography and paleobiogeography, interpreting past environments of deposition and their biological significance, and the integration of these research areas into better global understanding of (1) past plate motions (plate tectonics and seafloor spreading), (2) past sea-level events, including their identification and ages, and/or (3) climate changes and effects of those climate changes on Earth's inhabitants through geologic time. The 2002 recipient is Ian M. Miller, Yale University, for

*continued on page 22*

continued from page 21

"Paleofloral and Paleotemperature Tests for the Baja B.C. Hypothesis."

**Other Applicants Recommended for**

**Funding:** Markus Albertz, Jessica Allen, Helge Alsleben, Darlene Anthony, Edwin Apel, Brooke Asbury, James Ashby, Kerry Ayers, Allison Bair, Nicholas Balascio, Jeff Bandow, Wendy Barrow, Sean Bemis, Melody Bergeron, Melissa Berke, Lauren Bierly, Jessica Black, Anand Boice, Ninad Bondre, Melissa Boysun, Christopher Breeding, Jordon Bright, David Broughton, David Buck, Noel Bush, Christina Calvin, Matthew Campbell, Henrietta Cathey, Zhaoshan Chang, Jay Chennault, Jennifer Cole, Joseph Colgan, Tim Cope, Dan Core, Moise Coulombe-Pontbriand, Ronald Conts, John Crockett, Brent Dalzell, Brian Darby, Vionette De Choudens, Stephen Delong, Stephen Deoreo, Stephen Devogel, Margaret Dodds, Anna Draa, Peter Druschke, Gita Dunhill, Guillaume Dupont-Nivet, Alison Duvall, Mason Dykstra, Melissa Edwards, Emily Elliott, Joseph English, Lawrence Febo, Craig Finnigan, Rebecca Flowers, Amy Gaffney, Beatriz Garcia-Fresca, Christofer Garvin, Michael Giallorenzo, Scott Giorgis, Mary Good, Kelly Greaser, William Griffith, Leah Gruhn, Melissa Haddad, Paul Hanson, Ulysses Hargrove, Melissa Harper, Jerry Harris, Marylea Hart, Russell Hatlaub, Christopher Heiny, Pamela Hill, Sarah Hill, Gregory Hoke, Kimberly Hoke, Camille Holmgren, Benjamin Hooks, Travis Horton, Michael Hsieh, Timothy Huff, John Huntley, Scott Hynek, Luke Jensen, Alexis Johnson, Kathleen Johnson, Neil Jones, Thomas Jones, Taylor Joyal, Christopher Junium,

## *Cole Awards for Postdoctoral Research:* **Gladys W. Cole and W. Storrs Cole Memorial Research Awards Announced**

GSA Foundation funded the 2002 Cole Awards at \$9,500 from the Gladys W. Cole Fund for research in geomorphology of semiarid and arid terrains, and \$8,700 from the W. Storrs Cole Fund for research in invertebrate micropaleontology.

The Gladys W. Cole Memorial Research Award recipient is Cassandra Rose Fenton, University of Utah, for her project "Age-Dating of Quaternary Climate Changes Preserved in Fluvial and Alluvial Deposits in the Colorado River Basin, Southwestern USA." The W. Storrs Cole Memorial Research Award recipient is John R. Groves, University of Northern Iowa, for his project "Evolution or Extinction of Lagenoid Foraminifera during the end-Permian Mass Extinction."

Keena Kareem, Robyn Kelly, Chris Kelson, Ben Kennedy, Brian Kirchner, James Klaus, Joseph Kopera, Marloes Kortekaas, Greta Kristjansdottir, Benjamin Laabs, Jade Star Lackey, France Lagroix, William Lambert, Elizabeth Langenburg, Jason Lederer, Andrew Leier, Jerome-Etienne Lesemann, Dave Lewis, Jeffrey Lewis, Ted Lewis, F. Lo Re, Steven Loheide, Ramon Lopez Perez, Nathaniel Lorentz, Jared Lubben, Sara Lubkin, Zachary Lundeen, Jillian Lynch, Andrew Maas, Kevin Mahan, Nancy Mahlen, Lori Manship, Pedro Marengo, Amanda Mayes, Joyce McBeth, Lindsay McHenry, Jennifer McIntosh, Alexander McKenzie-Johnson, Calla McNamee, Erwin Melis, Joseph Michalski, Kristin Miller, Scott Miller, Vernon Moore, Ryan Morelli, Ron Morris, Christopher Moses, Ryan Murphy, Elisabeth Nadin, Lynde Nanson, Stephen Nathan, Alexis Navarre, Brian Nicklen, Eric Ober, Paul Petersen, Gary Petro, Charity Phillips, Jeff Pigati, Christa Placzek, Aaron Potito, James Powell,

Lauren Powell, Jason Raucci, Jason Reed, Alberto Reyes, Bethany Rinard, Elizabeth Robertson, Elizabeth Roller, Tara Root, Lanya Ross, Amanda Rowe, Joel Rowland, Juan Ruiz Parraga, Morgan Salisbury, Karen Samonds, Amos Sanders, Claudia Sartini-Rideout, Chris Schneider, David Shields, Sarah Shoemaker, Heather Short, Renee-Luce Simard, Chris Simpson, Michael Smith, Darin Snyder, Colleen Stapleton, Lauren Steely, Ellen Stein, James Stevenson, William Sullivan, David Szymanski, Benjamin Tanner, Nicole Tardif, Stephanie Tassier-Surine, Rebecca Tedford, Karen Tefend, Iulia Tomescu, Jaime Toney, Amy Townsend-Small, David Tucker, Allison Tumarkin, Julie Turrentine, David Vacco, Gregory Ventura, Pieter Vermeesch, Adrian Villegas-Jimenez, Ela Viray, Karen Waggoner, Suzanne Walther, Shizuko Watanabe, Andrew Alexander Webb, Amy Weislogel, Karah Wertz, Robin Whatley, Ian White, David Young, Ziming Yue, Tracy Zayac, and Aubrey Zerkle.

## **Earth Science Week is October 13–19**

Increasing public understanding and appreciation of the earth sciences is of critical importance to our nation and to the geoscience profession. Since its inception in October 1998, Earth Science Week has been celebrated annually in every state and several countries. Through these activities, thousands of scientists, educators, and youth leaders have reached millions of students and individuals. The American Geological Institute (AGI) is the national coordinator and sponsor of Earth Science Week efforts. This year's theme is "Water Is All Around You." Visit AGI's Web site at [www.earthscienceworld.org/week/](http://www.earthscienceworld.org/week/) for the latest news and information about Earth Science Week.

### **What is GSA doing for Earth Science Week?**

In celebration of Earth Science Week, GSA and Recreation Equipment Incorporated (REI), will again co-host "Adventure Geology—Celebrating the Earth" presentations during Earth Science Week, October 13–19. They will be held at the REI Flagship Store Auditorium, 1416 Platte St., Denver, Colorado, and are free and open to the public. Geoscientists will give presentations on topics in geology, water resources, and climate. See the GSA Earth Science Week Web site for details about the presentations at [www.geosociety.org/educate/earthweek.htm](http://www.geosociety.org/educate/earthweek.htm), or contact Julie Sexton, [jsexton@geosociety.org](mailto:jsexton@geosociety.org).

What are you and your community doing for Earth Science Week? We want to know. Send a description of your activities and events to Julie Sexton, [jsexton@geosociety.org](mailto:jsexton@geosociety.org).

# GSA EMPLOYMENT SERVICE

NOW ONLINE

## **JOB SEEKERS: Let employers know what you have to offer!**

You can now post your profile on the GSA Web site and receive international exposure. Employers looking for candidates that match your qualifications can view your information, and can contact you directly to express interest. You may register at any time throughout the year, and you can add to or revise your profile as long as your registration is current. A one-year listing for GSA Members and Associates in good standing is \$35; for nonmembers the cost is \$65. To register, go to [www.geosociety.org/profdev/empsvc1.htm](http://www.geosociety.org/profdev/empsvc1.htm). Let GSA help you find the right job!

## **EMPLOYERS: Find the perfect match for your position.**

You can save time and resources in your search for qualified employees throughout the year by using GSA's database of job-seeking geoscientists. Complete the Employer's Request for Earth Science Applicants form on the GSA Web site at [www.geosociety.org/profdev/ems\\_emp.htm](http://www.geosociety.org/profdev/ems_emp.htm). Specify educational and professional experience requirements as well as the area or areas of expertise your applicant should have.

You'll be able to access and print the online profiles of matching candidates, complete with information on areas of specialty, type of employment desired, degrees held, years of professional experience, publications, and current employment status. The cost of access to applicants in one or two geoscience fields is \$175. Each additional field selected is \$50. Access to the entire applicant database is available for \$350. It is solely the employer's decision to contact applicants who interest them; GSA does not notify applicants of matches. Employers using the matching service are invited, at no additional cost, to have their position announcement posted for three months on the GSA Web site.

## **Employment Interview Service at the Annual Meeting**

Take advantage of GSA's Employment Interview Service, which is conducted each fall in conjunction with the Society's Annual Meeting. The on-site service traditionally brings more than 200 applicants together with 50 or so employers for face-to-face interviews. Mark your calendar now for the on-site interview service at the GSA Annual Meeting, in Denver, Colorado. Interviews will be conducted Sunday, October 27, through Tuesday, October 29; interview scheduling will start on a first-come, first-served basis at noon on Saturday, October 26, and will continue through Tuesday.

**APPLICANTS:** The earlier you register with the service, the more time employers will have to find your profile online. Indicate on your profile that you would like to interview in Denver. Employers also will have onsite access to your information and profile. Even if you decide to take part at the last minute, you can register with the service on-site and schedule interviews.

**EMPLOYERS:** When you rent interview space at GSA's Annual Meeting, our staff will schedule interviews for you. Plus, you'll have access to the entire applicant database and profiles, a message center, ongoing posting of job openings, on-site applicant registration and profile updating, and photocopying services. Space is rented in half-day increments. Or, you can forego the interview booth, but use all the other services with the Message Center Only option. We offer flexibility and service—it's your choice!

More information and forms are posted in the Employment Opportunities section of the GSA Web site at [www.geosociety.org](http://www.geosociety.org). Or, contact Nancy Williams, Director of Member Services, Geological Society of America, P.O. Box 9140, Boulder, CO 80301-9140, (303) 357-1017, [nwilliams@geosociety.org](mailto:nwilliams@geosociety.org).

The Geological Society of America  
**Science at the Highest Level**  
*DENVER 2002*  
Time is running out to register online for this year's meeting, and events are filling fast!  
**Are You Registered?**  
Preregistration deadline: Friday, September 20  
Online registration deadline: Wednesday, October 9  
SUBARU  
The Sponsor of the 2002 GSA Annual Meeting  
View this year's exciting schedule of events at [www.geosociety.org](http://www.geosociety.org).

# ANNOUNCEMENTS

## 2003

- March 27–April 2      Second Conference on Salt Water Intrusion in Coastal Aquifers: Monitoring, Modeling and Management, Merida, Yucatan, Mexico. Information: [www.igeofcu.unam.mx/swica2/](http://www.igeofcu.unam.mx/swica2/).
- April 27–30            Eleventh Williston Basin Horizontal Well and Petroleum Conference, Regina, Saskatchewan, Canada. Information: Vivian Barkman, Saskatchewan Industry and Resources, 2101 Scarth Street (8th Floor), Regina, Saskatchewan, Canada S4P 3V7; (306) 787-7662, fax 306-787-2333, [vbarkman@ir.gov.sk.ca](mailto:vbarkman@ir.gov.sk.ca), [www.gov.sk.ca/enermine/about/semnew.htm](http://www.gov.sk.ca/enermine/about/semnew.htm).
- June 1–5                22nd World Gas Conference Tokyo 2003, Tokyo. Information: Mika Iseki, National Organizing Committee, Tokyo, 81-3-3502-0620, [mika.iseki@wgc2003.gr.jp](mailto:mika.iseki@wgc2003.gr.jp), [www.wgc2003.com](http://www.wgc2003.com).
- September 22–26      7th International Conference on Gas Geochemistry, Freiberg, Germany. Information: [www.copernicus.org/ICGG7](http://www.copernicus.org/ICGG7) or Jens Heinicke, phone and fax +49-3731-392212; [heinicke@physik.tu-freiberg.de](mailto:heinicke@physik.tu-freiberg.de).
- September 24–27      Structures of Continental Crust and Geothermal Resources, Siena University, Italy. Information: [www.unisi.it/eventi/geothermics](http://www.unisi.it/eventi/geothermics).

## 2004

- April 13–17            Fifth International Conference on Case Histories in Geotechnical Engineering, New York, New York, USA. Information: Shamsheer Prakash, Conference Chairman, University of Missouri—Rolla, (573) 341-4489, fax 573-341-4729, [prakash@umt.edu](mailto:prakash@umt.edu), [www.umr.edu/~eqconf/5thCHConf](http://www.umr.edu/~eqconf/5thCHConf). (*Abstracts deadline: November 15, 2002.*)
- June 27–July 2        11th International Symposium on Water-Rock Interaction, Saratoga Springs, New York. Information: Barbara Impellitteri, Pennsylvania State University, 118 Keller Building, University Park, PA 16802-1308, (814) 865-4591, [www.outreach.psu.edu/C&I/WRI/](http://www.outreach.psu.edu/C&I/WRI/).

## You Are Invited: Golden Celebration of Geologic Excellence

In honor of GSA Fellows **Lauren Wright** and **Bennie Troxel**, friends and colleagues have organized a “Golden Celebration of Cooperative Geologic Research,” to be held Saturday, November 9, 2002, in Shoshone, California (Death Valley).

### Schedule of Events:

- 9 a.m.–3 p.m.      Field Trip to the Amargosa Chaos, Death Valley, led by Lauren Wright and Bennie Troxel. Free; carpooling suggested to reduce traffic.
- 4–5:30 p.m.        Happy Hour at the Crowbar
- 5:30–7 p.m.        Dinner
- 7–8:30 p.m.        Speeches and Awards

To register for dinner and the awards ceremony, please call Michael Sorrells, (760) 852-4224. Due to the large number of people expected to attend the dinner, the organizers will not be able to plan for those with special dietary needs. However, the regular menu at the Red Buggy Café in Shoshone will be available as usual.

Again, due to the large number of people expected to attend, the organizers leave the lodging reservations to you. Some choices: Shoshone Inn, (760) 852-4335; Amargosa Hotel, (760) 852-4441 (in Death Valley Junction, Calif., approximately 30 minutes north of Shoshone); Furnace Creek Ranch, (760) 786-2345 (in Death Valley National Park, approximately one hour north of Shoshone); Tecopa Cabana (formerly Delight’s Hot Spa), (760) 852-4343 (in Tecopa, Calif., approx. 15 minutes south of Shoshone); Best Western Pahrump Station, (775) 727-5100 (in Pahrump, Nev., approximately 30 minutes east of Shoshone); and Saddle West, (775) 727-1111 (in Pahrump, Nev.).

Questions about the event? Please contact Jim Calzia, (650) 329-5538, [jcalzia@usgs.gov](mailto:jcalzia@usgs.gov).

## About People

On July 1, 2002, GSA member **Glenn Roquemore** was appointed president of Irvine Valley College in Irvine, California.



## 2002–2003 Congressional Science Fellow Appointed

Raphael Sagarin has been appointed as the GSA–U.S. Geological Survey Congressional Science Fellow for 2002–2003. Sagarin earned a B.S. in earth systems from Stanford University in 1994. He was drawn to the earth systems program because it seeks to break down academic barriers between the traditionally disparate fields of biology, earth sciences, economics, and public policy. Accordingly, Sagarin's research is broadly focused and he has continually worked to highlight the links between his scientific work and conservation policy.

As an undergraduate, Sagarin attended Stanford University's Washington, D.C., program where he studied Endangered Species Act law and interned at the Wilderness Society. While in Washington, he realized that he could be a more credible and effective advocate for conservation if he had a solid scientific background. Thus, Sagarin enrolled in the Ph.D. program in the Department of Ecology, Evolution, and Marine Biology at the University of California, Santa Barbara, earning his degree in 2001. His dissertation work focused on documenting responses of coastal marine communities to climate warming using historical and observational techniques. Sagarin's research took him to the shores of Chile and the Pacific coast of North America from Baja California, Mexico, to southern Alaska.

More recently, Sagarin has analyzed long-term records of the timing of annual natural events such as ice thaw and bird migrations as a method of documenting natural systems' responses to climate change. In this work, he has stressed the importance of non-traditional data sets, such as amateur observations, merchant ship logs, and even gambling contest records in linking pre-twenty-first century climate change to changes in other components of the earth system. Sagarin is also a participant in an interdisciplinary collaboration with Mexican scientists and resource managers to study the successes and failures of small-scale fisheries in maintaining resource and ecosystem integrity along the Pacific coast of Mexico. In spring 2002, Sagarin designed and taught undergraduate courses on the science and politics of global environmental problems for California State University Monterey Bay.

Sagarin considers it a great honor to be selected as a congressional science fellow and is excited to return to Washington, D.C., with the perspective of a scientist. He looks forward to working with past and present fellows to help bolster the role of earth science in policy decisions. He is especially interested in working on climate change and energy issues as well as fisheries conservation. He also hopes to use his participation in GSA meetings and activities to highlight the connections between the geological and ecological sciences.

For information  
on the Call for Applications  
for the 2003–2004  
GSA–USGS Congressional Science Fellowship,  
see page 18.



**DISCOVER** an actual  
**60** MILLION  
YEAR OLD **FISH**

**ULRICH'S  
FOSSIL  
GALLERY**

Student  
Fossil  
Preparation  
Kits  
Quality  
Grade "A" Kits  
**\$21.50**  
(6 or more,  
\$15.50 each;  
plus shipping  
and handling)

Fossil Station #308  
Kemmerer, WY 83101  
PH (307) 877-6466  
FAX (307) 877-3289

For the Earth  
Science-Minded  
Student

**Hey!**  
**You**  
**There.**

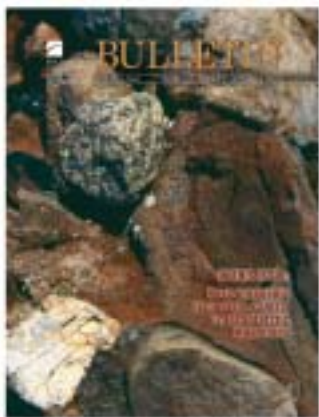
*Did you know that...*  
**ADS GET RESULTS?**

Display ad rates are available by  
calling GSA Today advertising,  
1-800-472-1988, ext. 1053  
or, go to [www.geosociety.org](http://www.geosociety.org).  
Go to Publications, then Advertising.

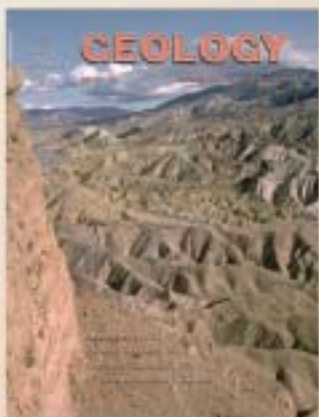
**Thank you!** GSA Foundation would like to thank you, the membership of GSA, for your past support and ask that you please consider a gift to the Foundation as you renew your membership. If you would like to see how donations were used this year, visit the Foundation Web site, [www.geosociety.org/gsaf/](http://www.geosociety.org/gsaf/).

**For more Foundation news, see page 13.**

# Journal Highlights



In September *GSA Bulletin*  
Ross orogenic tectonism, central  
Transantarctic Mountains



In September *Geology*  
Mantle traps  
Elevated bubbles  
One-slice Sandwich  
P-T bang or whimper



THE GEOLOGICAL SOCIETY  
OF AMERICA

To subscribe, contact [member@geosociety.org](mailto:member@geosociety.org)  
1-888-443-4472, or (303) 447-2020.  
Visit our online journals at [www.gsa-journals.org](http://www.gsa-journals.org).

## GSA THANKS LONG-TIME MEMBERS

GSA is fortunate to have among its ranks many long-term members who have served their Society with a remarkable level of dedication. GSA proudly honors the following members and fellows who reached the 50-year mark in their membership in 2002.

### 50-YEAR MEMBERS

John W. Blagbrough  
H. Richard Blank Jr.  
Jess R. Bushman  
William L. Duggan  
G. Sidney Fox  
John R. Gealy  
James J. Geraghty  
David Graham Hardy  
Elbert Nelson Harshman  
Lummie C. Lovely Jr.  
Willis H. Nelson  
Richard B. Palmer  
John D. Vogel  
James E. Werner  
Frederick P. Young Jr.

### 50-YEAR FELLOWS

J. Kaspar Arbenz  
Daniel D. Arden Jr.  
William C. Bradley  
Daniel J. Brennan  
James E. Brooks  
Anton J. Budding  
C. Wayne Burnham  
John Frederick Burst Jr.  
John V. Byrne  
Robert O. Castle  
William A. Cobban  
Arthur L. Cochrum  
Earle R. Cressman  
Robert E. Davis  
Frank W. Dickson  
Henry James Dorman  
Robert H. Dott Jr.  
John Thomas Dutro Jr.  
Donald P. Elston  
Kenneth J. Englund  
Warren I. Finch  
James H. Fisher  
Robert L. Fisher  
Gordon A. Gross  
John D. Haun  
Hugh Hay-Roe  
Edgar Neal Hinrichs  
John H. Hoke  
Fred T. Holden  
Heinrich D. Holland  
Clifford A. Hopson  
Benjamin F. Howell Jr.  
Vernon J. Hurst  
Robert B. Johnson

William R. Judd  
Henry E. Kane  
Douglas M. Kinney  
Robert P. Kunkel  
Edwin R. Landis  
Rufus J. LeBlanc  
Stanley J. Luft  
David B. MacKenzie  
Harold E. Malde  
Wayne D. Martin  
James G. Moore  
Ernest H. Muller  
John F. Murphy  
Donald R. Nichols  
William A. Oliver Jr.  
Franklin Howard Olmsted  
Richard H. Olson  
Carel Otte  
Eldon Joseph Parizek  
Elmer D. Patterson  
David A. Phoenix  
William H. Poole  
Claude M. Quigley Jr.  
John R. Rand  
John E. Reesor  
Rolland R. Reid  
Robert W. Rex  
Ralph J. Roberts  
G.D. Robinson  
Nathaniel McLean Sage Jr.  
Melvin C. Schroeder  
Zane Spiegel  
Harold K. Stager  
Colin W. Stearn  
Richard G. Stearns  
Takeo Susuki  
Atholl Sutherland-Brown  
Richard L. Threet  
William H. Tonking  
Priestley Toulmin  
Joshua I. Tracey Jr.  
Alfred Traverse  
Sherwood D. Tuttle  
Robert H. Weber  
Paul L. Weis  
David Archer White  
Harry B. Whittington  
George Arthur Williams  
James E. Wilson  
M. Gordon Wolman  
Keith P. Young



THE  
GEOLOGICAL  
SOCIETY  
OF AMERICA

Ads (or cancellations) must reach the GSA Advertising office one month prior. Contact Advertising Department, (303) 357-1053, 1-800-472-1988, ext. 1053, fax 303-357-1073, [acrawford@geosociety.org](mailto:acrawford@geosociety.org). Please include address, phone number, and e-mail address with all correspondence.

Classification	Per Line for 1st month	Per line each add'l month (same ad)
Situations Wanted . . . . .	\$.25	\$1.90
Positions Open . . . . .	\$.70	\$6.00
Consultants . . . . .	\$.70	\$6.00
Services & Supplies . . . . .	\$.70	\$6.00
Opportunities for Students		
first 25 lines . . . . .	\$.00	\$2.85
additional lines . . . . .	\$.185	\$2.85
Web Only Ads . . . . .	\$.70	\$6.00
live link: add \$25		

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.

## Situations Wanted

Ph.D. in geology/paleontology w/ 5+ years exper in science research, oil industry, grad & undergrad teaching. Field experience in W. America, Europe, Greenland. Bilingual, published. Want to again be a geologist in USA. Willing to relocate. Contact @ (352) 278-3481.

## Positions Open

### LECTURER POSITIONS INDIANA UNIVERSITY PURDUE UNIVERSITY INDIANAPOLIS

The Department of Geology at Indiana University Purdue University Indianapolis (IUPUI) has an opening for a full-time, non tenure-track, lecturer position. This appointment is renewable yearly subject to performance and funding and includes promotion opportunities.

The Department seeks a highly qualified candidate who has a strong commitment to excellence in teaching geology and to undergraduate education. Candidates should have a Ph.D. in geology, a record of high quality teaching at the introductory/undergraduate levels, and have the ability and interest to work with a diverse student population. Responsibilities include teaching 4 sections each semester and service to the Department. Salary level will be commensurate with degree and prior teaching experience.

Application materials must include the following: a letter of application, curriculum vitae, at least three letters of recommendation addressing the candidates teaching qualifications, a statement on teaching philosophy, graduate transcripts where appropriate, and any other materials that document teaching experience and effectiveness, including recent teaching evaluations. We will begin to review applications on November 1, 2002, but will continue to accept applications until the position has been filled. All applications should be mailed to: Lecturer Search Committee, Department of Geology, IUPUI, 723 W Michigan St. SL 118, Indianapolis, IN 46202-5132.

IUPUI is an Equal Opportunity/Affirmative Action Employer and strongly encourages applications from women and underrepresented minorities. Additional information about the university and the Geology Department is available at [www.iupui.edu](http://www.iupui.edu) and [www.geology.iupui.edu](http://www.geology.iupui.edu), respectively.

### GEOLOGY ASSISTANT PROFESSOR

The Department of Environmental Science and Geology at Mary Washington College seeks applications for a full-time, tenure-track position, at the rank of Assistant Professor, to begin in the fall of the 2003-2004 academic year. Ph.D. required. The Department seeks an individual with expertise in the area of surficial processes or sedimentary geology. In addition to introductory physical and historical geology courses, the successful candidate will teach a class in sedimentation and stratigraphy and a course in environmental geology. The candidate may also develop a course in his or her area of expertise. Mary Washington College is a highly selective public undergraduate liberal arts college that stresses teaching excellence and fosters opportunities for undergraduate research. The Department is housed in the new Jepson Science Center, which possesses modern labs and extensive networked computer



**DEAN**  
**COLLEGE OF MATHEMATICAL  
AND PHYSICAL SCIENCES**

The Ohio State University invites nominations and applications for the position of Dean of the College of Mathematical and Physical Sciences. The Dean will have a solid base on which to build increased national and international standing and, as the College's Chief Executive Officer, will report directly to the Executive Vice President and Provost of the University.

The University has implemented an Academic Plan to enhance academic excellence and to raise the standards of colleges, departments, centers, and institutes. The University is strongly committed to diversity, a cornerstone of the Academic Plan, and seeks an individual with a strong commitment to success in this area.

Qualifications for the position include a distinguished record in research and teaching plus demonstrated leadership and administrative ability. Candidates must qualify for a tenured appointment as Professor in one of the departments in the College. The College includes six departments: Astronomy, Chemistry, Geological Sciences, Mathematics, Physics, and Statistics, in addition to several cross-disciplinary degree programs, research centers, and institutes. The College has a faculty of 225 and an annual budget of \$80 million.

The position is available July 1, 2003. Salary and other considerations will be competitive and consistent with the University's commitment to recruiting the best-qualified individual. **To assure full consideration, applications and nominations should be received by October 15, 2002.** The Search Committee will begin screening dossiers on that date and will continue to receive applications until the Dean is selected.

Applications and nominations should be addressed to:

**Chairperson, MAPS Dean Search Committee, Office of Academic Affairs,  
The Ohio State University, 203 Bricker Hall, 190 North Oval Mall,  
Columbus, OH 43210-1358**

Website for the Search: <http://www.mps.ohio-state.edu/deansearch>.  
For further information, contact Molly Davis, Office of Academic Affairs, at  
614/292-5881 or at [Davis.436@osu.edu](mailto:Davis.436@osu.edu).

The Ohio State University is an Equal Opportunity/Affirmative Action Employer. Women, minorities, veterans, and individuals with disabilities are encouraged to apply.

facilities. Further information about the College and Department may be found at <http://www.mwc.edu>.

Applicants should send a one-page letter of application, statements of teaching and research interests, detailed c.v., undergraduate and graduate transcripts, and the names and addresses of three references to the Chair of the Search Committee, Department of Environmental Science and Geology, Mary Washington College, 1301 College Avenue, Fredericksburg, VA 22401-5258. Deadline for receipt of applications is October 15, 2002, by 5:00 p.m. Postmarks will not be honored. In a continuing effort to enrich its academic environment and provide equal educational and employment opportunities, Mary Washington College encourages women and minorities to apply.

### UNIVERSITY OF WASHINGTON, TACOMA ASSISTANT PROFESSOR IN ENVIRONMENTAL GEOSCIENCE

Interdisciplinary Arts and Sciences at the University of Washington, Tacoma (UWT) seeks a geologist to teach upper-division undergraduate courses to majors and non-majors within an interdisciplinary framework. The successful candidate will contribute to the development of the new and expanding environmental science/studies curriculum and will have ample opportunities to create innovative interdisciplinary courses, including field courses. Applicants should consider teaching, institution building, and research high priorities. This tenure track faculty position begins 16 September 2003, and requires a Ph.D. by the time of appointment.

The successful candidate will enhance the present environmental science curriculum by teaching and performing research in riverine, estuarine, marine or watershed geologic systems/processes and teaching specific courses in environmental geology, sedimentology, geomorphology, and Pacific Northwest field geology, as well as electives in such areas as biogeochemistry, hydrogeology, soil science, paleontology, geophysics or other specialties. GIS experience is a plus. Facilities for teaching and research at UWT include a new science building, proximity to the Water Resources Division of USGS,

access to several University of Washington vessels and field facilities, and potential collaborations at the University of Washington Seattle campus, 35 miles to the north.

One of three University of Washington campuses, UWT offers upper-division and graduate education to students of a wide variety of ages and backgrounds in the South Puget Sound region. Founded in 1990, the non-residential campus is located in new facilities in downtown Tacoma and is growing steadily. For a more complete description of this position and UWT visit our website at: <http://www.tacoma.washington.edu/ias>.

Screening of applications will begin 1 October 2002 and will continue until the position is filled. Send a letter describing your interests in and qualifications for this position, including a description of your teaching philosophy and research interests, a curriculum vitae, three letters of reference, syllabi or a description of courses you would like to teach in our program and evidence of teaching effectiveness to: University of Washington, Tacoma, Finance and Administration, Geology Position, 1900 Commerce St., Box 358431, Tacoma, WA 98402-3100. Electronic application materials may be sent to: [janruttle@u.washington.edu](mailto:janruttle@u.washington.edu). Specific inquiries may be directed by e-mail to Dr. Cheryl Greengrove at [cgreen@u.washington.edu](mailto:cgreen@u.washington.edu).

The University of Washington does not discriminate on the basis of race, color, creed, religion, national origin, gender, sexual orientation, age, marital status, disability or status as a disabled veteran or Vietnam Era veteran. The University of Washington is an equal opportunity, affirmative action employer.

### GEOCHEMISTRY POSITION FACULTY OPENING

**UNIVERSITY OF OREGON—GEOCHEMISTRY**  
The Department of Geological Sciences invites applications for a faculty position to begin in fall 2003. While it is likely that the position will be filled at the assistant professor level, exceptional applicants may be considered at the associate professor level. We seek an individual who applies light stable isotopic, trace element, or other inor-

# WANTED

Interested in  
purchasing technical  
and geological  
databases, libraries,  
and personal files  
as they pertain to  
COAL and COALBED  
METHANE.

Send responses to  
R.G.L.  
PO Box 1947  
Addison, Texas 75001

organic geochemical techniques to the study of chemical processes on the Earth's surface or within the Earth's crust or hydrosphere.

The successful candidate will be expected to establish a laboratory appropriate for her or his research focus, develop an externally funded, academically oriented research program, and contribute to teaching at both the undergraduate and graduate levels.

Completion of the Ph.D. is required and postdoctoral research experience is desirable. Applicants should send a curriculum vitae, statements of teaching and research interests, and the names, postal and email addresses, and telephone numbers of three referees to Geochemistry Search Committee, Department of Geological Sciences, 1272 University of Oregon, Eugene, OR 97403-1272. We will begin reviewing completed applications November 15, 2002, and will continue until the position is filled.

The University of Oregon is an equal opportunity/affirmative action institution committed to cultural diversity and compliance with the Americans with Disabilities Act.

## COLBY COLLEGE

### SABBATICAL YEAR REPLACEMENT

The Department of Geology invites applications for a one-year sabbatical replacement position (Faculty Fellow) beginning September 2003. The successful applicant will be expected to teach four undergraduate courses including Structural Geology, Introductory Environmental Geology, a January Program course in Natural Hazards, and a course of his/her choice that will complement other departmental course offerings. A Ph.D. with teaching experience at time of employment is preferred, but ABDs are encouraged to apply. Colby is a highly selective liberal arts college recognized for excellence in undergraduate education and for close student-faculty interaction. Applicants should submit a letter of application, curriculum vitae, a statement of teaching and research interests, and the names and contact information (including e-mail addresses) for three referees. All materials should be sent to: Dr. Robert A. Gastaldo, Chair, Department of Geology, 5807 Mayflower Hill Drive, Waterville, ME 04901. Review of applications will begin on 1 November 2002 and will continue until the position is filled. Interviews will be available at GSA in Denver. Colby College is an Equal Opportunity/Affirmative Action employer. Applications and nominations of women and minorities who would enrich the diversity of the campus community are strongly encouraged. For more information about the College, please visit the Colby web site: [www.colby.edu](http://www.colby.edu).

## COLBY COLLEGE

### ONE-SEMESTER REPLACEMENT

The Department of Geology invites applications for a one-semester replacement position for fall 2003 commencing September 2003. The successful applicant will be expected to teach three undergraduate courses including

Introductory Physical Geology, Geomorphology, and a course of his/her choice that will complement other departmental course offerings. A Ph.D. or ABD with teaching experience at time of employment is preferred. Colby is a highly selective liberal arts college recognized for excellence in undergraduate education and for close student-faculty interaction. Applicants should submit a letter of application, curriculum vitae, a statement of teaching interests and experience, and names and contact information (including e-mail addresses) for three referees. All materials should be sent to: Dr. Robert A. Gastaldo, Chair, Department of Geology, 5807 Mayflower Hill Drive, Waterville, ME 04901. Review of applications will begin on 6 January 2003 and will continue until the position is filled. Colby College is an Equal Opportunity/Affirmative Action employer. Applications and nominations of women and minorities who would enrich the diversity of the campus community are strongly encouraged. For more information about the College, please visit the Colby web site: [www.colby.edu](http://www.colby.edu).

## FACULTY POSITION ENVIRONMENTAL GEOCHEMISTRY UNIVERSITY AT BUFFALO THE STATE UNIVERSITY OF NEW YORK

The Department of Geology invites applications for a tenure-track faculty position in environmental geochemistry starting in September 2003 at the Assistant Professor level. The successful candidate will demonstrate a potential for research and teaching, which will both complement and integrate with our existing program in environmental geology. We seek a person with primary interest in geochemical modeling of engineered or natural subsurface aqueous systems. Expertise in designing and conducting relevant field and laboratory testing experiments and/or familiarity with the applications of geochemical and isotopic (stable/radiogenic) techniques in assessment and remediation of aquatic systems is a plus. Preference will be given to candidates who use spatial data to infer geochemical evolution of pristine or contaminated subsurface aqueous environments. We encourage collaboration with departmental researchers in hydrogeology and environmental geophysics (see [www.geology.buffalo.edu](http://www.geology.buffalo.edu)), and with engineering faculty in the areas of ground-water remediation, water quality, and ground-water modeling (see [www.groundwater.buffalo.edu](http://www.groundwater.buffalo.edu)). The successful candidate is expected to develop an active, externally funded research program, and to teach undergraduate and graduate level courses. A Ph.D. degree is required 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, State University of New York at Buffalo, 876 Natural Sciences Complex, Buffalo, NY 14260-3050. We will begin evaluating applicants on December 1, 2002. The University at Buffalo is an Equal Opportunity Employer/Recruiter.

## WELLESLEY COLLEGE

### ASSISTANT OR ASSOCIATE PROFESSOR

The Geology Department at Wellesley College invites applications for a tenure-track faculty position at the rank of second-level assistant or first-level associate professor beginning September 2003. We seek an exceptional scientist whose teaching and research will expand our current geologically oriented program into some area of environmental problem solving. Applicants should have expertise in hydrology, low temperature geochemistry, soil science or civil and environmental engineering with geo-environmental emphasis. Candidates are also expected to have at least three years of undergraduate teaching experience and an established, externally funded research program that can engage undergraduate students.

Applicants should send their curriculum vitae, a statement of teaching and research interests and the names and contact information (including email address) of three referees to Dr. Margaret D. Thompson, Chair, Geology Department, Wellesley College, Wellesley, MA 02481. Applications will be accepted until December 1, 2002.

Wellesley College is an Equal Opportunity/Affirmative Action educational institution and employer; successful candidates must be able to work effectively in a culturally diverse environment. Applications from women, minorities, veterans, and candidates with disabilities are encouraged.

## CURATOR/RESEARCH POSITION U.S. POLAR ROCK REPOSITORY

Byrd Polar Research Center at The Ohio State University is seeking a Curator for the new United States Polar Rock Repository currently under construction. This national facility will house rock collections from Antarctica and the Arctic, obtained by U.S. earth scientists, along with associated materials and data. These collections will be accessible to the earth science community for research. All relevant collection, lithologic and analytic data will also be

available in an online database. Prior to completion of the Repository building, the curator will be expected to develop a cataloging system, and develop (with a National Steering Committee) policies for use of materials. The curator will be responsible (with student help) for cataloging and shelving all available rock collections on completion of building construction (in early 2003), and thereafter provide full curatorial services for the facility.

Most of the materials housed in this facility will be from Antarctica, and candidates must have a strong background and ongoing research interest in Antarctic geology. Strong computer skills would be an advantage. This position requires the candidate to have a Ph.D. The curator position will be funded at 100% for the first 2 to 2-1/2 years. Thereafter this position is expected to be funded at 50%, with the remainder of support covered by the individual's research funding.

We wish to fill this position in winter 2002. Applications should include a complete resume, a statement outlining research interests, a statement regarding their qualifications for the curatorial position and the compatibility of their research with this position, and the names and contact details for at least three individuals who could provide references. The Ohio State University is an equal opportunity employer. For further information please contact Rosemary Askin ([askin.1@osu.edu](mailto:askin.1@osu.edu)).

Please send applications by September 30 to: Rock Repository Curator Search Committee, Byrd Polar Research Center, The Ohio State University, 1090 Carmack Road, Columbus, Ohio 43210 (fax 614-292-4697).

## CHAIR, DEPARTMENT OF GEOLOGICAL SCIENCES WRIGHT STATE UNIVERSITY

Applications are invited for the position of Chair of Geological Sciences, Wright State University, Dayton, Ohio. The department has 12 full-time faculty members. It has undergraduate and masters degree programs and, in conjunction with the Departments of Chemistry and Biological Sciences, is implementing a Ph.D. program in Environmental Sciences. The Chair will have an important part in shaping the development of this program. The Department of Geological Sciences emphasizes applied aspects of geological sciences with concentrations in environmental geology, environmental geochemistry, hydrogeology, geophysics, sedimentary geology, and earth science education. Candidates must hold a Ph.D. in Geological Sciences or a closely related discipline and have a record of excellence in teaching, research, and service with expertise that relates to emphasis areas in the department. Preference will be given to candidates with experience with both undergraduate and graduate programs, familiarity with strategies for increasing external funding, an administrative style that promotes faculty involvement, and commitment to earth science education emphasizing inquiry-based learning. Candidates must be familiar with the factors influencing the future of geological sciences and have the ability to provide leadership for the department's involvement in the Environmental Sciences Ph.D. program. Applicants should send a curriculum vitae; a statement of capabilities and qualifications; and the names, addresses, telephone numbers, and email addresses of at least 3 professional references. Send applications to Geology Chair Search Committee, College of Science and Mathematics, 134 Oelman Hall, Wright State University, Dayton, OH 45435. Formal review of applications will begin Dec. 2, 2002. Applications will be accepted until the position is filled. Questions may be directed to Paul Wolfe at 937-775-3455 or [paul.wolfe@wright.edu](mailto:paul.wolfe@wright.edu). Wright State University is committed to a policy of equal opportunity and affirmative action, and specifically encourages applications from members of underrepresented groups.

## THE UNIVERSITY OF TEXAS AT AUSTIN PETROLOGY/GEOCHEMISTRY

The Department of Geological Sciences of the John A. and Katherine G. Jackson School of Geosciences, The University of Texas at Austin seeks to fill two faculty positions in the general areas of igneous petrology, metamorphic petrology, and high-temperature geochemistry. These searches will be focused at the level of tenure-track Assistant Professor, but full consideration will be given to outstanding scientists at more senior levels. The successful candidates will conduct vigorous externally funded research programs that integrate field-based investigations with modern analytical/experimental methods to attack fundamental geologic problems. We seek enthusiastic teachers to participate in undergraduate courses in earth materials, igneous and metamorphic petrology, and introductory physical geology, and to offer graduate courses and direct the research of M.S. and Ph.D. students. The persons filling these positions will join a large, diverse and active geoscience department with superb analytical facilities and research support. See [www.geo.utexas.edu](http://www.geo.utexas.edu) for complete information. The anticipated starting date for these positions is August 2003; a Ph.D. is required at the time of appointment. To apply,

please send a curriculum vitae, statements of research and teaching interests, and the names and contact information for five references to: Chair, Petrology/Geochemistry Search Committee, Department of Geological Sciences, The University of Texas at Austin, Austin TX 78712. Review of applications will begin on October 15, 2002, and will continue until the positions are filled. The University of Texas at Austin is an Equal Opportunity/Affirmative Action employer.

#### THE UNIVERSITY OF TEXAS AT AUSTIN APPLIED CLASTIC SEDIMENTOLOGY

The Department of Geological Sciences of the John A. and Katherine G. Jackson School of Geosciences, The University of Texas at Austin seeks to fill a faculty position in the area of applied clastic sedimentology and stratigraphy. The position is open at all levels, including the chair level. We seek applicants with a strong background in depositional systems, stratigraphy, and basin analysis. Experience in application of subsurface well and seismic databases to research and interpretation projects is highly desirable. The successful applicant will teach a graduate level course in terrigenous clastic depositional systems, as well as related undergraduate courses, actively supervise graduate research of M.S. and Ph.D. students, interact with colleagues within the Jackson School, and develop an active, funded research program. The person filling this position will join a large, diverse and active geoscience department and geoscience school. See [www.geo.utexas.edu](http://www.geo.utexas.edu) for complete information. The anticipated starting date is August 2003; a Ph. D. is required at the time of appointment. To apply, please send a curriculum vitae, statements of research and teaching interests, and the names and contact information for five references to: Chair, Applied Clastic Sedimentology Search Committee, Department of Geological Sciences, The University of Texas at Austin, Austin TX 78712. Review of applications will begin on October 15, 2002, and will continue until the position is filled. The University of Texas at Austin is an Equal Opportunity/Affirmative Action employer.

#### CANADA RESEARCH CHAIR TIER 1 UNIVERSITY OF TORONTO

The Department of Geology, University of Toronto is seeking an outstanding individual for an appointment in history and dynamics of climate change at the level of full professor on its St. George campus. The successful candidate will be nominated for a Tier I Canada Research Chair (CRC; see [www.chairs.gc.ca](http://www.chairs.gc.ca)). This is the first of four anticipated CRCs in global environmental change at the university. Others will be in the Departments of Chemistry, Geography and Physics.

Candidates must demonstrate outstanding performance in an aspect of earth and ocean science pertaining to climate change through publications in first-class refereed journals and internationally recognized leadership. Existing research programs in the department are described on our web site [www.geology.utoronto.ca](http://www.geology.utoronto.ca). The successful candidate will be expected to teach both graduate and undergraduate courses. The position is available from July 1, 2003. Salary is commensurate with experience.

Applicants should provide their curriculum vitae, including a list of publications, and a brief statement describing their research program. They should also provide the names and contact information of at least six earth scientists who could be approached for a letter of reference. Applications should be sent to: Chair, Climate Change Search, 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 October 15, 2002. Applications received after this date will be considered if the position has not 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.

Any inquiries about the application should be sent to [geol\\_sec@geology.utoronto.ca](mailto:geol_sec@geology.utoronto.ca).

#### ASSISTANT PROFESSOR EARTH AND PLANETARY MATERIALS UNIVERSITY OF TORONTO

The Department of Geology at the University of Toronto is re-advertising its vacant tenure stream position on the St. George campus in the field of earth and planetary materials at the assistant professor level. We are particularly interested in 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 to achieve excellence for independent research and

evidence of potential to complement existing research programs described on our web site—[www.geology.utoronto.ca](http://www.geology.utoronto.ca). In addition to establishing an internationally recognized independent research program, the successful candidate will have a strong commitment to excellence in teaching at all levels. Salary will be commensurate with the candidate's qualifications and experience. The position is available from January 1, 2003.

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 and teaching philosophy. They should also arrange to have at least three letters of reference sent directly to: Chair, Department of Geology, University of Toronto, 2 Russell Street, Room 1066, Toronto, Ontario, Canada M5S 3B1

To ensure full consideration, all information should be received by October 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.

All qualified candidates are encouraged to apply; however, Canadians and permanent residents will be given priority.

#### HALEY & ALDRICH, INC.

Haley & Aldrich, Inc., a national firm specializing in underground engineering and environmental solutions, needs client-focused, motivated staff to support our growing practice in the Kansas City area.

Field Engineer: 2-6 years, B.S. or M.S. in Mechanical/Civil/Environmental. Design and implementation of soil and groundwater remediation systems, strong communication skills, travel required.

Hydrogeologist: 2-6 years, M.S./Ph.D. in Geology/Hydrogeology/Hydrology. Good knowledge of KS/MO geology and hydrogeology, and environmental regulations. Strong communication skills, travel required.

Project Manager: 8-15 years, B.S./M.S./Ph.D. in environmental science or engineering discipline. Management of the investigation and remediation of contaminated sites, experience with state and federal environmental regulations, appropriate professional registration, strong communication and leadership skills.

Environmental Field Technician: 2-6 years. Experience with environmental data collection; well installation, sampling and testing.

Senior Geotechnical Engineer: 12+ years, M.S./Ph.D. in Geotechnical Engineering. Experience with all aspects of underground engineering. Professional registration, and strong communication and leadership skills.

All environmental positions require OSHA 40-hour training.

Contact: Dr. Michael Basel, Haley & Aldrich, Inc., 8700 Monrovia, Suite 310-AD, Lenexa, KS 66215-3500, (913) 599-5802, fax 913-599-5822.

#### TULANE UNIVERSITY—SEDIMENT TRANSPORT

The Department of Geology at Tulane University invites applications for a tenure track Assistant Professor position to begin in the fall, 2003, in the field of sediment transport. Applicants will be expected to develop an externally funded research program that builds upon the expertise of a growing, interdisciplinary department (<http://tulane.edu/~geology>) and the Institute for Earth and Ecosystem Sciences (<http://tulane.edu/~iees>) conducting basic and applied research in fluvial, deltaic, and/or coastal environments. In particular, we seek applicants who utilize field observations in concert with numerical or laboratory modeling in one or more of the following areas: (1) suspended sediment transport, (2) bedform migration, (3) surface water hydrology, or (4) fluvial geomorphology. Candidates will have completed their Ph.D. by the start date, and will be expected to teach undergraduate and graduate courses in their field of expertise, and to mentor graduate students. Applicants should send a letter of application, statement of research and teaching interests, current curriculum vitae and the names, addresses, and telephone numbers of 3 references to Dr. George C. Flowers, Chair, Department of Geology, Tulane University, New Orleans, Louisiana 70118, e-mail [flowers@tulane.edu](mailto:flowers@tulane.edu). The closing date for applications is November 15, 2003, although the search will remain open until the position is filled. Tulane University is an affirmative action/equal opportunity employer. Women and minorities are encouraged to apply.

The U.S. Nuclear Regulatory Commission, which is responsible for safeguarding the civilian use of nuclear power and materials, has the following opportunity in Rockville, Maryland.

## Associate Chief Administrative Judge (Technical)

Salary: \$138,200

Vacancy Announcement: #ASLBP-2002-0002

The incumbent will assist the Chief Administrative Judge/Chairman in addressing scientific/technical matters involving the Atomic Safety and Licensing Board Panel (ASLBP) and serve as a technical member on three-member Atomic Safety and Licensing Boards or as a single presiding officer or a special assistant in informal proceedings. Candidate will monitor the professional activities of the technical members of the Panel and organize periodic meetings/presentations to keep Panel members current on scientific/technical and policy matters affecting the regulation of nuclear energy. Candidate also serves as a member of the Panel's Administration Committee, participating in the management and administrative activities of the Panel as directed by the Chief Administrative Judge.

Applicants must have at least 7-10 years of specialized experience that demonstrates comprehensive knowledge in an engineering or scientific discipline that can be directly applied to the adjudicatory work of the ASLBP in the areas of nuclear facility and materials safety, reactor design and construction, operation of reactors and nuclear facilities, nuclear waste disposal, and radiological and environmental protection.

### How to Apply

For a detailed job description and to apply on-line, please visit our Web site at: [www.nrc.gov/who-we-are/employment.html](http://www.nrc.gov/who-we-are/employment.html) and refer to Vacancy Announcement #ASLBP-2002-0002. To enter your resume into the system, simply prepare it using WordPerfect, Word, or another commonly used program (please reference Dept. A-2382 in your resume), then copy and paste your resume into NRCareers. On-line applications will be accepted through 9/30/02.



U.S. NUCLEAR  
REGULATORY  
COMMISSION

An equal opportunity employer. M/F/D/V.  
U.S. citizenship required.

CLASSIFIED ADVERTISING

**TENURE TRACK FACULTY POSITION  
GEOMICROBIOLOGIST, BIOGEOCHEMIST,  
OR ORGANIC GEOCHEMIST  
UNIVERSITY OF IDAHO**

The Department of Geological Sciences at the University of Idaho is soliciting applications for a 9-month tenure-track position in Geomicrobiology, Biogeochemistry, or Organic Geochemistry. Candidates for the position should have a strong commitment to research in biological/ecological activity within subsurface environments. The successful candidate will have research interests in one or more of the following areas of coupled geological-biological processes: reactive biogeochemistry in geothermal environments, biogeochemical processes associated with subsurface contamination and remediation, the effect of biogeochemical interactions on material stability and corrosion in thermal, chemical, and/or radiologically stressed subsurface environments, or biologically-assisted transport in saturated or unsaturated environments. The position involves teaching (40-60%), research (40-60%), and service (5-10%).

The position is open at the Assistant Professor level. A Ph.D. in Geology, Microbiology, or related science is required at the time of appointment. The successful candidate must be committed to both undergraduate and graduate education and to the development of an externally funded research program. The successful candidate also will be expected to teach undergraduate courses, as well as advanced courses in his or her specialty.

The University of Idaho, located in Moscow, is Idaho's primary institution for graduate education and research. The Department of Geological Sciences is part of the College of Sciences and has close working relations with the Idaho Geological Survey. The 12-member faculty has a strong commitment to undergraduate and graduate education. Interested applicants are referred to the department web site for additional information (<http://geoscience.uidaho.com>).

Applications, with a curriculum vitae, statement of research interests and teaching philosophy, and the names, addresses, telephone numbers and e-mail addresses of at least three references, should be sent to Professor Scott Wood, Department of Geological Sciences, Box 443022, University of Idaho, Moscow, ID, 83844-3022. Salary will be competitive and commensurate with experience. Search and selection procedures will be closed when a sufficient number of qualified candidates have been identified, but no earlier than September 1, 2002. The starting date is negotiable.

To enrich education through diversity, the University of Idaho is an equal opportunity/affirmative action employer.

**BELOIT COLLEGE**

Beloit College invites applications for a full-time, tenure-track position (beginning mid-August 2003) at the assistant professor rank in geology, with expertise in tectonics/igneous and metamorphic petrology. Course

responsibilities include an introductory course in physical geology, mineralogy, petrology, structural geology (on a rotating basis), and selected advanced courses (e.g., tectonics, geochemistry, isotope geology). The successful candidate will also be expected to teach a six-week summer field-geology course on a rotating basis, participate in the departmental field-trip program, and supervise undergraduate research projects. Finally, the successful candidate will contribute to all-college programs (e.g., first-year seminars, interdisciplinary courses, writing program, and international education).

Beloit College is a selective undergraduate liberal-arts college with an enrollment of 1,100 students. The college emphasizes excellence in teaching, breadth and versatility in its faculty, and collaborative research between students and faculty. The city of Beloit is located in southern Wisconsin, close to Madison, Milwaukee, and Chicago.

Applicants should have a Ph.D. by the time of appointment. Send a letter of application, a statement of teaching and research interests, a vita, college-level transcripts, and three letters of reference by 15 October 2002 to Carl Mendelson, Geology Search Committee, Beloit College, 700 College St., Beloit, WI 53511. Inquiries may be directed to Prof. Mendelson (608-363-2223 or [mendelson@beloit.edu](mailto:mendelson@beloit.edu)).

Preliminary interviews for this position will be conducted at the GSA annual meeting in Denver (October 2002). For more information, see <http://geology.beloit.edu/>.

Beloit College is committed to cultural and ethnic diversity, and urges all interested individuals to apply. AA/EEO Employer.

**Opportunities for Students**

**Attention students! Looking for a job or an internship?**

Then join us in Houston for the 5th Annual National AAPG/SEG Student Expo on October 20-21, 2002! The Expo is a great opportunity for students to meet with representatives from oil and gas and environmental companies, some of which recruit only at the Expo. Students will have the chance to showcase their research in a poster session and network with potential employers. Successful job searches result from the Expo every year. And use this occasion to explore Houston, a vibrant city, an oil capital, and home to the largest geoscientist population in the world! Contact Kerri Donathan at AAPG for more information ([donathan@aapg.org](mailto:donathan@aapg.org)).

**Services and Supplies**

**Services and Supplies**

**TRAVEL MAPS**—The world's largest online map catalog. Featuring city maps, topographic maps and digital maps worldwide. Call (336) 227-8300 or visit: [www.omnimap.com](http://www.omnimap.com).

**RECENT, RARE, AND OUT-OF-PRINT BOOKS.** We purchase single books and complete collections. Find our catalog at <http://home.earthlink.net/~msbooks> for books on Geology, Paleontology, Mining History (U.S. & International), Ore Deposits, USGS, Petroleum, Coal; e-mail: [msbooks@earthlink.net](mailto:msbooks@earthlink.net); MS Book and Mineral Company, P.O. Box 6774, Lake Charles, LA 70606-6774.

**MINERAL SPECIMENS FOR RESEARCH, EDUCATION, AND FOR MINERAL COLLECTIONS.** Our website at [www.mineralminers.com](http://www.mineralminers.com) displays thousands of photographic images of unique mineral specimens from mining locations around the world. Also displayed are natural color gemstones, mineral spheres, large "decorator" minerals, lapidary rough, and a variety of handcrafted mineral gift ideas. [www.mineralminers.com](http://www.mineralminers.com)—"Collector Quality at Miner's Prices"™.

**FRENCH-ENGLISH/ENGLISH-FRENCH TRANSLATION.** Specializing in Geology/Environmental Science. Ph.D. in Geology. Native-level knowledge of French and English. Professional experience in French and English. [nathalie@geol.umd.edu](mailto:nathalie@geol.umd.edu). ph: (301) 405 8752.

**ROCKWARE.** Geologic Software. Visit us on the Web at [www.rockware.com](http://www.rockware.com).

**RIGAKU.** Complete line of X-ray diffraction and fluorescence instruments. Visit us on the Web at [www.rigaku.com](http://www.rigaku.com).

**MEIJI.** Complete line of high quality microscopes and accessories. Visit us on the Web at [www.meijitechno.com](http://www.meijitechno.com).

**RITE IN THE RAIN.** All weather fieldbooks, writing papers. Visit us on the Web at [www.riteintherain.com](http://www.riteintherain.com).

**MOUNTAIN PRESS.** Roadside Geology series and Geology Underfoot series, plus other books of interest. Visit us on the Web at [www.mountainpress.com](http://www.mountainpress.com).

The Geological Society of America

**Science at the Highest Level**

*Denver 2002*

Annual Meeting & Exposition • Colorado Convention Center

October 27-30

The deadline to preregister for the Annual Meeting is Friday, September 20.

Be sure to register by this date to save money on registration fees and to assure your spot at this year's meeting.

Go to [www.geosociety.org](http://www.geosociety.org) and register today!

(Online registration will be available through

Wednesday, October 9, but after September 20, you'll need to pay the on-site prices.)

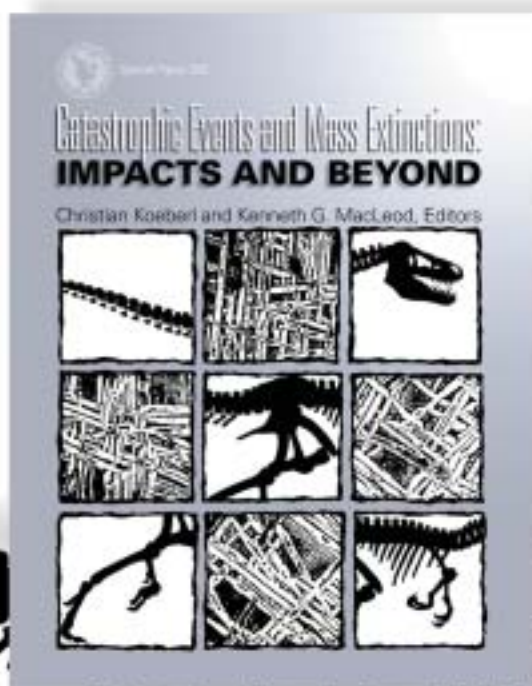


Title Sponsor of the 2002 GSA Annual Meeting

# Catastrophic Events and Mass Extinctions: **IMPACTS AND BEYOND**

Christian Koeberl and Kenneth G. MacLeod, Editors

This volume contains the proceedings of the fourth of an informal series of meetings on mass extinctions, global catastrophes, and the geological and biological consequences of large-scale impact events. Previous meetings were held in 1981 and 1988 at Snowbird, Utah, and in 1994 in Houston, Texas. The present meeting, held in 2000 in Vienna, Austria, concentrated on if (and how) short-term, high-energy events influence the biological evolution on the Earth. Recently, much attention has been focused on the Permian-Triassic extinction, at which about 80% of all species became extinct. The cause for this global catastrophe is currently unknown. Other short-term events (e.g., late Devonian, Triassic-Jurassic, late Eocene) in the stratigraphic record of the Earth are now receiving unprecedented attention. The papers in this volume discuss the character and causes of mass extinctions and catastrophic events in the history of our planet. The 56 chapters are grouped under the following categories:



- The Big Picture
- Chicxulub and the Cretaceous-Tertiary Boundary Deposits
- Biological and Chemical Changes Across the Cretaceous-Tertiary Boundary
- Permian-Triassic Boundary
- Other Extinctions and Boundaries
- Case Studies
- Experiments, Methods, and Model Calculations
- Astronomical Studies
- Impacts and Extinction Mechanisms

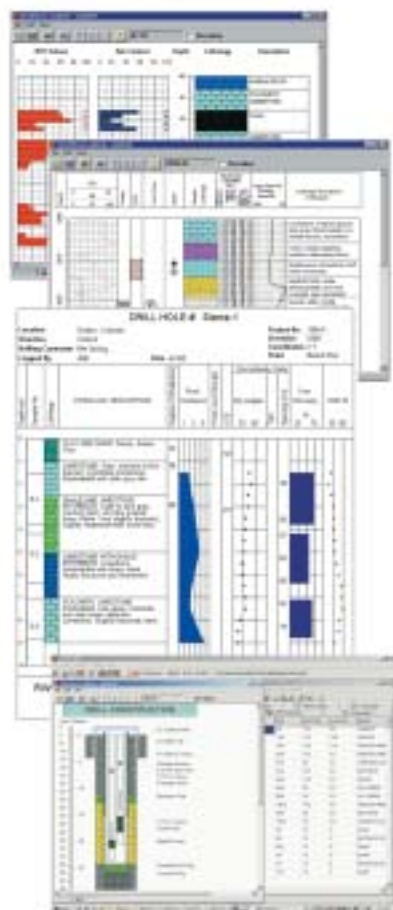
SPE356, ISBN 0-8137-2356-6, softcover,  
729 p., indexed, \$170.00 Member price \$136.00

**GSA Publication Sales**  
P.O. Box 9140 • Boulder, CO 80301-9140, USA  
Toll-free: 888-443-4472 • Fax: 303-357-1071  
[www.geosociety.org](http://www.geosociety.org)



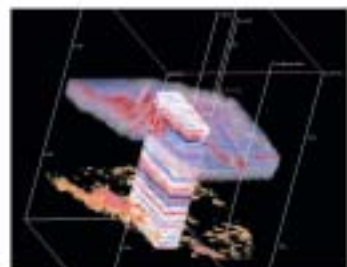
**THE  
GEOLOGICAL  
SOCIETY  
OF AMERICA**

# Logplo™ 2001



\$599.00 Standard  
\$199.00 Academic

## RockWare® Visual Seismic

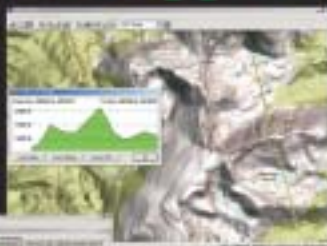


3D & 4D Reservoir Analysis,  
Visualization & Interpretation

\$999.00 Standard  
\$499.00 Academic

## Global Mapper

Global Mapper lets you view, merge, and export a variety of vector, raster, and elevation data sets.



Before



After

Free Demo at:  
[www.rockware.com](http://www.rockware.com)

Seamlessly view a collection of adjacent DRG files after clipping off their colors.

View: DLG-O, DRG, DOQ, DEM, DXF, SDTS DEM, ECW, MrSID, ESRI Shapefiles, ESRI ASCII Grid, ESRI Binary Grid, E00, etc.

Export: DLG-O, DXF, ESRI Shapefile, ESRI ASCII Grid, XYZ ASCII, DRG, DOQ, GeoTIFF DEM, Surfer Grid, etc.

\$129.00 Single User License

## RockPack III

ROCK Slope Stability Analyses PACKAGE For Windows

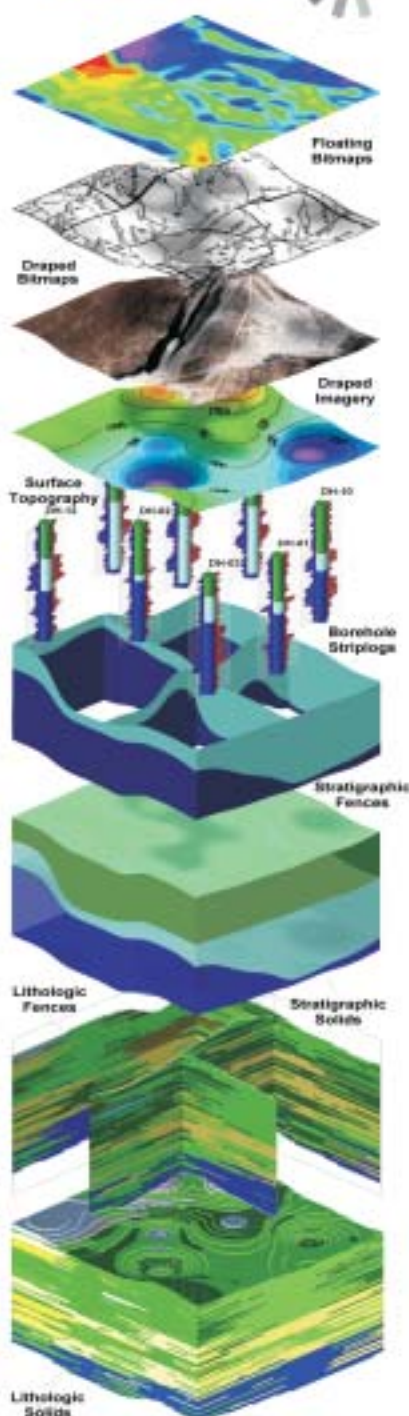


- NEW! RockPack III, ROCK slope stability analyses PACKAGE for Windows
- Improved data entry
- Quick tests for planar wedge, and toppling failures
- Enhanced stereonet plots for kinematic evaluation
- Different symbols for different geologic structures
- Safety factor calculations including remediation design

\$875.00 Standard \$499.00 Academic

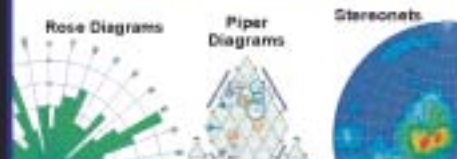
## RockWorks™

Your Geology Toolbox



\$999.00 Standard  
\$399.00 Academic

Deviated Drillholes and more!



Over 200 Software Solutions at <http://www.rockware.com>

2221 East St. • Suite 101, Golden • Colorado 80401  
1-800-775-6745 or 303-278-3534 • Fax 303-278-4099

RockWare Europe: vicolo dei Saroli 1 • 6944 Cureglia • Switzerland  
Tel: ++41 91 967 52 53 • Fax: ++41 91 967 55 50 Email: [europe@rockware.com](mailto:europe@rockware.com)



# RockWare®

Earth Science & GIS Software