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**The long-term strength of continental lithosphere: “jelly sandwich” or “crème brûlée”?**

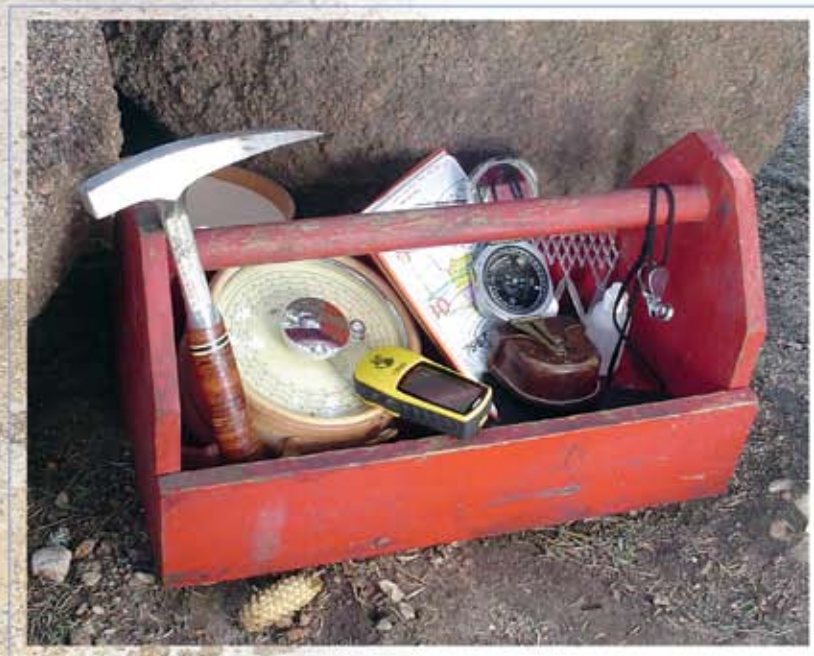
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**Cover:** Oblique view of the Himalayas looking south from over the Tibetan Plateau, photographed by astronauts on the International Space Station in low orbit, ~360 km from Earth. The high peaks include Everest (right, 8850 m elevation) and Makalu (left, 8462 m); the foreground subdued relief of the Tibetan plateau is >4 km in elevation. The collisional process that created the Himalayas began during the Eocene (ca. 50 Ma), when the Indian plate underthrust the Eurasian plate. Modeling of gravity anomalies suggests that the strong Indian plate, where it flexes down toward the Himalayas, has an effective elastic thickness ( $T_e$ ) of ~70 km. See "The long-term strength of continental lithosphere: "jelly sandwich" or "crème brûlée"?" by E.B. Burov and A.B. Watts, p. 4–10. Photo ISS008-E-13304 (28 January 2004) courtesy of the U.S. National Aeronautics and Space Administration (NASA).

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# The long-term strength of continental lithosphere: “jelly sandwich” or “crème brûlée”?

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## ABSTRACT

**There has been much debate recently concerning the long-term (i.e., >1 m.y.) strength of continental lithosphere. In one model, dubbed jelly sandwich, the strength resides in the crust and mantle, while in another, dubbed crème brûlée, the mantle is weak and the strength is limited to the crust. The different models have arisen because of conflicting results from elastic thickness and earthquake data. We address the problem here by first reviewing elastic thickness estimates and their relationship to the seismogenic layer thickness. We then explore, by numerical thermomechanical modeling, the implications of a weak and strong mantle for structural styles. We argue that, irrespective of the actual crustal strength, the crème-brûlée model is unable to explain either the persistence of mountain ranges or the integrity of the downgoing slab in collisional systems. We conclude that while the crème-brûlée model may apply in some tectonic settings, a more widely applicable model is the jelly sandwich.**

## INTRODUCTION

The strength of Earth's outermost layers has been a topic of debate ever since the turn of the last century when Joseph Barrell first introduced the concept of a strong lithosphere that overlies a weak fluid asthenosphere (Barrell, 1914). The concept played a major role in the development of plate tectonics (e.g., Le Pichon et al., 1973), and the question of how the strength of the plates varies spatially and temporally is a fundamental one of wide interest in geology.

One proxy for strength is the effective elastic thickness of the lithosphere,  $T_e$  (see Watts, 2001 and references therein). By comparing observations of flexure in the region of long-term loads such as ice, sediment, and volcanoes to the predictions of simple elastic plate (flexure) models, it has been possible to estimate  $T_e$  in a wide range of geological settings. Oceanic flexure studies suggest that  $T_e$  is in the range of 2–40 km and depends on load and plate age. In the continents, however,  $T_e$  ranges from 0 to 100 km and shows no clear relationship with age.

The results of flexure studies are qualitatively consistent with the results of experimental rock mechanics. The Brace-Goetze failure envelope curves (Goetze and Evans, 1979;

Brace and Kohlstedt, 1980), for example, predict that strength increases with depth and then decreases in accordance with the brittle (e.g., Byerlee) and ductile deformation laws. In oceanic regions, the envelopes are approximately symmetric about the depth of the brittle-ductile transition (BDT), where the brittle-elastic and elastic-ductile layers contribute equally to the strength. Since both  $T_e$  and the BDT generally exceed the mean thickness of the oceanic crust (~7 km), the largest contribution to the strength of oceanic lithosphere must come from the mantle, not the crust.

In the continents, the strength envelopes are more complex, and there may be more than one brittle and ductile layer. Despite this, Burov and Diament (1995) have been able to show that a model in which a weak lower crust is sandwiched between a strong brittle-elastic upper crust and an elastic-ductile mantle accounts for the wide range of  $T_e$  values observed due to the wide variation in composition, geothermal gradient, and crustal thickness possible in continental lithosphere.

Recently, Jackson (2002) challenged this so-called jelly sandwich model for the rheology of continental lithosphere. He stated the model was incorrect, proposing instead a model in which the upper crust is strong, but the mantle is weak. We dub this here the “crème-brûlée” model (Fig. 1). Jackson (2002) bases his model on the observations of Maggi et al. (2000), which suggest that earthquakes in the continents are restricted to a single layer (identified as the seismogenic thickness,  $T_s$ ) in the upper brittle part of the crust and are either rare or absent in the underlying mantle.

It is well known that experimental rock mechanics data are based on relatively low temperatures and pressures and strain rates that are orders of magnitude greater than those that apply to the lithosphere ( $\sim 10^{-6}$ – $10^{-4}$  s $^{-1}$  compared to  $\sim 10^{-17}$ – $10^{-13}$  s $^{-1}$ ). Hence, it is not really possible to use these data to distinguish between different rheological models (e.g., Rutter and Brodie, 1991). We therefore take a different approach. First, we review the  $T_e$  estimates because they, we believe, best reflect the integrated strength of the lithosphere. Then, we use numerical models to test the stability and structural styles associated with rheological models.

In order to focus the debate, we limit our study to the two rheological models considered by Jackson (2002): crème brûlée and jelly sandwich. This is not intended to exclude other models. We regard crème brûlée as including all models with a weak mantle and jelly sandwich as all models with a strong mantle, not just those with a weak lower crust. The effect of strong, rather than weak, lower crust depends on its strength with respect to the mantle. If the mantle is weaker than the lower crust, and the crust is not strong at the Moho depth, then the system is mechanically decoupled (e.g., upper panel, Fig. 1C) and we obtain a plate with a strength that is not significantly different from crème brûlée. In contrast, if the mantle is stronger than the lower crust, and the crust is strong at the Moho depth, then the system is coupled (e.g., lower panel, Fig. 1C), and this yields a plate that is capable of considerable strength.

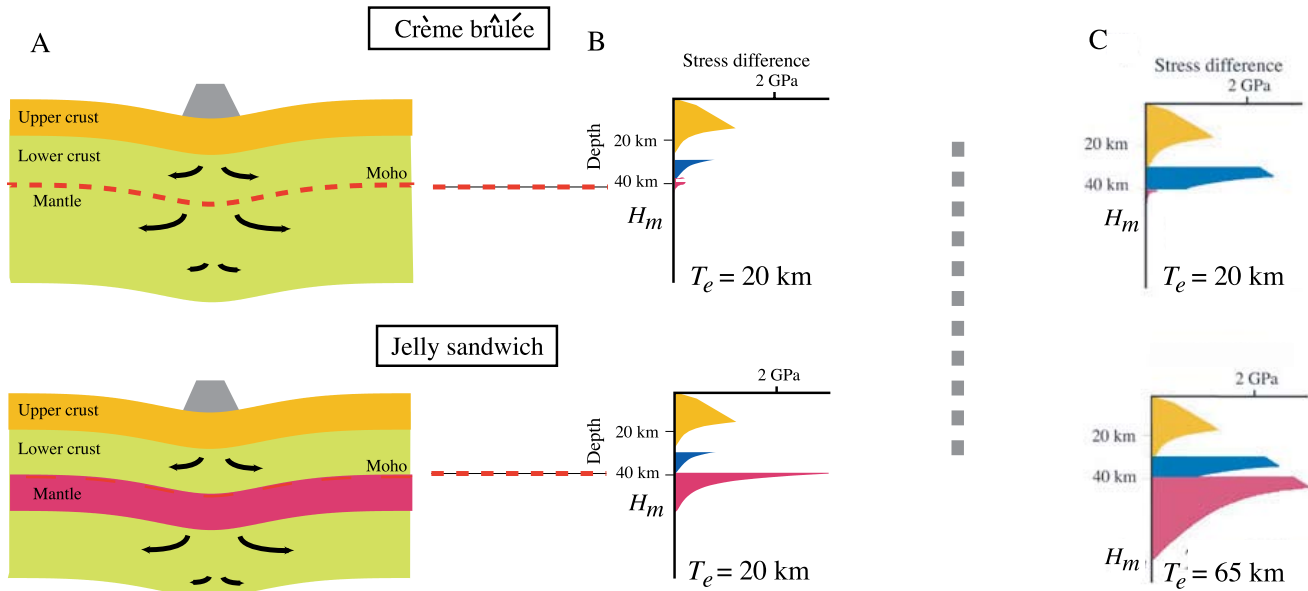


Figure 1. Schematic diagram illustrating different models for the long-term strength of continental lithosphere. In the crème-brûlée model, the strength is confined to the uppermost brittle layer of the crust, and compensation is achieved mainly by flow in the weak upper mantle. In the jelly sandwich model, the mantle is strong and the compensation for surface loads occurs mainly in the underlying asthenosphere. (A) Models of deformation. Arrows schematically show the velocity field of the flow. (B) Brace-Goetze failure envelopes for a thermotectonic age of 150 Ma, a weak, undried granulite lower crust, a uniform strain rate of  $10^{-15} \text{ s}^{-1}$ , and either a dry (jelly sandwich) or wet (crème brûlée) olivine mantle.  $H_m$  is the short-term mechanical thickness of the lithosphere;  $T_e$  is the long-term elastic thickness. Other parameters are as given in Tables 1 and 2. The two envelopes match those in Figures 5B and 5D of Jackson (2002). They yield a  $T_e$  of 20 km (e.g., Burrov and Diament, 1995), which is similar to the thickness of the most competent layer. This is because the competent layers are mechanically decoupled by weak ductile layers and so the inclusion of a weak lower crust or strong mantle contributes little to  $T_e$ . (C) Brace-Goetze failure envelopes for a thermotectonic age of 500 Ma. Other parameters are as in (B) except that a strong, dry, Maryland diabase has been assumed for the lower crust. The two envelopes show other possible rheological models: in one, the upper and lower crusts are strong and the mantle is weak (upper panel); in the other, the upper and lower crusts and the mantle are strong (lower panel). The assumption of a strong lower crust in the weak mantle model again contributes little to  $T_e$  because of decoupling, although  $T_e$  would increase from 20 to 40 km if the upper crust was strong at its interface with the lower crust. In contrast, a strong lower crust contributes significantly to the  $T_e$  of the strong mantle model. This is because the lower crust is strong at its interface with the mantle and so the crust and mantle are mechanically coupled.

TABLE 1. SUMMARY OF THERMAL AND MECHANICAL PARAMETERS USED IN MODEL CALCULATIONS

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Thermal	Surface temperature (0 km depth)	0 °C
	Temperature at base of thermal lithosphere	1330 °C
	Thermal conductivity of crust	2.5 Wm <sup>-1</sup> °C <sup>-1</sup>
	Thermal conductivity of mantle	3.5 Wm <sup>-1</sup> °C <sup>-1</sup>
	Thermal diffusivity of mantle	10 <sup>-6</sup> m <sup>2</sup> s <sup>-1</sup>
	Radiogenic heat production at surface	9.5 × 10 <sup>-10</sup> W kg <sup>-1</sup>
	Radiogenic heat production decay depth constant	10 km
	Thermo-tectonic age of the lithosphere	150 Ma (Fig. 1B); 500 Ma (Fig. 1C)
	Mechanical	Density of upper crust
Density of lower crust		2900 kg m <sup>-3</sup>
Density of mantle		3330 kg m <sup>-3</sup>
Density of asthenosphere		3310 kg m <sup>-3</sup>
Lamé elastic constants $\lambda$ , $G$ (here, $\lambda = G$ )		30 GPa
Byerlee's law—Friction angle		30°
Byerlee's law—Cohesion		20 MPa

TABLE 2. SUMMARY OF DUCTILE PARAMETERS ASSUMED IN MODEL CALCULATIONS\*

TABLE 2. SUMMARY OF DUCTILE PARAMETERS ASSUMED IN MODEL CALCULATIONS*					
	Composition	Pre-exponential stress constant, A MPa <sup>-n</sup> s <sup>-1</sup>	Power law exponent, n	Activation energy, Q KJ mol <sup>-1</sup>	Figure 1
Upper crust	Wet quartzite	1.1 × 10 <sup>-4</sup>	4	223	B, C
Lower crust	Dry Maryland diabase	8 ± 4	4.7 ± 0.6	485 ± 30	C
	Undried Pikwitonei granulite	1.4 × 10 <sup>4</sup>	4.2	445	B
Mantle	Dry olivine	4.85 × 10 <sup>4</sup>	3.5	535	B, C (jelly sandwich)
	Wet olivine	417	4.48	498	B, C (crème brûlée)

\*The failure envelopes in this paper match those in Jackson (2002); the Jackson (2002) envelopes are based on Figure 4 in Mackwell et al. (1998), who did not list all the parameters, referring instead to primary references. We therefore list here the parameters we have used.

## GRAVITY ANOMALIES AND $T_e$

Gravity anomalies, especially their departures from local isostatic models (e.g., Airy, Pratt), have long played a key role in the debate concerning the strength of the lithosphere. Modern isostatic studies follow either a forward or inverse modeling approach. In forward modeling, the gravity anomaly due, for example, to a surface (i.e., topographic) load and its flexural compensation is calculated for different values of  $T_e$  and compared to the observed gravity anomaly. The best fit  $T_e$  is then determined as the one that minimizes the difference between observed and calculated gravity anomalies. In inverse (e.g., spectral) models, gravity and topography data are used to estimate  $T_e$  directly by computing the transfer function between them as a function of wavelength and comparing it to model predictions. The different approaches should yield the same results.

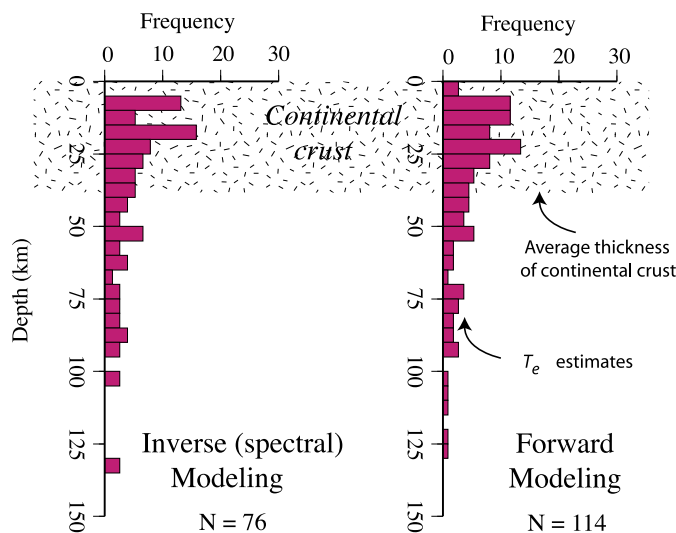


Figure 2. Histograms showing continental  $T_e$  estimates based on forward and inverse (i.e., spectral) gravity anomaly modeling methods. The histograms are based on data in Tables 5.2 and 6.2b of Watts (2001) and references therein. The data reflect a mix of tectonic settings. The spectral estimates mainly reflect old cratons, but include orogenic belts and rifts. The forward estimates are mainly from foreland basins. They reflect mainly rifts, since their mechanical properties are usually inherited during foreland basin formation, but include old cratons. The two modeling methods yield similar results and show that continental lithosphere is characterized by both low and high  $T_e$  values. In general, low values correlate with rifts, intermediate values with orogenic belts, and high values with old cratons. N—number of estimates.

In oceanic regions, forward and inverse models do yield similar  $T_e$  values. This is exemplified along the Hawaiian-Emperor seamount chain in the Pacific Ocean. Forward modeling reveals a mean  $T_e$  of  $25 \pm 9$  km, while inverse (spectral) modeling using a free-air admittance method obtains 20–30 km (Watts, 1978). When the  $T_e$  estimates are plotted as a function of load and plate age, they yield the same result:  $T_e$  increases with age of the lithosphere at the time of loading, small (2–6 km) over young lithosphere and large over old lithosphere (>30 km).

In continental regions, the two modeling approaches have yielded different results. The earliest spectral studies, for example, recovered  $T_e$  values that were significantly smaller than those derived from forward modeling (see Cochran, 1980, and references therein). The subsequent development of more robust methods of determining  $T_e$  using a Bouguer coherence method (e.g., Forsyth, 1985; Lowry and Smith, 1994), however, has yielded values more compatible with forward modeling (Fig. 2).

Recently, McKenzie and Fairhead (1997) argued that most previous continental  $T_e$  estimates based on the Bouguer coherence (spectral) method are overestimates rather than true values. They used a free-air admittance method to argue that continental  $T_e$  was low, <25 km. Since their estimates of the elastic thickness are comparable to the seismogenic layer thickness,  $T_s$ , they proposed that the strength of the continental lithosphere resides in the crust, not the mantle.

Tests with synthetic and observed gravity anomaly and topography data show, however, that when the Bouguer coherence

and free-air admittance methods are similarly formulated, they yield the same results; namely, that continental  $T_e$  ranges from a few km to >70 km and that it varies spatially over relatively short (~100 km) horizontal scales (e.g., Pérez-Gussinyé and Watts, 2005).

While  $T_e$  values that exceed the local thickness of the crust do not indicate which layer, crust or mantle, is strong (Burov and Diament, 1995), they imply high mantle strength. For example, the Bouguer anomaly associated with the flexure of the Indian shield beneath the Ganges foreland basin by the load of the Himalaya requires a  $T_e$  of ~70 km (Fig. 3), which is significantly higher than the local crustal thickness of ~40 km. It is difficult using the Brace-Goetze failure envelopes to explain such high values without invoking a significant contribution to the strength from the subcrustal mantle.

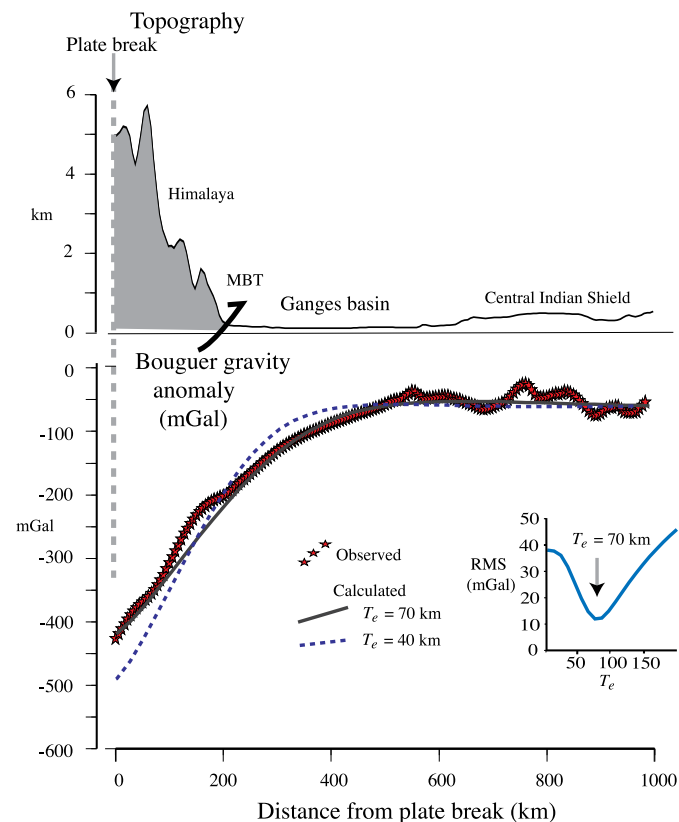


Figure 3. Comparison of observed and calculated Bouguer gravity anomalies along a profile of the Himalayan foreland at about longitude  $80^\circ$  E. The observed profile is based on GETECH (UK geophysical consultancy) Southeast Asia Gravity Project (SEAGP) gravity data. The calculated profile is based on a discontinuous (i.e., broken) elastic plate model, a load comprising the topography (density =  $2650 \text{ kg m}^{-3}$ ) above sea level between the Main Boundary Thrust (MBT) and plate break (gray shaded region) and the material (density =  $2650 \text{ kg m}^{-3}$ ) that infills the flexure (density =  $2650 \text{ kg m}^{-3}$ ); a mantle density of  $3330 \text{ kg m}^{-3}$ ; and elastic thickness,  $T_e$ , of 70 km. Jordan and Watts (2005) have shown that this combination of load and elastic thickness parameters yields the best fit to the observed Bouguer anomaly. The dashed blue line shows the calculated Bouguer anomaly for the same load, but with  $T_e = 40$  km, which is the value preferred by McKenzie and Fairhead (1997). The difference between the observed and calculated Bouguer anomaly for this  $T_e$  is, however, up to  $-70$  mGal beneath the load and up to  $+30$  mGal in flanking regions. The inset shows the root mean square (RMS) difference between the observed and calculated Bouguer anomaly for  $0 < T_e < 180$  km.

Irrespective of the different methodologies, it is clear from Figure 2 that  $T_e$  can be high and may well exceed not only the seismogenic layer thickness,  $T_s$  (typically 10–20 km), but also the local crustal thickness. We are not surprised by this result.  $T_e$  reflects, we believe, the long-term integrated strength of the lithosphere, while  $T_s$  is representative of the strength of the uppermost of the crust on short time scales. It is difficult to use the failure envelopes to predict the actual depth to which seismicity should occur. However, if we assume that Byerlee's law is applicable to great depths, then the BDT increases from 15–25 km for the relatively low strain rates of flexure to 50–70 km for relatively high seismic strain rates. We attribute the general absence of mantle earthquakes at these latter depths to the lack of sufficiently large tectonic stresses (>2 GPa) to generate sliding.

### SIMPLE PHYSICAL CONSIDERATIONS

The crème-brûlée and jelly sandwich models imply fundamental differences in the mechanical properties of mantle lithosphere. In the crème-brûlée model, for example, the mantle lithosphere is mechanically indistinguishable from asthenosphere, which suggests a very low viscosity. Here, we explore the stability of mantle lithosphere by posing the question “What do the different rheological models imply about the persistence of topography for long periods of geological time?”

The mean heat flow in Archean cratons is  $\sim 40 \text{ mW m}^{-2}$ , which increases to  $\sim 60 \text{ mW m}^{-2}$  in flanking Phanerozoic orogenic belts (Jaupart and Mareschal, 1999). As Pinet et al. (1991) have shown, a significant part of this heat flow is derived from radiogenic sources in the crust. Therefore, temperatures at the Moho are relatively low ( $\sim 400\text{--}600 \text{ }^\circ\text{C}$ ). The mantle must maintain a fixed, relatively high, viscosity that prevents convective heat advection to the Moho. Otherwise, surface heat flow would increase to  $>150 \text{ mW m}^{-2}$ , which would be the case in an actively extending rift (e.g., Sclater et al., 1980). Since heat flow this high is not observed in cratons and orogens, a thick, cool, stable mantle layer should remain that prevents direct contact between the crustal part of the lithosphere and the convective upper mantle.

The negative buoyancy of the mantle lithosphere at subduction zones is widely considered as a major driving force in plate tectonics. The evidence that the continental mantle is  $\sim 20 \text{ kg m}^{-3}$  denser than the underlying asthenosphere and is gravitationally unstable has been reviewed by Stacey (1992), among others. Although this instability is commonly accepted for Phanerozoic lithosphere, there is still a debate about whether it applies to the presumably Mg-rich and depleted cratonic lithospheres. Irrespective, volumetric seismic velocities, which are generally considered a proxy for density, are systematically higher in the lithosphere mantle than in the asthenosphere. Depending on its viscosity, the mantle lithosphere therefore has the potential to sink as the result of a Rayleigh-Taylor (RT) instability (e.g., Houseman et al., 1981).

We can estimate the instability growth time (i.e., the time it takes for a mantle root to be amplified by  $e$  times its initial value) using Chandrasekhar's (1961) formulation. In this formulation, a mantle Newtonian fluid layer of viscosity,  $\eta$ , density,  $\rho_m$ , and thickness,  $d$ , is placed on top of a less dense fluid asthenospheric layer of density,  $\rho_a$ , and the same thickness.

(We note that this formulation differs from that of Conrad and Molnar [1997] who used a fluid layer that is placed on top of a viscous half-space. However, both formulations are valid for instability amplitudes  $< d$ ). The most rapidly growing instability wavelength,  $\lambda$ , is  $Ad$ , where  $2.5 < A < 3.0$  and the corresponding growth time,  $t_{min}$ , is  $B\eta[(\rho_m - \rho_a)gd]^{-1}$ , where  $6.2 < B < 13.0$  and  $g$  is average gravity. We can evaluate  $t_{min}$  for a particular  $\eta$  by assuming  $(\rho_m - \rho_a) = 20 \text{ kg m}^{-3}$  and  $80 < d < 100 \text{ km}$ . If the continental mantle can support large stresses (>2 GPa) and has a high viscosity ( $10^{22}\text{--}10^{24} \text{ Pa s}$ ), as the jelly sandwich model implies, then  $t_{min}$  will be long ( $>0.05\text{--}2 \text{ b.y.}$ ). If, on the other hand, the stresses are small (0–10 MPa) and the viscosity is low ( $10^{19}\text{--}10^{20} \text{ Pa s}$ ), as the crème-brûlée model suggests, then it will be short (0.2–2.0 m.y.).

The consequence of these growth times for the persistence of surface topographic features and their compensating roots or anti-roots are profound. The long growth times in the jelly sandwich model imply that orogenic belts, for example, could persist for up to several tens of m.y. and longer, while the crème-brûlée model suggests collapse within a few m.y.

We have so far considered a Newtonian viscosity and a large viscosity contrast between the lithosphere and asthenosphere. However, a temperature-dependent viscosity and power law

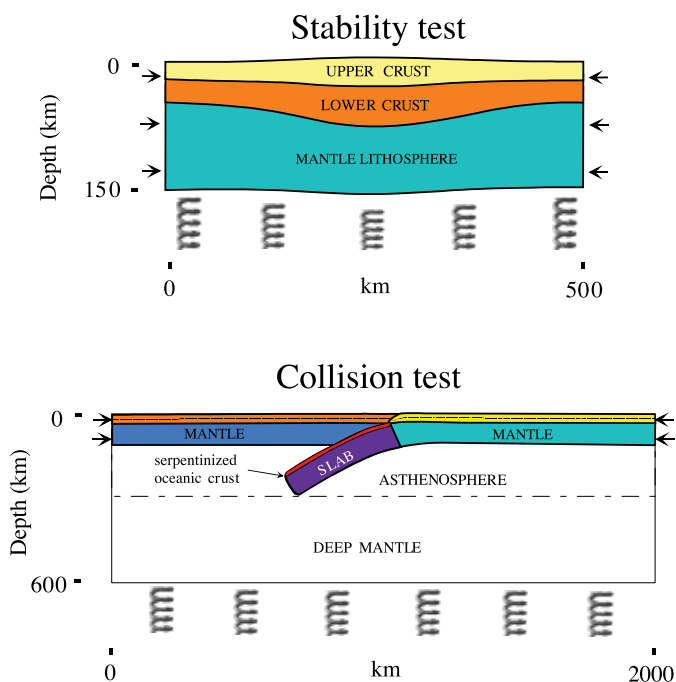


Figure 4. Numerical model set-up. The models assume a free upper surface and a hydrostatic boundary condition at the lower surface (depicted by springs in the figure). (A) The stability test is based on a mountain range height of 3 km and width of 200 km that is initially in isostatic equilibrium with a zero elevation 36-km-thick crust. We disturbed the isostatic balance by applying a horizontal compression to the edges of the lithosphere at a rate of  $5 \text{ mm yr}^{-1}$ . The displacements of both the surface topography and Moho were then tracked through time. (B) The collision test was based on a continent-continent collision initiated by subduction of a dense, downgoing, oceanic plate. We assumed a normal thickness oceanic crust of 7 km, a total convergence rate of  $60 \text{ mm yr}^{-1}$ , and a serpentinitized subducted oceanic crust (Rupke et al., 2002). Rheological properties and other parameters are as given in Tables 1 and 2.

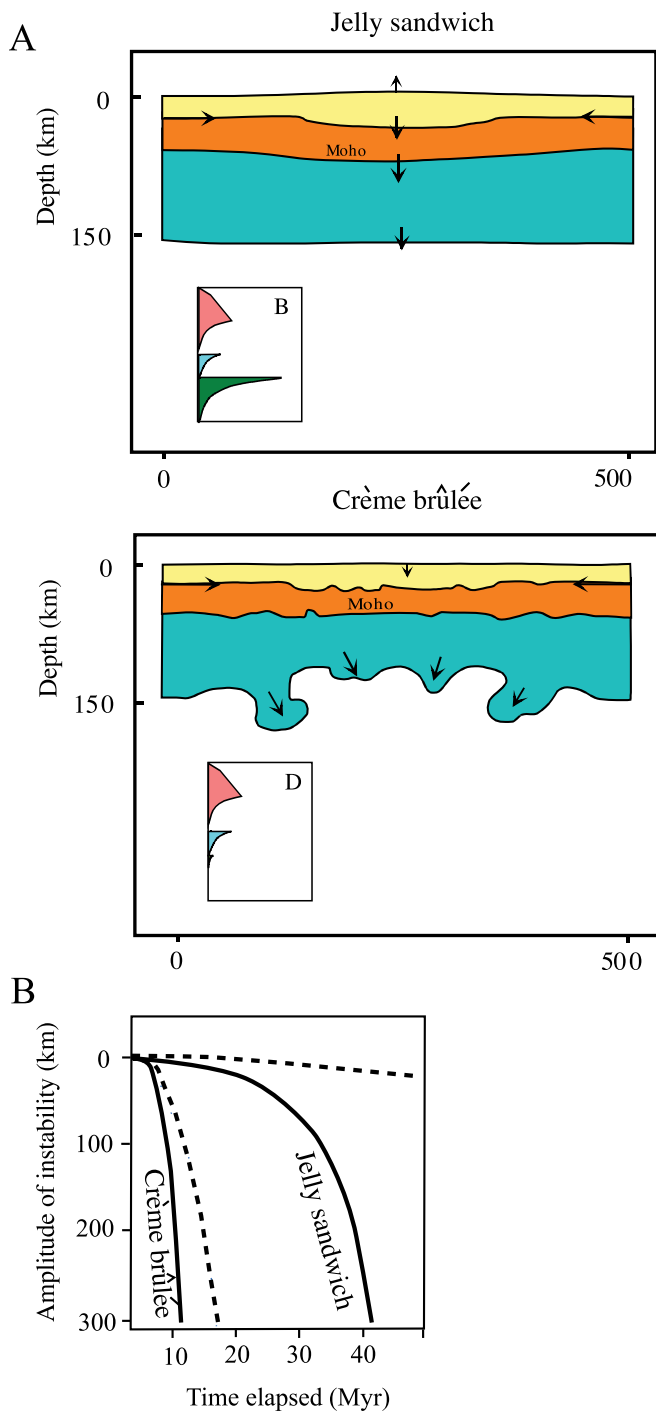


Figure 5. Tests of the stability of a mountain range using the failure envelopes associated with the jelly sandwich (Figure 5B of Jackson, 2002) and crème-brûlée (Figure 5D of Jackson, 2002) rheological models. The thermal structure is equivalent to that of a 150 Ma plate. (A) Crustal and mantle structure after 10 m.y. has elapsed. (B) The amplitude of the mantle root instability as a function of time. The figure shows the evolution of a marker that was initially positioned at the base of the mechanical lithosphere (i.e., the depth where the strength = 10 MPa). This initial position is assumed to be at 0 km on the vertical plot axis. The solid and dashed lines show the instability for a weak, young (thermotectonic age = 150 Ma) and strong, old (thermotectonic age = 500 Ma) plate, respectively.

rheology result in even shorter growth times than the ones derived here for constant viscosity (Conrad and Molnar, 1997; Molnar and Houseman, 2004). Moreover, if either the viscosity contrast is small or a mantle root starts to detach, then Equation (1) in Weinberg and Podladchikov (1995) suggests that the entire system will begin to collapse at a vertical Stokes flow velocity of  $\sim 1 \text{ mm yr}^{-1}$  for the jelly sandwich model and  $\sim 100\text{--}1000 \text{ mm yr}^{-1}$  for the crème-brûlée model. (We note that these flow velocities depend strongly on the sphere diameter, which we assume here to be  $\lambda$ ). Therefore, our assumptions imply that a surface topographic feature such as an orogenic belt would disappear in  $<0.02\text{--}2 \text{ m.y.}$  for the crème-brûlée model, whereas it could be supported for as long as 100 m.y.–2 b.y. for a jelly sandwich model.

### DYNAMICAL MODELS

In order to substantiate the growth times of convective instabilities derived from simple viscous models, we carried out sensitivity tests using a numerical model that allows the equations of mechanical equilibrium for a viscoelasto-plastic plate to be solved for any prescribed rheological strength profile (Poliakov et al., 1993). Similar models have been used by Toussaint et al. (2004), for example, to determine the role that the geotherm, lower crustal composition, and metamorphic changes in the subducting crust may play on the evolution

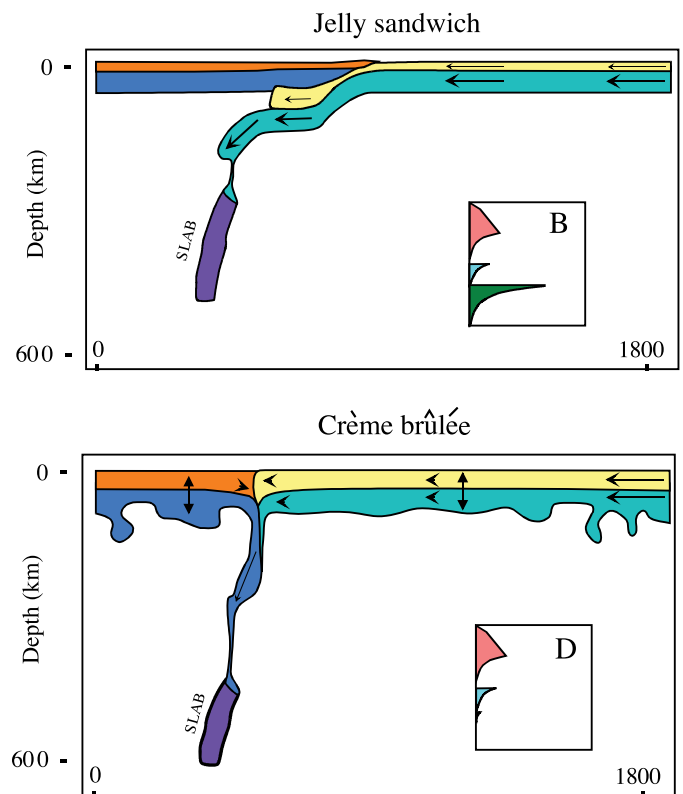


Figure 6. Tests of the stability of a continental collisional system using the failure envelopes associated with the jelly sandwich (B—Figure 5B of Jackson, 2002) and crème-brûlée (D—Figure 5D of Jackson, 2002) models. The elastic thickness,  $T_e$ , and Moho temperature are  $\sim 20 \text{ km}$  and  $600 \text{ }^\circ\text{C}$ , respectively, for both models. The figure shows a snapshot at 5 Ma of the structural styles that develop after 300 km of shortening.



of continental collision zones. We ran two separate tests (Fig. 4) using rheological properties that matched the envelopes in Figures 5B and 5D of Jackson (2002). Our aim in using these envelopes, which otherwise yield a similar  $T_e$  (Fig. 1), was to determine what the crème-brûlée and jelly sandwich models imply about the stability of mountain ranges and the structural styles that develop.

Figure 5 shows the results of the stability tests. The figure shows a snapshot of the deformation after 10 m.y. We found that in the crème-brûlée model the crust and mantle already become unstable after 1.5–2.0 m.y. By 10 m.y., the lithosphere disintegrates due to delamination of the mantle followed by its convective removal and replacement with hot asthenosphere. This leads eventually to a flattening of the Moho and tectonic erosion of the crustal root that initially supported the topography. The jelly sandwich model, on the other hand, is more stable, and we found few signs of crust and mantle instability for the duration of the model run (10 m.y.).

Figure 6 shows the results of a collision test. The figure shows a snapshot of the deformation after 300 km of shortening, which at 60 mm yr<sup>-1</sup> takes 5 m.y. The jelly sandwich model is stable and subduction occurs by the underthrusting of a continental slab that, with or without the crust, maintains its overall shape. The crème-brûlée model, on the other hand, is unstable. There is no subduction, and convergence is taken up in the suture zone that separates the two plates. The crème-brûlée model is therefore unable to explain those features of collisional systems that require subduction such as kyanite- and sillimanite-grade metamorphism. The jelly sandwich model can explain not only the metamorphism, but also some of the gross structural styles of collisional systems such as those associated with slab flattening (e.g., Western North America—Humphreys et al., 2003), crustal doubling (e.g., Alps—Giese et al., 1982), and arc subduction (e.g., southern Tibet—Boutelier et al., 2003).

## CONCLUSIONS

We have shown here that observations of flexure and the results of thermal and mechanical modeling are compatible with the view that the mantle part of the lithosphere is strong and is capable of supporting stresses (and surface and subsurface loads) for long periods of geological time.

Oceanic flexure studies show that  $T_e$  is high and that large loads such as oceanic islands and seamounts are supported, at least in part, by the subcrustal mantle. While the role of the mantle lithosphere in the continents is more difficult to quantify, there is evidence from cratonic regions and both forward and inverse (i.e., spectral) gravity modeling that  $T_e$  is high and can locally significantly exceed the crustal thickness.

We find no difficulty in reconciling the results of seismogenic layer,  $T_s$ , and elastic thickness,  $T_e$ , studies. While both parameters are proxies for the strength of the lithosphere, they are not the same.  $T_s$  reflects the thickness of the uppermost weak brittle layer that responds on historical time scales to stresses by faulting and earthquakes.  $T_e$ , in contrast, reflects the integrated strength of the entire lithosphere that responds to long-term (>10<sup>5</sup> yr) geological loads by flexure.

There is almost certainly no one type of strength profile that characterizes all continental lithosphere. We have only tested two possible models in this paper. Nevertheless, they are rep-

resentative and useful. They are based on the same failure envelopes that Jackson (2002) used to argue that the mantle is weak, not strong. Moreover, they allow us to speculate on the stability of other models. The crème-brûlée model considered by Jackson (2002) yields a  $T_e$  of 20 km that is at the *high* end of the seismogenic layer thickness (typically 10–20 km). We have already shown that the crème-brûlée model is mechanically unstable. Therefore, weaker crème-brûlée models (e.g., ones with a weaker upper crust and  $T_e < 20$  km) will be even more unstable. The jelly sandwich model of Jackson (2002) yields a  $T_e$  of 20 km that is at the *low* end of continental  $T_e$  estimates (which, as Fig. 2 shows, may exceed 70 km). We have already shown that this model is stable. Stronger jelly sandwich models (e.g., ones with a strong, coupled, lower crust and  $T_e > 20$  km) will be even more stable. The wide range of continental  $T_e$  estimates suggest that while the crème-brûlée model may apply to some specific settings (e.g., young, hot, rifts such as parts of the Basin and Range, western USA; the Salton Sea, southern California; and Taupo volcanic zone, north island New Zealand), the jelly sandwich model, and its stronger variants, is more widely applicable (e.g., rifts, orogenic belts, cratons).

Thermomechanical modeling of lithospheric deformation suggests that the persistence of surface topographic features and their compensating roots require that the subcrustal mantle is strong and able to act as both a stress guide and a support for surface loads. It might be thought that it would not matter which competent layer in the lithosphere is the strong one. However, our tests show that the density contrast between the crust and mantle is sufficient to ensure that it is the mantle, rather than the crust, that provides both the stress guide and support. In our view, subduction and orogenesis *require* a strong mantle layer. We have found this to be true irrespective of the actual strength of the crust. Weak mantle is mechanically unstable and tends to delaminate from the overlying crust because it is unable to resist forces of tectonic origin. Once it does delaminate, hotter and lighter mantle asthenosphere can flow upward to the Moho. The resulting increase in Moho temperature would lead to extensive partial melting and magmatic activity as well as further weakening such that subduction is inhibited and surface topography collapses in a relatively short interval of time.

We conclude that rheological models such as crème brûlée that invoke a weak mantle are generally incompatible with observations. The jelly sandwich is in better agreement and provides a useful first-order explanation for the long-term support of Earth's main surface features.

## ACKNOWLEDGMENTS

The kernel of the numerical code used in Figs. 5 and 6 is based on Parovoz (Poliakov et al., 1993). We thank P. Molnar, D. McKenzie, and S. Lamb for discussions, E. Humphreys, W. Royden, B. Kaus, W. Thatcher, and K. Howard for their constructive reviews, and the Dyeti and the University of Paris 6 visiting professor program for support.

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## TWO NEW POSITION STATEMENTS ADOPTED BY GSA COUNCIL

### Geoscience Data Preservation

#### Contributor:

Jamie Robertson, Chair

#### Panel Members:

Odin Christensen, Linda Gunderson,  
Christopher Keane, Emi Ito, Robert Schafer,  
Marvin Carlson, Kerstin Lehnert, and Warren Allmon

#### Position Statement:

The Geological Society of America supports the preservation of geoscience samples and data sets for the public good and urges public and private sector organizations and individuals to routinely catalog and preserve their collections and make them more widely accessible.

*Adopted by GSA Council October 2005.*

Background information and recommendations for implementation of this policy are detailed at [www.geosociety.org/aboutus/position9.htm](http://www.geosociety.org/aboutus/position9.htm).

### Geoscience and Natural Hazards Policy

#### Contributors:

Lou Gilpin, George Linkletter, Co-Chairs

#### Panel Members:

David Applegate, Vic Baker, Susan Cannon,  
John Costa, Orrin Pilkey

#### Position Statement:

The Geological Society of America (GSA) urges the public, scientists, and policy makers to work together to reduce our vulnerability to natural hazards.

*Adopted by GSA Council October 2005.*

Background information and recommendations for implementation of this policy are detailed at [www.geosociety.org/aboutus/position6.htm](http://www.geosociety.org/aboutus/position6.htm).



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To read GSA's position statements (2001 to present) and to find out more about how to participate in supporting and implementing these position statements, check out the geology and public policy section of GSA's Web site, [www.geosociety.org/science/govpolicy.htm](http://www.geosociety.org/science/govpolicy.htm).

The most effective way to influence the success of GSA's geology and public policy efforts is to **communicate** among your colleagues and scientists in related professions, to students and members of the public and media, and with your congressional representatives.



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## Attention Voting Members:

## JULY 2006—OFFICER AND COUNCILOR NOMINEES



### GSA Election Starts 30 January 2006

The success of GSA depends on you, the Members, and on the work of the elected officers who serve on GSA's Executive Committee and Council. Please make your wishes for GSA known by voting for the nominees listed here.

In late January, you'll receive a postcard with instructions on how to access a secure Web site and your electronic ballot listing officer and councilor nominees. Biographical information on each candidate will be available for review at [www.geosociety.org](http://www.geosociety.org) beginning mid-January. Paper versions of the ballot and candidate information will be available for those unable to vote online.

Watch for your ballot information and vote!

**Ballots must be submitted electronically or postmarked by 28 February 2006.**

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Gustavo Tolson  
Universidad Nacional Autónoma  
de México  
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## NORTH-CENTRAL

**40th Annual Meeting  
North-Central Section, GSA  
Akron, Ohio**

**20–21 April 2006**

[www.geosociety.org/sectdiv/northc/06ncmtg.htm](http://www.geosociety.org/sectdiv/northc/06ncmtg.htm)

The Department of Geology and the Office for Terrestrial Records of Environmental Change of the University of Akron, in conjunction with the Ohio Department of Natural Resources Division of Geological Survey, the Cleveland Museum of Natural History, and the Northern Ohio Geological Society, will host the 2006 Annual Meeting of the North-Central Section of the Geological Society of America. The meeting will be held Thurs.–Fri., 20–21 April, at the Student Union on the campus of the University of Akron in Akron, Ohio. Detailed meeting information is available on the GSA Web site, [www.geosociety.org/sectdiv/Northc/06ncmtg.htm](http://www.geosociety.org/sectdiv/Northc/06ncmtg.htm).

The meeting's theme is terrestrial records of change. Our technical program emphasizes both the human impact on the environment and the record of natural change that can be extracted from terrestrial records. Join your colleagues for a diverse, illuminating meeting on these and other topics.

### ENVIRONMENT

Akron, Ohio, is located on a continental divide about 30 miles south of Lake Erie. The high upland, from which Akron derives its name, separates drainage that eventually flows to the St. Lawrence River from drainage that empties into the Mississippi River. The city is built on the Sharon Formation, the basal unit of the Pennsylvanian strata in the area, and is situated on the northwestern edge of the Allegheny Plateau, east of the Central Lowlands.

Akron played an important role in transportation and manufacturing during the nineteenth and twentieth centuries. The Ohio & Erie Canal, employing a sequence of many locks, crossed the divide at Akron. As a consequence, the city was a major stopping point for travelers as canal boats transited the locks. Agricultural implement manufacturers took advantage of available transportation links and set up factories in the city. Quaker Oats located a major processing facility in Akron; some of you may reserve a room in one of their former grain silos, now part of the Crowne Plaza Hotel. The canal competed with the railroads during the latter half of the nineteenth century until many of its locks were blown up to release waters from a powerful 1913 flood. At the turn of the century, several local companies (Firestone, Goodyear, others) took advantage of the advent of the automobile and began manufacturing tires. This prompted a wave of immigrants, causing tremendous growth and a need

for water that resulted in the creation of a large surface-water reservoir system on the upper Cuyahoga River. The rubber industry moved south and overseas during the last quarter of the twentieth century and was succeeded by smaller polymer-based industries. The southern part of downtown has become a major restaurant and nightclub area, with restored segments of the Ohio & Erie Canal. We hope that you take advantage of your stay to visit this area.

The valley of the lower Cuyahoga River between Akron and Cleveland remained rural until the mid-1970s when the National Park Service created what is now known as the Cuyahoga Valley National Park. This area had remained rural because of low-yield aquifers, steep topography, and low-permeability soils that defied septic system designs. The national park contains over 30,000 acres of wooded ravines and overgrown farmland, and was the third most visited national park in the nation in 2004. Hiking trails abound; the crown jewel is the towpath trail that runs from the city limits of Cleveland, south through Akron, eventually ending near Zoar, Ohio, 30 miles south of Akron.

### REGISTRATION

**Standard Registration Deadline:** 20 March 2006

**Cancellation Deadline:** 27 March 2006

#### Registration Fees

	Standard	On-site
Professional Member.....	US\$140	US\$160
Professional Nonmember.....	US\$175	US\$195
Student Member .....	US\$40	US\$55
Student Nonmember .....	US\$55	US\$65
K–12 Professional .....	US\$30	US\$30
Guest.....	US\$30	US\$30

GSA Headquarters will handle meeting registration. Please register online at [www.geosociety.org](http://www.geosociety.org). On-site registration will be available during the meeting at the Student Union on the University of Akron campus. Register in advance to qualify for lower rates.

#### On-Site Registration Schedule

Wednesday, 19 April	4:30–8 p.m.
Thursday, 20 April	7:30 a.m.–4:30 p.m.
Friday, 21 April	7:30 a.m.–noon

### STUDENT TRAVEL

The North-Central Section and the GSA Foundation have made travel assistance grants available for GSA Student Members and Associates to attend the North-Central Section Meeting. Assistance is offered with priority given to students presenting oral or poster papers. More information is available on the North-Central Section Web site, <http://ncgsa.unl.edu/current-forms/student-forms.htm>.

### STUDENT AWARDS

Awards will be given for the best student (undergraduate and graduate) oral and poster presentations. To be eligible, a student must be the lead author and the presenter, and she or

he should be capable of answering detailed questions about the research project.

## CALL FOR PAPERS

**Abstract Deadline:** 25 January 2006

If you wish to participate in a particular symposium or theme session or would like more information on these symposia and sessions, please contact one of the individuals responsible for the specific symposium or session. Symposia participants must contact the organizer(s) listed for an invitation. Volunteered papers will be considered for any general discipline session as listed on the GSA abstracts form. An individual may be a presenter for only one volunteered paper in either a theme or general discipline session (symposia papers are excepted) but may co-author any number of abstracts. Abstracts for all sessions must be submitted online at [www.geosociety.org/sectdiv/northc/06ncmtg.htm](http://www.geosociety.org/sectdiv/northc/06ncmtg.htm). An abstract submission fee of US\$10 will be charged. If you cannot submit your abstract electronically, contact Nancy Carlson, +1-303-357-1061, [ncarlson@geosociety.org](mailto:ncarlson@geosociety.org).

Oral presentations in most technical sessions will be 15 min long with 5 min for questions. All oral sessions will use a single digital projector and PowerPoint software running on Gateway laptop computers. **Please embed all links in your PowerPoint presentation. Presentations prepared using MacOS should be saved through a Windows machine to assure compatibility.** Computers will be available in the speaker ready-room for this purpose.

Use of overhead projectors and 35 mm slides is discouraged and can only be accommodated by special arrangement with the session chair. Poster space will be 4' × 8', and authors must be present at their poster for at least two hours. Authors with posters requiring an electrical connection must make arrangements with the technical program chair in advance, and a fee may be charged.

## TECHNICAL PROGRAM

Descriptions of symposia and theme sessions can be found at [www.geosociety.org/sectdiv/northc/06ncmtg.htm](http://www.geosociety.org/sectdiv/northc/06ncmtg.htm).

### Symposia

- Carboniferous Sedimentology and Stratigraphy.** Sponsored by *Great Lakes Section, Society for Sedimentary Geology (SEPM)*. Elizabeth Gierlowski-Kordesch, Ohio University, [gierlows@ohio.edu](mailto:gierlows@ohio.edu); Ronald Martino, Marshall University, [martinor@marshall.edu](mailto:martinor@marshall.edu).
- A Tribute to the Life and Work of Barry Miller.** Rodney Feldmann, Kent State University, [rfeldman@kent.edu](mailto:rfeldman@kent.edu); Michael Tevesz, Cleveland State University, [tevesz@urban.csuohio.edu](mailto:tevesz@urban.csuohio.edu).
- Cultural Geology: Building Stones, Gravestones, Cement, Gemstones, and Terrain.** Sponsored by *GSA Geology and Society Division*. Joe Hannibal, Cleveland Museum of Natural History, [hannibal@cmnh.org](mailto:hannibal@cmnh.org).
- Fractures in Ohio's Glacial Till.** Julie Weatherington-Rice, Ohio State University, [weatheringtn-rice.1@osu.edu](mailto:weatheringtn-rice.1@osu.edu).
- Glacial Geology: Sediment, Landforms, and Chronology.** Timothy Fisher, University of Toledo, [timothy.fisher@utoledo.edu](mailto:timothy.fisher@utoledo.edu); Mandy Munro-Stasiuk, Kent State University, [mmunrost@kent.edu](mailto:mmunrost@kent.edu).

- The World Encompassed: New and Collaborative Research in Cenozoic Processes at University of Akron and Kent State University.** Alison Smith, Kent State University, [alisonjs@kent.edu](mailto:alisonjs@kent.edu); Lisa Park, University of Akron, [lepark@uakron.edu](mailto:lepark@uakron.edu).

### Theme Sessions

- Biophysical Forcing of Water Quality in Large Lakes.** Joseph Ortiz, Kent State University, [jortiz@kent.edu](mailto:jortiz@kent.edu); Donna Witter, Kent State University, [dwitter@kent.edu](mailto:dwitter@kent.edu).
- Biological Lake Proxies of Paleoenvironmental and Climate Change.** Julie Wolin, Cleveland State University, [j.wolin@csuohio.edu](mailto:j.wolin@csuohio.edu); Jeffrey Snyder, Bowling Green State University, [jasnyd@bgnet.bgsu.edu](mailto:jasnyd@bgnet.bgsu.edu).
- Lakes: A Reflection of Their Watersheds.** Dana Oleskiewicz, Ohio State University, [oleskiewicz.1@osu.edu](mailto:oleskiewicz.1@osu.edu); Greg Nageotte, Ohio Department of Natural Resources, [greg.nageotte@dnr.state.oh.us](mailto:greg.nageotte@dnr.state.oh.us).
- Lakes and Rivers: Environmental Concerns.** Dina L. Lopez, Ohio University, [lopezd@ohio.edu](mailto:lopezd@ohio.edu); Elizabeth Gierlowski-Kordesch, Ohio University, [gierlows@ohio.edu](mailto:gierlows@ohio.edu).
- Technology for Water Resource Management.** Mike Angle, Ohio Department of Natural Resources, [mike.angle@dnr.state.oh.us](mailto:mike.angle@dnr.state.oh.us); Wayne Jones, Ohio Department of Natural Resources, [wayne.jones@dnr.state.oh.us](mailto:wayne.jones@dnr.state.oh.us).
- Dam Removals as a Tool for River Restoration.** Sponsored by *GSA Geology and Society Division; GSA Geology and Public Policy Committee*. James E. Evans, Bowling Green State University, [evansje@bgsu.edu](mailto:evansje@bgsu.edu).
- Fate and Transport of Nitrate in Hydrologic Systems of Agricultural Watersheds.** Mohammad Iqbal, University of Northern Iowa, [m.iqbal@uni.edu](mailto:m.iqbal@uni.edu); Shafiul Chowdhury, State University of New York–New Paltz, [chowdhus@newpaltz.edu](mailto:chowdhus@newpaltz.edu).
- Karst in Glaciated Regions.** C. Pius Weibel, Illinois State Geological Survey, [weibel@isgs.uiuc.edu](mailto:weibel@isgs.uiuc.edu); Patrick Mills, U.S. Geological Survey, [pcmills@usgs.gov](mailto:pcmills@usgs.gov).
- Slope Stability Considerations in the Appalachian Region: Investigation, Design, and Remediation.** Abdul Shakoor, Kent State University, [ashakoor@kent.edu](mailto:ashakoor@kent.edu); Brian Greene, U.S. Army Corps of Engineers, Pittsburgh District, [brian.greene@lrp02.usace.army.mil](mailto:brian.greene@lrp02.usace.army.mil).
- Solid Waste Disposal and Geology.** Lynn Chyi, University of Akron, [lchy@uakron.edu](mailto:lchy@uakron.edu).
- Multi-Proxy Investigations of Black Shales: What Can They Tell Us?** Sue Rimmer, University of Kentucky, [srimmer@uky.edu](mailto:srimmer@uky.edu); Harry Rowe, University of Kentucky, [hrowe@uky.edu](mailto:hrowe@uky.edu).
- Geoarchaeology Studies of Mounds and Earthworks in the Ohio Valley.** David Cremeens, GAI Consultants, Inc., [d.cremeens@gaiconsultants.com](mailto:d.cremeens@gaiconsultants.com).
- Teaching and Practicing Geophysical Prospecting in Archaeology.** Timothy Matney, University of Akron, [matney@uakron.edu](mailto:matney@uakron.edu); Mark Schurr, University of Notre Dame, [mark.r.schurr.1@nd.edu](mailto:mark.r.schurr.1@nd.edu).
- Evaluating Student Learning in Geoscience Courses.** Sponsored by *Central Section, National Association of Geoscience Teachers*. David Steer, University of Akron,

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- steer@uakron.edu; David McConnell, University of Akron, dam6@uakron.edu.
- Issues in Geoscience Education.** Sponsored by *Central Section, National Association of Geoscience Teachers*. Annabelle Foos, University of Akron, afoos@uakron.edu; Cinzia Cervato, Iowa State University, cinzia@iastate.edu.
  - Climate Change, Natural Hazards, and the Teaching of Earth System Science.** Sandra Rutherford, Eastern Michigan University, srutherford@emich.edu.
  - Countering Creationism in the Classroom.** Sponsored by *Central Section, National Association of Geoscience Teachers*. Patricia Princehouse, Case Western Reserve University, evolution@case.edu.
  - Recent Advances in Systematics, Evolution, and Paleobiology of Fossil Vertebrates.** Darin Croft, Case Western Reserve University, dcroft@case.edu; Michael Ryan, Cleveland Museum of Natural History, mryan@cmnh.org.
  - Fossils of Ohio: A Century after Newberry.** Lisa Park, University of Akron, lepark@uakron.edu.
  - Using Biogeochemistry to Solve Paleontologic and Geologic Problems.** David Goodwin, Denison University, goodwind@denison.edu.
  - Carbon Dioxide Sequestration: From Surface to Subsurface and All Points in between, Terrestrial, Geologic, and Applied.** Ernie R. Slucher, Ohio Geological Survey, ernie.slucher@dnr.state.oh.us.
  - Undergraduate Research Poster Session.** Sponsored by *Council on Undergraduate Research, Geoscience Division*. Robert D. Shuster, University of Nebraska–Omaha; David J. Matty, Central Michigan University; Karen Fryer, Ohio Wesleyan University; Joseph Ortiz, Kent State University, jortiz@kent.edu.
  - Phytoremediation.** Alison L. Spongberg, University of Toledo, alison.spongberg@utoledo.edu.

### FIELD TRIPS

For further information regarding these field trips, please contact the field trip leader(s) indicated below, or the field trip czar, Joe Hannibal, +1-216-231-4600 ext. 3233, hannibal@cmnh.org. All trips will leave from the University of Akron's Gardner Student Center at 8 a.m. and return to the Student Center at 6 p.m. on the day indicated. All trips, except the trip along Lake Erie, will be one day. Trips are limited to 44 people.

### Premeeting

- Geologic Setting and Processes along Lake Erie from Fairport to Sandusky, Ohio.** (Two-day trip) Tues.–Wed., 18–19 Apr. Donald Guy, Ohio Department of Natural Resources, Ohio Division of Geological Survey, +1-419-626-4296, don.guy@dnr.state.oh.us; Laura Moore, Oberlin College, laura.moore@oberlin.edu.

We will examine the geologic setting and processes of the Lake Erie shore from the 15-m-high bluffs of Ohio's eastern lakeshore to the low lake plain and wetlands of the western lakeshore. Stops will provide access to glaciolacustrine sediments and tills and to Devonian shale and limestone. We will also consider the impacts of urbanization on lakeshore processes and geologic resources. Access to some stops will involve walking across irregular terrain

and exposure to the elements, including winds off the lake. Please bring appropriate footwear and clothing. Overnight in Vermilion, Ohio. Cost: US\$140, includes coffee and donuts the first morning, box lunch the first day, breakfast the second day, transportation, overnight accommodation (double occupancy), and field guide.

- The Geology and Hydrology of Gorge Metro Park, Cuyahoga Falls, Ohio.** (One-day trip) Wed., 19 Apr. Annabelle Foos, University of Akron, +1-330-972-7991, afoos@uakron.edu.  
Classic exposures of the Pennsylvanian Sharon Formation and underlying Mississippian Cuyahoga Formation at Gorge Metro Park in Cuyahoga Falls will be visited. We will have a unique glimpse into the Sharon Aquifer where it has been recently dissected by downcutting of the Cuyahoga River at the Cuyahoga Falls Gorge. The chemistry of natural springs and seeps at this location has yielded information about the heterogeneous flow through the aquifer. Early settlers built dams and associated mills where the rivers flowed over resistant layers such as the Sharon Formation. We will discuss the history of power generation at the site and controversy over the removal of dams along the Cuyahoga River. Sample collection is prohibited within the park. Field trip will involve ~3 miles of hiking on groomed trails. Cost: US\$45, includes morning coffee and donuts, box lunch, transportation, and field guide.
- Guide to the Building Stones and Cultural Geology of Akron.** Sponsored by *National Association of Geoscience Teachers, Central Section*. (One-day trip) Wed., 19 Apr. Joe Hannibal, Cleveland Museum of Natural History, +1-216-231-4600 ext. 3233, hannibal@cmnh.org.

This trip will explore the relationship between the setting of Akron on a major divide underlain chiefly by the Sharon Formation and its development as a city. It will pay special attention to the use of building stone, including the Sharon, in constructing the city. Individual stops, chosen for their geological, cultural, and historical importance, will include the Portage Path, historic stone buildings, canal locks, the John Brown Monument, a garden-style cemetery with a large Civil War memorial, stone fences and bridges, and modern buildings clad in limestone and granite. This trip is open to guests as well as professionals. Cost: US\$50, includes morning coffee and donuts, lunch (sandwich and fruit), transportation, and field guide.

- Hydrogeologic Setting and Design of a Sanitary Landfill: American Landfill, Stark County, Ohio.** (One-day trip) Wed., 19 Apr. Mohammed Ali, Waste Management, +1-330-575-4329, mali1@wm.com.

This trip will review the hydrogeologic strata directly beneath and surrounding a municipal solid-waste landfill that resides on a former strip mine in southeast Stark County. There will be discussions of the history of the facility, landfill cell construction, groundwater protection systems, groundwater monitoring, and expansion. In a period when protection of groundwater resources is of major concern, the construction and operation of facilities designed with the protection of groundwater, surface water, and air should be of interest to all who work in hydrogeologic and

related fields. Cost: US\$40, includes morning coffee and donuts, box lunch, transportation, and handouts.

### Postmeeting

5. **Quaternary Geology of the Interlobate Area between the Cuyahoga and Grand River Lobes, Northeastern Ohio.** (One-day trip) Sat., 22 Apr. John P. Szabo, University of Akron, +1-330-972-8039, jpszabo@uakron.edu; Mike Angle, Ohio Geological Survey, mike.angle@dnr.state.oh.us; Julie Weatherington-Rice, weatheringtn-rice.1@osu.edu; Mandy Munro-Stasiuk, mmunrost@kent.edu

This trip will examine the topography and stratigraphy of the interlobate area formed during the topographically controlled late Wisconsinan glaciation in northeastern Ohio. This area directed meltwater from both the Cuyahoga and Grand River lobes into the Ohio River drainage system. It includes a large and poorly understood area of ice-contact features deposited during the advance of Kent ice and an area of kames along the eastern margin of the Cuyahoga lobe that was overridden by younger advances. One stop will illustrate the complex interaction of glacial stratigraphy and local hydrology in maintaining wetlands, whereas another may illustrate possible thrust-stacking of Illinoian till sheets. One stop may include a dye test in fractured till. Access to some stops will involve walking across irregular terrain and exposure to the elements. Some wading of streams may be expected; bring your own knee boots. Cost: US\$75, includes morning coffee and donuts, box lunch, afternoon snack, transportation, and field guide.

6. **Surface Water Hydrology of The Wilds, a Reclaimed Surface Mine, Southeastern Ohio.** (One-day trip) Sat., 22 Apr. Stephen Van Horn, Muskingum College, +1-740-826-8306, svanhorn@muskingum.edu.

This trip will examine the hydrology and water chemistry of lakes, streams, and springs on a reclaimed surface mine. We will examine changes in reclamation practices and the effect these practices have had on the topography, soil, and hydrology across The Wilds. We will also examine the water chemistry of flow-through versus non-flow-through lakes. One stop will focus on the influence of groundwater and springs in the water chemistry of the lakes. The last stop of the trip will visit Big Muskie's bucket at the Miner's Memorial Park in Reinersville, Ohio. There will be moderate hiking involved to reach some of the lakes. Please bring appropriate footwear, clothing, and bug spray as ticks can be a problem. Cost: US\$50, includes morning coffee and donuts, box lunch, transportation, and handouts.

7. **Classic Cleveland Shale Localities in the Cleveland, Ohio Area.** (One-day trip) Sat., 22 Apr. Joe Hannibal, Cleveland Museum of Natural History, +1-216-231-4600 ext. 3233, hannibal@cmnh.org; Susan M. Rimmer, University of Kentucky, srimmer@uky.edu; Robert K. Carr, Ohio University, carr1@ohio.edu; Philip O. Banks, Case Western Reserve University, pobanks@ameritech.net.

Classic localities of the Cleveland Shale Member of the Ohio Shale, including outcrops along the Rocky River to the west of Cleveland, the type area along Doan Brook, and Euclid Creek to the east of Cleveland, will provide a close look at the Cleveland Shale and its components,

including the Skinners Run pyrite bed, a prominent basal lag deposit. Long-term collecting from this sparsely fossiliferous Famennian rock unit has yielded a rich, world-famous fauna of fossil fish as well as fossil invertebrates and plants. There will be some walking in streams: wear nonslip shoes that can get wet. Cost: US\$55, includes morning coffee and donuts, lunch (sandwich and fruit), transportation, and field guide.

8. **Geology of the Cuyahoga Valley National Park.** (One-day trip) Sat., 22 Apr. David Hacker, Kent State University, +1-330-675-8831, dhacker@kent.edu; Neil A. Wells, Kent State University, nwells@kent.edu; Tom Nash, National Park Service, tom\_nash@nps.gov.

We will explore the unique geologic and cultural beauty of Cuyahoga Valley National Park and see what inspired its formation in the year 2000, thus making it one of our newest National Parks. The park has been sculpted over time by running water, glaciers, and mass wasting; we will view many of its diverse landscape features, including meandering streams, deep gorges, ravines, towering rock ledges, and numerous waterfalls, and discuss the geologic processes of their formation. We will also see examples of ancient streams and shallow marine environments preserved in the exposed Upper Paleozoic bedrock, as well as glacial features left by retreating Pleistocene glaciers. Early human occupation of the valley is well preserved within the park. Historic towns boomed with the establishment of the Ohio & Erie Canal in the early 1820s; many of the locks, canal houses, and mills associated with the canal industry remain. The old farms, canal structures, and small towns within the park maintain a distinct New England look in the valley. We will stop at a number of these culturally important historic sites that have ties to the local geology. This field trip will involve ~3 miles of hiking on well maintained park trails. Sample collecting is prohibited within the national park. This trip is open to guests as well as professionals. Cost: US\$50, includes morning coffee and donuts, box lunch, transportation, and written materials.

### WORKSHOPS AND STUDENT ACTIVITIES

1. **Roy J. Shlemon Mentor Program in Applied Geoscience.** Sponsored by *GSA Foundation*. Thurs.–Fri., 20–21 Apr., 11:30 a.m.–1 p.m., Student Union, Room 335. Karlon Blythe, kblythe@geosociety.org. Lunch provided. This interactive and informative program for undergraduate and graduate students, led by professional geoscientists, will cover real life issues including professional opportunities and challenges that await students after graduation. Plan to attend both free luncheons to hear different presenters each day. Students will receive FREE LUNCH tickets in their registration packet to attend both Shlemon Programs, but space is limited: first come, first served.
2. **The John Mann Mentors in Applied Hydrogeology Program.** Sponsored by *GSA Foundation*. Thurs., 20 Apr., 5–6:30 p.m. Student Union, Room 335. Karlon Blythe, kblythe@geosociety.org. This early evening event presents mentoring opportunities for undergraduate and graduate students and recent graduates with interest in applied hydrogeology or hydrology as a

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career to interact and network with practicing hydro-geologic professionals. This program is a focused, small-scale event that features free pizza for participants. Every student will receive a FREE Pizza Dinner ticket in his or her registration packet to attend the Mann Program, but space is limited: first come, first served.

- Teaching Evolution in the K–12 Classroom.** Sponsored by *Central Section, National Association of Geoscience Teachers*. Sat., 22 Apr., 9 a.m.–4 p.m., Pamela Keiper, Cleveland Museum of Natural History, pkeiper@cmnh.org. Classroom techniques for teaching the basic concepts of evolution and the diversity of life throughout the K–12 curriculum. Fee: US\$25, includes resource packet and continental breakfast.
- Measurement of Indoor Radon in Geologically Diverse Terrains.** Tue.–Wed., 18–19 Apr., 9 a.m.–5 p.m., Crouse Hall, Room 119. Douglas Mose and George Mushrush, George Mason University, Fairfax, Virginia. This workshop provides training to understand, anticipate, and measure geologically dependent indoor radon and waterborne radon. Course is designed for teachers and researchers. An exam, if passed, earns a Radon Measurement Specialist Certificate (National Radon Safety Board, info@nrsb.org) for employment as a home inspector in the real estate market. A general knowledge of soil and hydrology is required. Min.: 5; max.: 25. Fee: US\$380, includes course manual and test.
- Using the Paleobiology Database (PBDB).** Sat., 22 Apr., 9 a.m.–1 p.m., Location TBA. Instruction team from PDPB; Arnie Miller, Department of Geology, University of Cincinnati, arnie.miller@uc.edu. Learn how to use the Paleobiology Database with this hands-on workshop. Computer terminals will be available for participants who will learn how to utilize the PBDB to answer paleobiological questions. Free, but registration is required.

### SPECIAL EVENTS

**Welcome Reception.** Wed., 19 Apr. 7–9 p.m. Student Union, Ballrooms A & B. Free.

**North-Central GSA Management Board Breakfast and Business Meeting.** Thurs., 20 Apr., 7–8:30 a.m. Student Union, Rm. 306. Invitation only.

**Great Lakes SEPM and Paleontological Society Luncheon.** Thurs., 20 Apr., noon–1 p.m. Martin Center, North Room. Cost: US\$20.

**North-Central GSA General Business Meeting:** Thurs., 20 Apr., 5:30–6 p.m. Student Union Auditorium. Free.

**Keynote Address by Richard Alley.** Thurs., 20 Apr., 6–7 p.m. Student Union Auditorium: “Seasons in the Sun: New Insights on Abrupt Climate Change from Terrestrial Records.” Free.

**Caribbean Bash (Gala Party).** Thurs., 20 Apr., 7–9:30 p.m. Student Union, Ballrooms A & B. Visit with colleagues and make new connections while enjoying exotic hors d’oeuvres and the internationally renowned University of Akron Steel Drum Band. Cost: US\$5.

**North-Central GSA Campus Representatives Continental Breakfast.** Fri., 21 Apr., 7 a.m., Student Union, Rm. 306.

Representatives only; please e-mail jpszabo@uakron.edu by 11 Apr. if you plan to attend.

**Association of Women Geoscientists Informal Breakfast Meeting.** Fri., 21 Apr., 7 a.m. Meet in the lobby of the Crowne Plaza Hotel. Please e-mail afoos@uakron.edu by 11 Apr. if you plan to attend.

**Central Section National Association for Geoscience Teachers (NAGT) Luncheon and Business Meeting.** Fri., 21 Apr., noon–1 p.m. Martin Center, South Room. Cost: US\$20.

**Local Committees Meeting (2005–2008).** Fri., 21 Apr., 4:30 p.m. Leaves from the south entrance of the Student Union.

**Pub Crawl through the South End.** Fri., 21 Apr., 5:30 p.m. Starts from the south entrance of the Student Union.

### GUEST ACTIVITIES

The Akron-Cleveland area offers a variety of cultural venues. These range from tours of Amish country to the Rock and Roll Hall of Fame. Northeastern Ohio supported the abolitionist movement before the Civil War and was an important stopping point on the Underground Railroad. John Brown lived both in Hudson, 10 miles northeast of Akron, and in west Akron. The following guest activities are scheduled and will run based on sufficient interest.

- Tour of Stan Hywet, a Tudor-style mansion formerly owned by the Seiberling family who made their fortune in the rubber industry, and the Cuyahoga Valley National Park.** Thurs., 20 Apr., 10 a.m. Depart from the south entrance of the Student Union. Lunch stop will be made. Cost including admission: US\$30. Min.: 8; registration deadline 11 Apr.
- Tour of the Rock and Roll Hall of Fame, Cleveland.** You saw it on the *Drew Carey Show* and are only a short trip away. Fri., 21 Apr., 9:30 a.m. Depart from the south entrance of the Student Union. Lunch may be purchased at the Rock Hall. Cost including admission: US\$40. Min.: 8; registration deadline 11 Apr.

### EXHIBITS

Booth and table space will be available in Ballrooms A & B of the Student Union adjacent to the poster sessions. Contact John Peck, Department of Geology, University of Akron, +1-330-972-7659, jpeck@uakron.edu.

### TRAVEL TO AKRON

Akron is linked to the interstate system and can be reached via I-77 and I-76, which connect to I-71, I-80, and I-90. Both Cleveland Hopkins airport (CLE; 40 miles away) and Akron-Canton Regional Airport (CAK; 14 miles away) are close to Akron. Most major airlines service Cleveland Hopkins, and limousine service is available to Akron. We recommend Akron-Canton airport because of its proximity to Akron (15 min), easy check-through, and direct access to the interstate system. Akron-Canton is served by AirTran, Delta, Frontier, Northwest AirlinK, United Express, and US Airways Express. The recommended shuttle company for transportation to and from the airport is SOS (+1-330-494-5800). Their rate is US\$35 for the first customer and US\$5 for each additional customer, and they



can accommodate 10 passengers and luggage. Please e-mail Elaine at [sinkovi@uakron.edu](mailto:sinkovi@uakron.edu) with your arrival time at CAK, and she will make sure that SOS is waiting. The major car rental agencies have offices at or near the airport.

### ACCOMMODATIONS

The Crowne Plaza Hotel is the official meeting hotel; a block of rooms has been reserved there for the meeting. It's location in the former Quaker Oats processing plant will provide a unique experience during your stay in Akron. Rooms are located in the former grain silos, and shops and restaurants occupy the remaining space. The Crowne Plaza is about three blocks from the Student Union and five blocks from the south-side restaurant and club district. The special GSA rate (tax excluded) is US\$70 for a single and US\$10 for each additional person. To ensure that you receive the GSA discount, call the Crowne Plaza Hotel directly at +1-330-253-5970. Other hotels are available in downtown Akron, adjacent to I-77 in the Montrose area west of Akron, and off State Route 8, north of Akron.

### SHUTTLE SERVICE

The Student Union is less than a 10-min walk from the Crowne Plaza, but limited van shuttle service will also be available between the south entrance of the Student Union and the Crowne Plaza, as scheduled:

Wed., 19 Apr., 4:30–9:30 p.m.

Thurs., 20 Apr., 7–9 a.m. and 6:30–9:30 p.m.

Fri., 21 Apr., 7–9 a.m. and 5–6:30 p.m.

### PARKING

As with many urban campuses, parking is tight. Please make

sure that your e-mail address is up-to-date in GSA records; we will attempt to e-mail you a parking permit useable in any lot or ramp. This is to be displayed on the dashboard of your vehicle, including Wed. and Sat. for those of you attending field trips. Remember that there are a large number of students on campus 10 a.m.–3 p.m.

### INTERNET ACCESS

The University of Akron is one of the most wired campuses in the nation; service is available throughout campus. The campus system supports the following wireless cards: Cisco Aironet 340 & 350 series, Dell True Mobile 1300 or higher, Broadcom, Intel Proset 2100's and 2200's b/g, and Atheros. Additional information will be available in your information packet. Stand-alone kiosks are available in the Student Union; instructions for accessing these will be available on-site.

### ACCESSIBILITY

GSA is committed to making its meetings accessible to all people interested in attending. Please indicate special requirements (wheelchair accessibility, etc.) on the registration form. The Student Union is ADA compliant.

### ADDITIONAL INFORMATION

Requests for additional information should be addressed to the general chair, John Szabo, +1-330-972-8039, [jpszabo@uakron.edu](mailto:jpszabo@uakron.edu). Technical program questions should be addressed to Lisa Park, +1-330-972-7633, [lepark@uakron.edu](mailto:lepark@uakron.edu), or Ira Sasowsky, +1-330-972-5389, [ids@uakron.edu](mailto:ids@uakron.edu), Department of Geology, University of Akron, Akron, OH 44325-4101, USA.

## Call for Applications



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

Opportunities to serve as a Congressional Science Fellow are rare, unique experiences.

This position may be a good fit for you. It will enable you to work directly with national leaders and put your expertise and experience to work helping shape science and technology policy on Capitol Hill.

The Congressional Science Fellow will be selected from top competitors early in 2006. Prospective candidates should be GSA Members with a broad geoscience background and excellent written and oral communication skills.

Minimum requirements are a master's degree with at least five years professional experience or a Ph.D. at the time of appointment.

If you possess this professional background, have experience in applying scientific knowledge to societal challenges, and share a passion for helping shape the future of the geoscience profession, GSA invites your application.

The fellowship is open to U.S. citizens or permanent U.S. residents.

### Deadline to apply: 1 February 2006

For application information, visit [www.geosociety.org/science/csf/](http://www.geosociety.org/science/csf/)  
or contact Ginger Williams, GSA Headquarters +1-303-357-1040, [gwilliams@geosociety.org](mailto:gwilliams@geosociety.org).



# JOINT MEETING

**102nd Annual Meeting of the Cordilleran Section, GSA; 81st Annual Meeting of the Pacific Section, AAPG; and the Western Regional Meeting of the Alaska Section, SPE  
Anchorage Hilton Hotel, Anchorage, Alaska**

**8–10 May 2006**

### **THEME: NORTH TO ALASKA: GEOSCIENCE, TECHNOLOGY AND NATURAL RESOURCES**

The 2006 annual meetings of the Cordilleran Section, GSA; the Pacific Section, American Association of Petroleum Geologists (AAPG); and the Alaska Section, Society of Petroleum Engineers (SPE), will be held jointly at the Hilton Hotel in Anchorage, Alaska. Details about the meeting can be found at <http://anchorage2006.com>.

### **ENVIRONMENT**

The city of Anchorage is located in a natural setting of unparalleled beauty, nestled between the wilderness of the Chugach Mountains and the two arms of upper Cook Inlet. Five mountain ranges and a number of active volcanoes can be seen from the city. The second highest bore tides in North America, numerous glaciers, and land submerged by the largest earthquake in North America are within easy driving distance. Temperatures are mild in early May (50–60 °F), with long hours of daylight.

Anchorage is served by several major airlines through Ted Stevens International Airport, ~5 miles from downtown. The meeting site is the Anchorage Hilton Hotel in the heart of downtown Anchorage. The Hilton is located three blocks from the Alaska Railroad station and several citywide bus routes. It is within easy walking distance of numerous restaurants and clubs, downtown shops, museums, bookstores, and Cook Inlet.

Please make plans to join us and your fellow geoscientists, engineers, and other professionals in a truly amazing state that boasts the nation's largest national parks, largest oil fields, and glaciers the size of other states!

### **CALL FOR PAPERS**

Papers are invited for a variety of technical sessions (oral and poster), including one symposium and many theme sessions. Authors interested in volunteering papers for the symposium should contact the appropriate convener prior to submitting an abstract. Oral presentations in most technical sessions will be 15–20 min, including 3–5 min for questions. SPE sessions will have 30-min presentations. Please contact session chairs for format details. All oral sessions will utilize a single digital projector and PowerPoint software. An overhead projector can be made available in each room. Use of 35 mm slides is discouraged and will only be accommodated by special arrange-

ment with the technical program chair at an additional cost. Requests for slide projectors must be made one month prior to the meeting. Dimensions for poster space can be found at <http://anchorage2006.com>; authors are required to be present at their poster for at least two hours.

### **ABSTRACTS**

**Abstract Deadline:** 7 February 2006

Abstracts for all sessions should be submitted online via a link on the meeting Web site, <http://anchorage2006.com>. If you cannot submit your abstract electronically, contact Nancy Carlson, +1-303-357-1061. Only one volunteered paper may be presented by an individual; however, a person may be co-author on other papers. Those invited to the symposium may present an additional paper.

### **REGISTRATION**

**Standard Registration Deadline:** 1 April 2006

Register online at <http://anchorage2006.com>; there is a substantial discount for early registration. On-site registration will be available at the Hilton Hotel during the meeting. Further details will be published at <http://anchorage2006.com> as they become available.

### **ACCESSIBILITY**

GSA, AAPG, and SPE are committed to making their meetings accessible to all people interested in attending. Please indicate special requirements (wheelchair accessibility, etc.) on the registration form. The Hilton Hotel is ADA compliant.

### **FIELD TRIPS**

Details of these and possibly other trips are still being finalized. For updated information on field trips, check <http://anchorage2006.com> or contact the field trip chair, Tom Plawman, at [tplawman@gci.net](mailto:tplawman@gci.net).

1. **Chugach Accretionary Prism and Resurrection Bay Ophiolite.** Dwight Bradley, U.S. Geological Survey, [dbradley@usgs.gov](mailto:dbradley@usgs.gov), +1-907-786-7434; Marti Miller, U.S. Geological Survey, [mllmiller@usgs.gov](mailto:mllmiller@usgs.gov), +1-907-786-7437.
2. **Late Mesozoic and Cenozoic Forearc Basins of the Matanuska Valley.** Jeff Trop, Bucknell University, [jtrop@bucknell.edu](mailto:jtrop@bucknell.edu), +1-570-577-3089; Tom Plawman, [tplawman@gci.net](mailto:tplawman@gci.net), +1-907-272-1232.
3. **Prince William Sound Tidewater Glacier Tour.** Tom Plawman, [tplawman@gci.net](mailto:tplawman@gci.net), +1-907-272-1232.
4. **Denali National Park: Mesozoic Marine and Cenozoic Nonmarine Basins, Tertiary Volcanics, and the Modern Denali Fault.** Phil Brease, National Park Service, [phil\\_brease@nps.gov](mailto:phil_brease@nps.gov), +1-907-683-9551.
5. **Kuparak River Oil Field Tour (tentative).** Gregory Wilson, [gregory.c.wilson@conocophillips.com](mailto:gregory.c.wilson@conocophillips.com), +1-907-263-4748. Sat., 6 May. Attendance for this no-cost trip to the North Slope will be by lottery.
7. **Anchorage 1964 Earthquake Tour.** Late afternoon–evening during the meeting. Tom Plawman, [tplawman@gci.net](mailto:tplawman@gci.net), +1-907-272-1232.

## TECHNICAL SESSIONS

In addition to general technical sessions, the program will include a symposium and a variety of theme sessions. Detailed descriptions of the symposium and theme sessions can be found at <http://anchorage2006.com>.

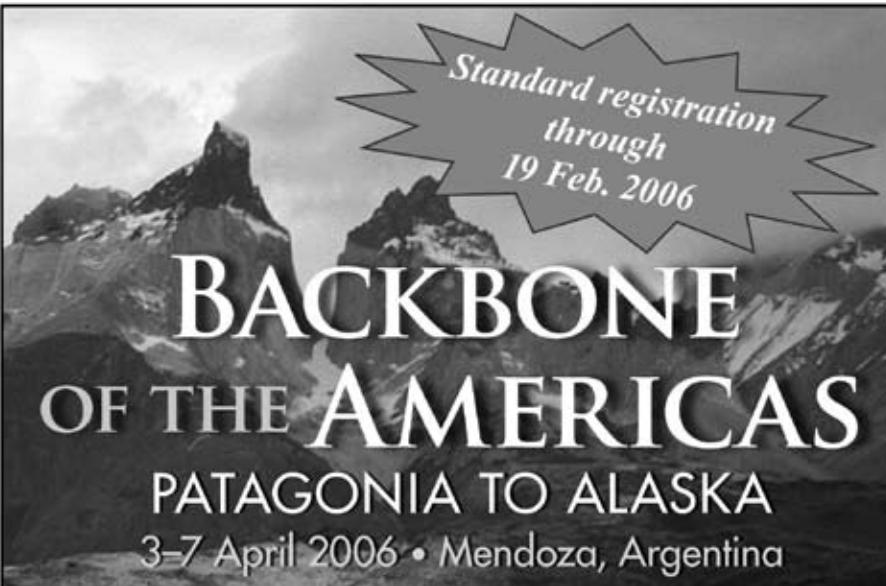
### Symposium

1. **The Brooks Range Orogen: A Symposium in Honor of Gil Mull.** Tom Moore, U.S. Geological Survey, [tmoore@usgs.gov](mailto:tmoore@usgs.gov), +1-650-329-5713; Marwan Wartes, Alaska Division of Geological and Geophysical Surveys, [marwan\\_wartes@dnr.state.ak.us](mailto:marwan_wartes@dnr.state.ak.us), +1-907-451-5056.

### Theme Sessions

#### Joint: Cordilleran Section, GSA, and Pacific Section, AAPG

1. **Foreland Basin Systems: Archives of Coupled Structural and Sedimentary Processes.** Marwan Wartes, Alaska Division of Geological and Geophysical Surveys, [marwan\\_wartes@dnr.state.ak.us](mailto:marwan_wartes@dnr.state.ak.us), +1-907-451-5056.
2. **Forearc Basins: Tectonostratigraphy and Resource Potential.** Bob Swenson, Alaska Division of Oil and Gas, [robert\\_swenson@dnr.state.ak.us](mailto:robert_swenson@dnr.state.ak.us), +1-907-269-8789.
3. **Geology of the Circum-Arctic.** Tom Homza, Shell E&P Co., [thomas.homza@shell.com](mailto:thomas.homza@shell.com), +1-907-770-3701; Jim Clough, Alaska Division of Geological and Geophysical Surveys, [jim\\_clough@dnr.state.ak.us](mailto:jim_clough@dnr.state.ak.us), +1-907-451-5030.
4. **Active Tectonics of the Northern Cordillera.** Peter Haeussler, U.S. Geological Survey, [pheuslr@usgs.gov](mailto:pheuslr@usgs.gov), +1-907-786-7447. Coordinates with Chapman conference on Southern Alaska active tectonics to follow this meeting.
5. **Late Paleozoic–Early Mesozoic Paleogeography of Northern Alaska.** Julie Dumoulin, U.S. Geological Survey, [dumoulin@usgs.gov](mailto:dumoulin@usgs.gov), +1-907-786-7439; Mike Whalen, University of Alaska–Fairbanks, [mtwhalen@gi.alaska.edu](mailto:mtwhalen@gi.alaska.edu), +1-907-474-5302.
6. **New Insights into the Origin and Evolution of the Northern Cordilleran Pericratonic Terranes.** Cynthia Dusel-Bacon, U.S. Geological Survey, [cdusel@usgs.gov](mailto:cdusel@usgs.gov), +1-650-329-5719; JoAnne Nelson, British Columbia Geological Survey, [joanne.nelson@gems1.gov.bc.ca](mailto:joanne.nelson@gems1.gov.bc.ca), +1-250-952-0438.
7. **Wrangellia—Tectonics and Metallogeny, 30 Years of Progress.** Jeanine Schmidt, U.S. Geological Survey, [jschmidt@usgs.gov](mailto:jschmidt@usgs.gov), +1-907-786-7494; Murray Hitzman, Colorado School of Mines, [mhitzman@mines.edu](mailto:mhitzman@mines.edu), +1-303-384-2127; Jason Price, Colorado School of Mines.
8. **Accreted Terranes of Western North America: An Update on Current Research on the Construction of the Cordillera.** Robert B. Blodgett, U.S. Geological Survey, [rblodgett@usgs.gov](mailto:rblodgett@usgs.gov), +1-907-786-7416; Erik C. Katvala, University of Calgary, [eckatval@ucalgary.ca](mailto:eckatval@ucalgary.ca).
9. **Environmental Issues Associated with Mineralized Regions.** LeeAnn Munk, University of Alaska–Anchorage, [aflm@uaa.alaska.edu](mailto:aflm@uaa.alaska.edu), +1-907-786-6895; Bronwen Wang, U.S. Geological Survey, [bwang@usgs.gov](mailto:bwang@usgs.gov), +1-907-786-7110.
10. **High Latitude–Altitude Hydrogeology and Weathering.** Bronwen Wang, U.S. Geological Survey, [bwang@usgs.gov](mailto:bwang@usgs.gov), +1-907-786-7110.
11. **Tectonic Setting of Mineral Occurrences in the Northern American Cordillera.** Bill McClelland, University of Idaho, [mcclell@uidaho.edu](mailto:mcclell@uidaho.edu), +1-208-885-4704; Richard Goldfarb, U.S. Geological Survey, [goldfarb@usgs.gov](mailto:goldfarb@usgs.gov), +1-303-236-2441.
12. **Geoscience Education and Public Outreach in Alaska—Unique Problems, Unique Solutions.** Catherine L. Hanks, University of Alaska–Fairbanks, [chanks@gi.alaska.edu](mailto:chanks@gi.alaska.edu), +1-907-474-5562.
13. **Volcano Hazards and Monitoring.** Steve McNutt, University of Alaska–Alaska Volcano Observatory, [steve@giseis.alaska.edu](mailto:steve@giseis.alaska.edu), +1-907-474-7131; Chris Nye, Alaska Division of Geological and Geophysical Surveys–Alaska



Standard registration  
through  
19 Feb. 2006


# BACKBONE OF THE AMERICAS

## PATAGONIA TO ALASKA


3–7 April 2006 • Mendoza, Argentina

Backbone of the Americas—Patagonia to Alaska is a GSA specialty meeting co-convened with the Asociación Geológica Argentina. The principal themes are ridge collision, shallow subduction, and plateau uplift along the Americas. Field trips are planned to Patagonia, the Chilean flat-slab, or Central Andean Puna plateau before and after the meeting. Suzanne Kay and Victor Ramos are meeting co-chairs.

Co-convened by:



Asociación Geológica  
Argentina



THE  
GEOLOGICAL  
SOCIETY  
OF AMERICA

See [www.geosociety.org/meetings/06boa/](http://www.geosociety.org/meetings/06boa/) for the second circular and to register.

## Joint Meeting

Volcano Observatory, [cnve@kiska.giseis.alaska.edu](mailto:cnve@kiska.giseis.alaska.edu), +1-907-474-7430.

14. **GSA Undergraduate Research Posters.** Jeff Marshall, Cal Poly–Pomona University, [marshall@csu.pomona.edu](mailto:marshall@csu.pomona.edu), +1-909-869-3461.
22. **Bering Glacier Symposium—Tectonics, Glaciology, Hydrology, Hazards, and Biology.** Kristine Crossen, University of Alaska–Anchorage, [afkjc@uaa.alaska.edu](mailto:afkjc@uaa.alaska.edu), +1-907-786-6838.

### Joint: Pacific Section, AAPG, and Alaska Section, SPE

15. **Arctic Gas Resources.** Dave Housenecht, U.S. Geological Survey, [dhouse@usgs.gov](mailto:dhouse@usgs.gov), +1-703-648-6466.
16. **Viscous Oil: Reservoir Characterization and New Technologies.** Sandy Phillips, BP Alaska, [phillis2@bp.com](mailto:phillis2@bp.com), +1-907-564-4587.
17. **New Development and Field Case Histories.** Sandy Phillips, BP Alaska, [phillis2@bp.com](mailto:phillis2@bp.com), +1-907-564-4587.

### Pacific Section, AAPG

18. **Petroleum Geology of Northern Alaska.** Ken Bird, U.S. Geological Survey, [kbird@usgs.gov](mailto:kbird@usgs.gov), +1-650-329-4907.
19. **Rural Energy in Alaska.** Travis Hudson, [ageology@olypen.com](mailto:ageology@olypen.com), +1-360-582-1844.
20. **Brookian Reservoirs of the North Slope.** Ken Helmold, Alaska Division of Geological and Geophysical Surveys, [kph@dnr.state.ak.us](mailto:kph@dnr.state.ak.us), +1-907-269-8673; Bill Morris, ConocoPhillips, [william.r.morris@conocophillips.com](mailto:william.r.morris@conocophillips.com), +1-281-293-4463.
21. **Reservoir Characterization: Recent Advances in Appraisal and Development.** Steve Jones, BP Alaska, [steve.jones@bp.com](mailto:steve.jones@bp.com), +1-907-564-5831.

### Alaska Section, SPE

Regarding these sessions, contact Gordon Posposil, BP, [pospigs@bp.com](mailto:pospigs@bp.com), +1-907-564-5769:  
Rotary and Coiled Tubing Drilling Applications  
Well Integrity Management  
Completion Innovations  
Reservoir Characterization and Formation Damage  
Surface Facility Applications  
Improved Oil Recovery and Reservoir Management  
Production Optimization and Artificial Lift  
Drilling Technology  
Novel Applications  
Independents  
GEMS Sessions (Short Topics)  
Student Papers

### STUDENT ACTIVITIES

**Roy J. Shlemon Mentor Program in Applied Geoscience.** Sponsored by *GSA Foundation*. Mon.–Tues., 8–9 May, 11:30 a.m.–1 p.m. Lunch provided; location information will be available at the meeting registration desk. Karlton Blythe, [kblythe@geosociety.org](mailto:kblythe@geosociety.org). This is a chance for students to discuss career opportunities and challenges with professional geoscientists from multiple disciplines. Plan to attend both free luncheons to hear different presenters. Students will receive FREE LUNCH tickets in their registration packet to attend the

Shlemon Programs. However, space is limited: first come, first served.

**John Mann Mentors in Applied Hydrogeology Program.** Sponsored by *GSA Foundation*. Tues., 9 May, 5–6:30 p.m. Location information will be available at the meeting registration desk. Karlton Blythe, [kblythe@geosociety.org](mailto:kblythe@geosociety.org). This event starts right after tech sessions end. It presents opportunities for students and recent graduates with interest in applied hydrogeology or hydrology as a career to chat over a meal with professionals practicing in these fields of interest. Students will receive a FREE Pizza Supper ticket in their registration packet to attend the Mann Program. However, space is limited: first come, first served.

### SHORT COURSES

**Alaska's Volcanoes, Earthquakes, and Subduction Zone—Real-Time Earthly Data for Classroom Use.** Sponsored by *National Association of Geoscience Teachers*. Jennifer Adleman, U.S. Geological Survey–Alaska Volcano Observatory, [jadleman@usgs.gov](mailto:jadleman@usgs.gov), +1-907-786-7019, 4200 University Drive, Anchorage, AK 99508, USA; Cathy Connor, University of Alaska–Southeast, [cathy.connor@uas.alaska.edu](mailto:cathy.connor@uas.alaska.edu), +1-907-465-6293.

**Application of Ichnology to Petroleum Exploration and Production.** Sponsored by *Pacific Section, AAPG*. Core Workshop. James MacEachern, Simon Fraser University, +1-604-291-5388, [jmaceach@sfu.ca](mailto:jmaceach@sfu.ca).

### SPECIAL EVENTS

**Icebreaker Reception.** Sun., 7 May, 5–7 p.m., Hilton Hotel.

**Opening Remarks (Henry Posamentier) and Welcoming Reception.** Mon., 8 May; remarks: 4:15–5 p.m.; reception: 5–7 p.m., Hilton Hotel.

**Alaska Section SPE/Pacific Section AAPG Awards Luncheon.** Tues., 9 May, 11:30 a.m.–1 p.m., Hilton Hotel.

**AAPG Division of Professional Affairs.** Wed., 10 May, 11:30 a.m.–1 p.m., Foraker Room.

**Annual Business Meeting,** Cordilleran Section, GSA. Tues., 9 May, 5–7 p.m.

**Annual Business Meeting,** Pacific Section, AAPG. TBA.

**Regional Section Officers' Meeting,** Western Region, SPE. TBA.

### SPOUSE AND GUEST ACTIVITIES

The municipality of Anchorage is located as far north as Helsinki, Finland, as far west as Honolulu, Hawaii, and covers an area nearly the size of the state of Delaware. It is the hub of south-central Alaska, which offers a wide variety of recreational opportunities from fishing, cruising, and bird watching to rock climbing, rafting, hiking, and sight-seeing. Cultural attractions include the Alaska Museum of History and Art, Alaska Native Heritage Center, Z.J. Loussac Library, Alaska Museum of Natural History, the Imaginarium science center, and the Alaska Aviation Heritage Museum. Most attractions are accessible by regularly scheduled bus routes as well as taxi. Anchorage has over 650 miles of hiking, biking, and multi-use trails, many of which wind along the city's greenbelts and creeks.

The Alaska Railroad provides access to Prince William Sound at Seward and Whittier on the Kenai Peninsula, as well as to Denali National Park (home of Mount McKinley, the highest point in North America), Talkeetna, Fairbanks, and other northern destinations.

For information on visitor attractions, sports, events, and tours, please visit the Web sites for the Anchorage Convention and Visitor's Bureau, [www.anchorage.net/2.cfm](http://www.anchorage.net/2.cfm), and the Municipality of Anchorage, [www.ci.anchorage.ak.us/homepage/index.cfm](http://www.ci.anchorage.ak.us/homepage/index.cfm).

#### TRAVEL

Alaska Airlines is offering discounted fares for travel to and from Anchorage in conjunction with this meeting. Fares on Alaska and Horizon airlines from 2 May to 15 May are included in this special offer. The event name for booking these fares is "AAPG Pacific Section Convention." Reservations must be made by contacting the Alaska Airlines group department at +1-800-445-4435.

#### STUDENT TRAVEL

The Cordilleran Section of GSA and GSA Foundation have made travel grants available for students who are presenting oral or poster papers. Students must be currently enrolled and must be members of the relevant section to apply for support. For more information, contact the Cordilleran Section secretary, Joan Fryxell, +1-909-880-5311. The Anchorage Hilton is offering student rates for the meeting. See <http://anchorage2006.com> for more details.

#### STUDENT AWARDS

Awards will be given for best student oral (undergraduate or graduate) and poster (undergraduate only) presentations. To be eligible, students must be lead authors and presenters, and they should clearly identify their abstracts as student work. For further information, contact Dwight Bradley, +1-907-786-7434, [dbradley@usgs.gov](mailto:dbradley@usgs.gov).

#### EXHIBITS

Exhibit booths will be available for commercial and nonprofit organizations. For more information or to reserve a booth, contact Tom Walsh, +1-907-272-1232, [tpwalsh@alaska.net](mailto:tpwalsh@alaska.net).

#### ACCOMMODATIONS

Rooms have been reserved at the Anchorage Hilton Hotel, the meeting headquarters. Special meeting rates are available for professionals as well as students. More information and a link to make hotel reservations are available at the meeting Web site, <http://anchorage2006.com>.

#### ADDITIONAL INFORMATION

To obtain the most complete and up-to-date information, visit <http://anchorage2006.com>. If you have questions or need further clarification, contact any of the convention co-chairs:

**GSA Cordilleran Section:** Jeanine Schmidt, +1-907-786-7494, [jschmidt@usgs.gov](mailto:jschmidt@usgs.gov).

**Pacific Section, AAPG:** Greg Wilson, +1-907-263-4748, [gregory.c.wilson@conocophillips.com](mailto:gregory.c.wilson@conocophillips.com).

**Alaska Section, SPE:** Bill Van Dyke, +1-907-269-8786, [bill\\_van\\_dyke@dnr.state.ak.us](mailto:bill_van_dyke@dnr.state.ak.us).

## Call for Geological Papers

### 2006 GSA Section Meetings

#### SOUTH-CENTRAL SECTION

6-7 March 2006

University of Oklahoma, Norman, Oklahoma

**Standard Registration Deadline: 31 January 2006**

**Information:** Neil Suneson, Oklahoma Geological Survey, University of Oklahoma, 100 E Boyd St., Rm N131, Norman, OK 73019-0628, +1-405-325-3031, [nsuneson@ou.edu](mailto:nsuneson@ou.edu)

#### NORTHEASTERN SECTION

20-22 March 2006

Radisson Penn Harris Hotel and Convention Center  
Camp Hill/Harrisburg, Pennsylvania

**Standard Registration Deadline: 7 February 2006**

**Information:** Noel Potter, Dickinson College, Dept. of Geology, Carlisle, PA 17013-2896, +1-717-245-1340, [pottern@dickinson.edu](mailto:pottern@dickinson.edu)

#### SOUTHEASTERN SECTION

23-24 March 2006

Marriott Hotel, Knoxville, Tennessee

**Abstract Deadline: 5 January 2006**

**Information:** Claudia Mora, University of Tennessee, Dept. of Earth and Planetary Sciences, 1412 Circle Drive, Knoxville, TN 37996-1410, +1-865-974-5499, [cmora@utk.edu](mailto:cmora@utk.edu)

#### NORTH-CENTRAL SECTION

20-21 April 2006

Student Center, University of Akron, Akron, Ohio

**Abstract Deadline: 25 January 2006**

**Information:** John Szabo, Dept. of Geology, University of Akron, Akron, OH 44325-4101, +1-330-972-8039, [jpszabo@uakron.edu](mailto:jpszabo@uakron.edu)

#### CORDILLERAN SECTION

**(Joint Meeting with PSAAPG and SPE-A)**

8-10 May 2006

University of Alaska, Anchorage, Alaska

**Abstract Deadline: 7 February 2006**

#### ROCKY MOUNTAIN SECTION

17-19 May 2006

Western State College, Gunnison, Colorado

**Abstract Deadline: 21 February 2006**

**Information:** Rob Fillmore, Western State College, Dept. of Natural and Environmental Sciences, Gunnison, CO 81231-0001, +1-970-943-2092, [rfillmore@western.edu](mailto:rfillmore@western.edu)

# STUDENTS—Mark Your Calendars!

Plan now to attend a Shlemon Mentor Program in Applied Geoscience and/or a Mann Mentor Program in Applied Hydrogeology at your 2006 Section Meeting to chat one-on-one with practicing geoscientists. These volunteers will answer your questions and share insights on how to get a job after graduation. When programs are scheduled for multiple days, each day's program will offer a different set of mentors.

**FREE lunches** will be served (students only) at the **Shlemon Mentor Programs**. Students will receive a free lunch ticket with their registration badge to attend each Shlemon Program. However, space is limited: first come, first served.

**FREE pizza suppers** will be served (students only) at the **Mann Mentor Programs**. Students will receive a free pizza supper ticket with their registration badge to attend the Mann Program. The Mann Program is geared toward careers in hydrogeology or hydrology. Whether you've already decided to head down the hydro career path or whether you just would like to know more about these career options, this meeting is for you! However, space is limited: first come, first served.

## Mentor Programs for 2006 Section Meetings

For program locations, ask at the Section Meeting registration desk.

### **SOUTH-CENTRAL SECTION MEETING**

University of Oklahoma, Norman, Oklahoma

#### **Shlemon Mentor Program Luncheon:**

Mon., 6 March, 11:30 a.m.–1 p.m.

#### **Mann Mentors in Applied Hydrogeology Program:**

Mon., 6 March, 5–6:30 p.m.

### **NORTH-CENTRAL SECTION MEETING**

Student Center, University of Akron, Akron, Ohio

#### **Shlemon Mentor Program Luncheons:**

Thurs.–Fri., 20–21 April, 11:30 a.m.–1 p.m.

#### **Mann Mentors in Applied Hydrogeology Program:**

Thurs., 20 April, 5–6:30 p.m.

### **NORTHEASTERN SECTION MEETING**

Radisson Penn Harris Hotel and Convention Center

Camp Hill/Harrisburg, Pennsylvania

#### **Shlemon Mentor Program Luncheons:**

Mon.–Tues., 20–21 March, 11:30 a.m.–1 p.m.

#### **Mann Mentors in Applied Hydrogeology Program:**

Mon., 20 March, 5–6:30 p.m.

### **CORDILLERAN SECTION MEETING**

University of Alaska, Anchorage, Alaska

#### **Shlemon Mentor Program Luncheons:**

Mon.–Tues., 8–9 May, 11:30 a.m.–1 p.m.

#### **Mann Mentors in Applied Hydrogeology Program:**

Tues., 9 May, 5–6:30 p.m.

### **SOUTHEASTERN SECTION MEETING**

Marriott Hotel, Knoxville, Tennessee

#### **Shlemon Mentor Program Luncheons:**

Thurs.–Fri., 23–24 March, 11:30 a.m.–1 p.m.

#### **Mann Mentors in Applied Hydrogeology Program:**

Thurs., 23 March, 5–6:30 p.m.

### **ROCKY MOUNTAIN SECTION MEETING**

Western State College, Gunnison, Colorado

#### **Shlemon Mentor Program Luncheons:**

Wed.–Thurs., 17–18 May, 11:30 a.m.–1 p.m.

#### **Mann Mentors in Applied Hydrogeology Program:**

Wed., 17 May, 5–6:30 p.m.



# PENROSE CONFERENCE SCHEDULED

## When Did Plate Tectonics Begin on Earth? Theoretical and Empirical Constraints

13–18 June 2006

Lander, Wyoming, USA

### Conveners:

**Kent C. Condie**, *Department of Earth & Environmental Science, New Mexico Tech, Socorro, New Mexico 87801, USA, kcondie@nmt.edu*

**Alfred Kröner**, *Institut für Geowissenschaften, Universität Mainz, D-55099 Mainz, Germany, kroener@mail.uni-mainz.de*

**Robert J. Stern**, *Geosciences Dept. (FO2.1), University of Texas at Dallas, Box 830688, Richardson, Texas 75083-0688, USA, rjstern@utdallas.edu*

### DESCRIPTION AND OBJECTIVES

Earth is the only planet with plate tectonics, and it is controversial why and when this began. Some argue that plate tectonics already operated in Archean time, whereas others argue for a much later beginning. Numerical experiments show that Earth's thermal boundary layer, the lithosphere, controls mantle convection. We now understand that the sinking of dense lithosphere in subduction zones is responsible for plate motions and seafloor spreading and is the principal way Earth cools. The hotter early Earth may have had a weaker and less dense lithosphere and so had a different style of mantle convection. This theoretical background is essential to provide context for empirical (field and lab analyses) results. Demonstrating that plate tectonics operated at any given time requires evidence for subduction and independent plate motions and rotations.

Understanding when and why plate tectonics began is one of the most important unresolved problems in understanding Earth; progress toward resolving this requires a creative and interdisciplinary effort. The purpose of this conference is to bring together scientists from different disciplines interested in discussing when plate tectonics began. To our knowledge, this is the first time a conference has been proposed specifically to address this issue. The conference will address both theoretical and empirical constraints on when the modern regime of plate tectonics began and what the best ways are to recognize this transition in the geologic record. Theoretical considerations include Earth's thermal history, what powers the plates, and how Earth's progressive cooling may have affected these forces. Empirical considerations include the results of a wide range of field- and laboratory-based measurements and analyses that serve as proxies for plate motion or operation of subduction zones and ocean ridges, including paleomagnetism, isotopic and trace element compositions of igneous rocks,

styles of deformation, the temporal distribution of hallmarks of subduction (ophiolites, blueschists, eclogites, and diamond- and coesite-bearing ultrahigh-pressure assemblages) and secular distribution of associations diagnostic of plate tectonics such as passive margin sequences and arc rock assemblages.

### Schedule

**Tues., 13 June:** Participants arrive and meet at the Pronghorn Lodge in Lander, Wyoming. Evening welcoming party.

**Wed., 14 June:** Introductory lectures and discussions. Poster session 1, late afternoon and evening. Evening lecture on Field Trip I.

**Thurs., 15 June:** Field Trip I.

**Fri., 16 June:** Talks and discussion. Poster session 2. Evening lecture on Field Trip II.

**Sat., 17 June:** Field Trip II.

**Sun., 18 June:** Talks and discussion; wrap-up discussion. Closing dinner.

(Note: most participants are expected to contribute a poster or oral presentation.)

### Venue and Estimated Costs

The conference will be held at the Pronghorn Lodge in Lander, Wyoming. Lander is near the south end of the spectacular Wind River Mountains, near exposures of Archean granite-greenstone terranes. During mid-June, the weather in this part of Wyoming can vary from sunny to rainy and cool. The closest airports are in Jackson, Wyoming (south of Yellowstone Park), and Riverton, Wyoming. Vans will be available to shuttle participants from those airports.

The **estimated registration fee of US\$985** will cover lodging, most meals, and the field trips, but *will not cover transportation to Wyoming*.

### PRELIMINARY OUTLINE OF SESSIONS

#### Wednesday, 14 June

##### Morning

Session 1: Introduction and contrasting views as to when plate tectonics began and alternatives to plate tectonics in the early Earth.

##### Afternoon

Session 2: Blueschists and UHP metamorphism through time.  
Session 3: Ophiolites and oceanic plateaus through time.

#### Friday, 16 June

##### Morning

Session 4: Proterectonic rock associations, geochemical and isotopic constraints: how definitive are they?  
Session 5: Paleomagnetic constraints.

##### Afternoon

Session 6: Theoretical (geodynamic) constraints on when and how subduction and plate tectonics began on Earth.

#### Sunday, 18 June

##### Morning

Session 7: Geophysical and structural constraints.

##### Afternoon

Session 8: Open discussion, including "Where do we go from here to solve the problem?"

## Field Trips

We will take two one-day field trips in the southern Wind River Mountains and adjacent areas to examine Archean greenstones, granites, and deformation zones. Included will be a visit to the historic South Pass greenstone, a juvenile terrane accreted to the Wyoming Province in the late Archean, ca. 2.65 Ga, and a traverse across the Oregon Trail structure, a well-exposed, high-grade, late Archean accretionary front in central Wyoming. Participants will have the opportunity to see primary textures preserved in greenstones, discuss rock associations in terms of possible tectonic settings, and examine both middle- and high-grade structures associated with lateral accretion.

### Application Deadline: 1 March 2006

Geoscientists interested in contributing to and participating in lively discussions on when plate tectonics began on Earth are encouraged to apply. Potential participants should send a letter of application to one of the conveners that includes a brief statement of interests, the relevance of the applicant's recent work to the themes of the meeting, the subject of proposed presentation, and contact information. Interested graduate students are strongly encouraged to apply; partial support is available. Invitations will be e-mailed to participants beginning in April 2006.

### Registrants with Special Needs

GSA is committed to making Penrose Conferences accessible to all. If you require special arrangements or have special dietary concerns, please contact Lisa Smith, lsmith@geosociety.org.

## New GSA Division: Geology and Health

At the 2005 GSA Annual Meeting, GSA Council approved the establishment of a new (sixteenth) GSA Division, the Geology and Health Division.

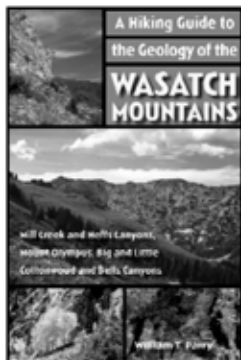
The Geology and Health Division is concerned with the intersection of geological conditions, whether natural or anthropogenic in origin, with health, disease, pathology, and death in modern and fossil humans, animals, and plants. With a focus on the interdisciplinary relationship of geology to medicine, biology, chemistry, and other sciences, the new division will foster communication and collaboration among scientists and practitioners who have differing professional perspectives. The division will also work to recognize significant contributions and accomplishments in this interdisciplinary field and to encourage and mentor interested students.

To join a GSA Division, go to [www.geosociety.org/sectdiv/](http://www.geosociety.org/sectdiv/), or contact GSA Sales and Service, +1-303-357-1000 option 3, fax +1-303-357-1071, [gsaservice@geosociety.org](mailto:gsaservice@geosociety.org).

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# Call for Nominations: GSA Division Awards



**Funds for the following GSA Division awards are administered through the GSA Foundation.**

## **Don J. Easterbrook Distinguished Scientist Award— Quaternary Geology and Geomorphology Division**

The Quaternary Geology and Geomorphology Division of GSA seeks nominations for the Don J. Easterbrook Distinguished Scientist Award. This award will be given to an individual who has shown unusual excellence in published research, as demonstrated by a single paper of exceptional merit or a series of papers that have substantially increased knowledge in Quaternary geology or geomorphology. No particular time limitations apply to the recognized research. The recognition is normally extended to an individual, but in the event of particularly significant research, two people may share the award. Monies for the award are derived from the annual interest income of the Don J. Easterbrook Fund, administered by the GSA Foundation.

Although recognition of extraordinary prior research excellence is the principal goal of this award, it carries with it an opportunity for funding additional research. The Easterbrook Distinguished Scientist is eligible to draw funds for research from the GSA Easterbrook Fund in an amount to be determined by the availability of funds. This opportunity to fund additional research by the awardee is a secondary consideration of the award.

Members of the Quaternary Geology and Geomorphology Division Award Panel will evaluate nominations for the Easterbrook Award. Because the award primarily recognizes research excellence, self-nomination is not allowed. Nominees need not be members of the division. Nominations are not automatically carried forward to subsequent years, but the same individuals may be renominated.

Nominations must be accompanied by supporting documentation, including a statement of the significance of the nominee's research, curriculum vitae, letters of support, and any other documents deemed appropriate by the nominating committee. Send nominations by 4 April 2006 to John E. Costa, U.S. Geological Survey, 1300 SE Cardinal Court, Bldg. 10, Suite 100, Vancouver, WA 98683, USA, [jecosta@usgs.gov](mailto:jecosta@usgs.gov).

## **Farouk El-Baz Award for Desert Research—Quaternary Geology and Geomorphology Division**

The GSA Quaternary Geology and Geomorphology Division seeks nominations for the Farouk El-Baz Award for Desert Research. This award rewards excellence in research in desert geomorphology worldwide and is intended to stimulate research in desert environments by recognizing an individual whose research has significantly advanced the understanding of the Quaternary geology and geomorphology of deserts. Although the award primarily recognizes achievement in desert research, the funds that accompany it (US\$5,000 anticipated for 2006) may be used for further research. The award is normally given to one person but may be shared by two people if the recognized research was the result of a coequal partnership. Monies for the award are derived from the annual interest income of the Farouk El-Baz Fund, administered by the GSA Foundation.

Any scientist from any country may be nominated for the award. Because the award recognizes research excellence, self-nomination is not permitted. Neither nominators nor nominees need be members of GSA. Nominations must be accompanied by a statement of the significance of the nominee's research, a curriculum vitae, letters of support, and documentation of published research results that have significantly advanced the knowledge of the Quaternary Geology and Geomorphology of desert environments.

Send nominations by 4 April 2006 to Jack F. Shroder, Jr., Dept. of Geography and Geology, University of Nebraska, Omaha, NE 68182-0199, USA, [jshroder@mail.unomaha.edu](mailto:jshroder@mail.unomaha.edu).

## **Laurence L. Sloss Award for Sedimentary Geology**

The Sedimentary Geology Division of GSA solicits nominations for the 2006 Laurence L. Sloss Award for Sedimentary Geology. This award is given annually to a sedimentary geologist whose lifetime achievements best exemplify those of Larry Sloss—i.e., achievements that contribute widely to the field of sedimentary geology and service to GSA. Monies for the award are derived from annual interest income from the Laurence L. Sloss Award for Sedimentary Geology fund, administered by the GSA Foundation.

Nominations should include a cover letter describing the nominee's accomplishments in sedimentary geology, contributions to GSA, and curriculum vitae. The management board of the Sedimentary Geology Division will choose the recipient from the two nominees forwarded from the nominations committee, and the award will be presented at the GSA Annual Meeting in Philadelphia in October 2006.

Send nominations electronically by 21 February 2006 to Paul Link, Secretary, Sedimentary Geology Division, [linkpaul@isu.edu](mailto:linkpaul@isu.edu).

## **Gilbert H. Cady Award—Coal Geology Division**

The Coal Geology Division of GSA seeks nominations for the 2006 Gilbert H. Cady Award, made for outstanding contributions in the field of coal geology. The first award, established by the division in honor of Gilbert H. Cady, was presented in 1973. Monies for the award are derived from annual interest income from the Gilbert H. Cady Memorial Fund, administered by the GSA Foundation. The award will be made for contributions that are considered to advance the field of coal geology within and outside North America and will be presented at the Coal Geology Division Business Meeting at the GSA Annual Meeting in Philadelphia in October 2006.

Nominations will be evaluated by the Gilbert H. Cady Award Panel and should include the name, office or title, and affiliation of the nominee; date and place of birth; education, degree(s), and honors and awards; major events in his or her professional career; and a brief bibliography noting outstanding achievements and accomplishments that warrant nomination.

Send three copies of the nomination by 28 February 2006 to Gretchen Hoffman, New Mexico Bureau of Geology, 801 Leroy Place, Socorro, NM 87801, USA, [gretchen@gis.nmt.edu](mailto:gretchen@gis.nmt.edu).



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Elizabeth Sara Bogatin  
Leslie Brock  
Rosmeiri Caliman  
Cori Cowan  
Michael J. Cronin  
Richard Dreiser  
Cindy Duckert  
Ralf Janas  
John R. Johnson  
John G. King  
Richard M. Knapek  
Randall L. Knight  
Rebecca Krieg  
Samuel D. Larsen  
Theresa Ledoux  
Roger Levine  
Ellen G. Light  
John J. Lloyd  
Ronald J. Long  
Jeremy K. Means  
Andrzej T. Midak  
Brian Mitchell  
Heather M. Mobley  
Christine Negra  
Steve Nofsinger  
Nicholas Novi  
K.C. Oren  
Matthew Parsons  
David A. Quick  
Krista Reichert  
Kent E. Richter  
George Rollason  
Peter G. Seroka  
Michael Slavin  
Richard Smedley  
Kenneth R. Storm Jr.  
Robert Suess  
Gianna Sullivan  
Rubens Valerio  
John Venton  
Charles Otho Williams  
L. Michele Wineman

# UPCOMING DEADLINES

## Medals and Awards

### Nominations Due 1 February 2006

Nominations of candidates are requested for the following medals and awards: Penrose Medal, Day Medal, Honorary Fellows, Young Scientist Award (Donath Medal), GSA Public Service Award, and GSA Distinguished Service Award. For details on the awards and nomination procedures, see the October 2005 issue of *GSA Today*. For the new online nomination form, go to [www.geosociety.org/aboutus/awards/](http://www.geosociety.org/aboutus/awards/), or call +1-303-357-1028. Materials and supporting information for any of the nominations may be sent to Grants, Awards, and Recognition, GSA, 3300 Penrose Place, P.O. Box 9140, Boulder, CO 80301-9140, USA.

## GSA Fellows

### Nominations Due 1 February 2006

The Committee on Membership requests nominations of members to be elevated to GSA Fellow status. Any GSA Fellow may nominate up to two members per election cycle for this honor. Two other supporting letters in addition to the online nomination form are needed. For details on nomination procedures, see the October 2005 issue of *GSA Today*, visit [www.geosociety.org/members/fellow.htm](http://www.geosociety.org/members/fellow.htm), call +1-303-357-1028, or e-mail [awards@geosociety.org](mailto:awards@geosociety.org).

## 2006 Subaru Outstanding Woman in Science Award (Sponsored by Subaru of America, Inc.)

### Nominations Due 1 February 2006

This award is given to a woman who has made a major impact on the field of the geosciences, based on her Ph.D. research. For details on the award and nomination procedures, see the October 2005 issue of *GSA Today*. For the new online nomination form, go to [www.geosociety.org/aboutus/awards/](http://www.geosociety.org/aboutus/awards/) or call +1-303-357-1028. Send nominations and supporting material to Grants, Awards, and Recognition, GSA, 3300 Penrose Place, P.O. Box 9140, Boulder, CO 80301-9140, USA.

## John C. Frye Environmental Geology Award

### Nominations Due 31 March 2006

In cooperation with the Association of American State Geologists, GSA makes an annual award for the best paper on environmental geology published either by GSA or by one of the state geological surveys. For details, see the October 2005 issue of *GSA Today*, visit [www.geosociety.org](http://www.geosociety.org), or call +1-303-357-1028. Nominations must be sent to Grants, Awards, and Recognition, GSA, 3300 Penrose Place, P.O. Box 9140, Boulder, CO 80301-9140, USA.

## Student Research Grants 2006

### Online submission must be completed by Wednesday, 1 February 2006, at 11:59 p.m. (MST).

The GSA student research grant application process is available **only** online. No paper applications or letters will be accepted.

In an effort to fund more GSA Student Members, students may now only receive GSA graduate student research grant money once at the master's level and once at the Ph.D. level. This policy affects all GSA research grantees retroactively. Those who have applied for grant funding but who did not receive a grant are welcome to apply again.

For further information on the 2006 Research Grant Program, see the October 2005 issue of *GSA Today*, visit [www.geosociety.org/grants/gradgrants.htm](http://www.geosociety.org/grants/gradgrants.htm), call +1-303-357-1028, or e-mail [awards@geosociety.org](mailto:awards@geosociety.org).

## Congressional Science Fellowship

### Applications Due 1 February 2006

For application information for the 2006–2007 GSA–U.S. Geological Survey Congressional Science Fellowship, visit [www.geosociety.org/science/csf/](http://www.geosociety.org/science/csf/) or contact Ginger Williams, GSA Headquarters, +1-303-357-1040, [gwilliams@geosociety.org](mailto:gwilliams@geosociety.org).

## National Awards

### Nominations Due 30 April 2006

Candidate nominations are needed for the following national awards: William T. Pecora Award, National Medal of Science, Vannevar Bush Award, and Alan T. Waterman Award. For details, see the October 2005 issue of *GSA Today*. Nominations should be sent to Grants, Awards, and Recognition, GSA, 3300 Penrose Place, P.O. Box 9140, Boulder, CO 80301-9140, USA.

## 2005 GSA ANNUAL MEETING RECORDED

With the permission of the presenters, GSA recorded more than 150 presentations at the 2005 GSA Annual Meeting in Salt Lake City. Among the recordings: the Keynote Pardee Sessions, including the late-breaking session on Katrina, and any Topical Sessions that were “In Honor of” or “In Memory of” geoscientists.

These recordings are now posted online at <http://gsa.confex.com/gsa/2005AM/finalprogram/>. From this page, you can search under the key words “recorded presentations.” You can also select a day from the Technical Session listings then browse the available recordings within that session, which are marked with the recording image.





## GSA Program Support

GSA Foundation supports many GSA programs and projects, including

- ❖ Research Grants
- ❖ GeoCorps America™
- ❖ Education & Outreach Programs
- ❖ Congressional Science Fellow
- ❖ GSA Public Service Award
- ❖ Field Forums
- ❖ Student Travel (both domestic and international)
- ❖ Publications

The GSA membership has provided substantial support to GSA Foundation, and we encourage members to continue helping the Foundation make a difference for the geosciences with a contribution to the Foundation this year. You may use the attached coupon to make your gift. Gifts to the "Greatest Needs" Fund will give the Foundation the flexibility to apply the dollars where GSA needs them the most.

If you have a specific fund to which you would like to contribute, please indicate this on the coupon below. A complete listing of GSA Foundation funds may be requested by contacting Donna Russell in the Foundation office, drussell@geosociety.org, +1-303-357-1054.

As the Foundation celebrates its 25th year, we need your support as much as ever. Help us make 2006 a huge success—your participation will be greatly appreciated.



*Most memorable early geologic experience:*

The 1947 University of Wyoming summer field camp was my first real experience with geology. One day we were encouraged to scramble up a roadside bank to find Eocene mammal remains. I found none, but at the top of the bank there was the complete skeleton of a small animal. Convinced that I had made a major discovery, I asked the teaching assistant in the most insouciant manner I could muster to look at my great find. He obliged, looked at the skeleton, and said in a kindly way, "Dick, that squirrel died about six months ago." I decided, then and there, to forego a career in paleontology.

—H.D. Holland

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### Is the GSA Foundation in Your Will?

If you are planning to update your will and want to include the GSA Foundation as a beneficiary, we can provide the appropriate language to accomplish your intent. Please contact the Foundation office, drussell@geosociety.org, +1-303-357-1054, for assistance.



### GSA FOUNDATION

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+1-303-357-1054  
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I have named GSA Foundation in my will.

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\$2,500  \$1,000  \$500 Other: \$\_\_\_\_\_.

Complimentary copy of *A Guide to Creative Planned Giving*

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# ANNOUNCEMENTS

## MEETINGS CALENDAR

### 2006

- 2–7 April EGU 2006, General Assembly of the European Geosciences Union, Vienna, Austria. **Information:** <http://meetings.copernicus.org/egu2006/>.
- 3–7 April Backbone of the Americas—Patagonia to Alaska, Mendoza, Argentina. Co-convened by Asociación Geológica Argentina and GSA. **Information:** Deborah Nelson, [dnelson@geosociety.org](mailto:dnelson@geosociety.org), +1.303.357.1014, [www.geosociety.org/meetings/06boa/](http://www.geosociety.org/meetings/06boa/).
- 18–22 April 100th Anniversary Earthquake Conference Commemorating the 1906 San Francisco Earthquake, San Francisco, California, USA. **Information:** [www.1906eqconf.org](http://www.1906eqconf.org).
- 14–17 May GAC–MAC 2006, joint annual meeting of the Geological Association and Mineralogical Association of Canada, Montreal, Québec. **Information:** General Chair Normand Goulet, Université du Québec à Montréal, [goulet.normand@uqam.ca](mailto:goulet.normand@uqam.ca), [www.er.uqam.ca/nobel/gacmac/welcome.html](http://www.er.uqam.ca/nobel/gacmac/welcome.html).
- 14–17 May CIM Vancouver 2006, Mining Conference and Exhibition, Canadian Institute of Mining, Metallurgy and Petroleum, Vancouver, British Columbia. **Information:** [www.cim.org/vancouver2006](http://www.cim.org/vancouver2006).
- 2–7 July Australian Earth Sciences Convention 2006, Geological Society of Australia 18th Australian Geological Convention and Australian Society of Exploration Geophysicists 18th International Geophysical Conference and Exhibit, Melbourne, Australia. **Information:** [www.earth2006.org.au](http://www.earth2006.org.au).



## In Memoriam

- Robert Taylor Bean**  
Claremont, California  
6 July 2005
- Bruce A. Bolt**  
Berkeley, California  
Notified 25 July 2005
- James C. Bradbury**  
Urbana, Illinois  
3 September 2005
- Ralph S. Brown**  
Fresno, California  
Notified 7 October 2005
- Johannes J. Brummer**  
Toronto, Ontario  
Notified 23 May 2005
- Robert P. Bryson**  
Salisbury, Maryland  
31 August 2005
- Paul E. Damon**  
Tucson, Arizona  
14 April 2005
- Robert W. Decker**  
Mariposa, California  
1 June 2005
- Ernest G. Ehlers**  
Fairhope, Alabama  
23 June 2005
- Pow-Foong Fan**  
Honolulu, Hawaii  
Notified 25 October 2005
- Erik Flugel**  
Erlangen, Germany  
14 April 2004
- Charles D. Foss**  
Fresno, California  
15 October 2005
- Sheldon K. Grant**  
New Harmony, Utah  
5 August 2005
- Elbert Nelson Harshman**  
Lakewood, Colorado  
1 March 2005
- Stuart P. Hughes**  
Missoula, Montana  
1 August 2003
- C.S. Hurlbut Jr.**  
Lexington, Massachusetts  
1 September 2005
- George F. Koehler**  
Spokane, Washington  
14 July 2005
- Otto C. Kopp**  
Knoxville, Tennessee  
1 April 2005
- Fitzhugh T. Lee**  
Gig Harbor, Washington  
1 June 2005
- Gary A. Lund**  
Bakersfield, California  
24 June 1905
- Louis H. Michaelson**  
Midland, Texas  
17 July 2005
- Craig W. Oyen**  
Shippensburg, Pennsylvania  
Notified 16 September 2005
- Sigmund D. Schwarz**  
Astoria, Oregon  
4 October 2005
- Maria I. Stercho**  
Baltimore, Maryland  
Notified 31 May 2005
- Richard D. Terry**  
Ventura, California  
30 May 2005
- George Arthur Williams**  
Englewood, Colorado  
23 February 2005
- Erhard M. Winkler**  
South Bend, Indiana  
30 August 2005

Please contact the GSA Foundation at +1-303-357-1054 or [drussell@geosociety.org](mailto:drussell@geosociety.org) for information on contributing to the Memorial Fund.

# Medlin Scholarship Award Offered

by GSA Coal Division

GSA's Coal Geology Division announces the availability of the Antoinette Lierman Medlin Scholarship in Coal Geology for the 2006–2007 academic year. The scholarship provides full-time students who are involved in research in coal geology (origin, occurrence, geologic characteristics, or economic implications of coal and associated rocks) with financial support for their project for one year.

Scholarship funding can be used for field or laboratory expenses, sample analyses, instrumentation, supplies, or other expenses essential to the successful completion of the research project. Approximately US\$2,000 will be available for the 2006–2007 scholarship award. In addition, the recipient of the scholarship may be provided with a stipend to present the results of the research at the 2007 GSA Annual Meeting.

For the academic year 2006–2007, the Coal Geology Division is also offering a field study award of approximately \$1,500. The recipient of this award will also be eligible to receive travel funds to present results of his or her study at the 2007 GSA Annual Meeting.

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

Interested students should submit five copies of the following: (1) a cover letter indicating which award(s) is(are) sought; (2) a

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

**Send the material to:** Allan Kolker, U.S. Geological Survey, 12201 Sunrise Valley Drive, 956 National Center, Reston, VA 20192, USA, [akolker@usgs.gov](mailto:akolker@usgs.gov), fax +1-703-648-6419.

The proposal and letter of recommendation must arrive no later than **15 February 2006**. Applicants will be notified of the scholarship committee's decision by 1 April 2006.

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



## About People

The American Association for the Advancement of Science (AAAS) has named 376 new AAAS Fellows, recognized for their distinguished contributions to science. In the geology and geography category, the AAAS elected the following: GSA Senior Fellows **Bruce A. Bolt**, **Roger L. Kaesler**, and **Erle G. Kauffman**; GSA Fellows **Richard Marston**, **Peter Molnar**, and **Youzue Zhang**; and GSA Members **J. David R. Applegate**, **Richard M. Forester**, and **Claude Hillaire-Marcel**. These and the other AAAS Fellows will be recognized at the AAAS Annual Meeting in St. Louis on 18 Feb. 2006.

GSA Senior Fellow **Don L. Anderson** was inducted into Rensselaer Polytechnic Institute's Rensselaer Alumni Hall of Fame in September 2006. Anderson, now professor Emeritus of geophysics at California Institute of Technology, is a member of Rensselaer's class of 1955.

## The GeoCorps America™ Application Deadline is Approaching!

Have you ever dreamed of working on an exciting project in a National Park or National Forest? *Now is your chance!* Visit the Web site below to discover exciting summer positions available to GSA Members. The deadline to apply for a GeoCorps America™ position is 3 February 2006. **Hurry and get your application in today!**



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

## CALL FOR APPLICATIONS:

# Planetary Geology Division's Stephen E. Dworkin Student Paper Award

### THE AWARD

Planetary geologist Stephen E. Dworkin established this award in 1991 to provide encouragement, motivation, and recognition to outstanding future scientists. Two awards are given annually, one for the best oral presentation, the other for the best poster presentation; each winner receives a citation and US\$500. The program is administered through the Planetary Geology Division of the Geological Society of America. The GSA Foundation manages the award fund.

### CRITERIA

The Dworkin Student Paper Award applies to papers presented at the annual Lunar and Planetary Science Conference held each March in Houston. Student applicants must be (1) the senior author of the abstract (the paper may be presented orally or in a poster session); (2) a U.S. citizen;

and (3) enrolled in a college or university, at any level of their education, in the field of planetary geosciences. Papers will be judged on the quality of the scientific contributions, including methods and results; clarity of material presented; and methods of delivery, oral or display.

### TO APPLY

The application form and instructions are found in the call for papers for the 37th Lunar and Planetary Science Conference, to be held 13–17 March 2006 at the South Shore Resort and Conference Center, League City, Texas.

**Please visit [www.lpi.usra.edu/meetings/lpsc2006.1st.html](http://www.lpi.usra.edu/meetings/lpsc2006.1st.html) for more information.**

**APPLICATION DEADLINE: 10 JAN. 2006.**

## GSA Offers Awards in Geomorphology and Micropaleontology



Two of GSA's most prestigious awards supporting research are made possible by the generosity of the late W. Storrs Cole. Qualified GSA Members and Fellows are urged to apply. The Gladys W. and W. Storrs Cole Award funds are managed by the GSA Foundation.

The **Gladys W. Cole Memorial Research Award** provides support for the investigation of the geomorphology of semiarid and arid terrains in the United States and Mexico. GSA Members and Fellows between the ages of

30 and 65 who have published one or more significant papers on geomorphology are eligible for the award. While the funds may not be used for work that is already finished, recipients of previous awards may reapply if they need additional support to complete their work. The 2006 award is for US\$8,200.

The **W. Storrs Cole Memorial Research Award** supports research in invertebrate micropaleontology. For 2006, this award carries a stipend of US\$7,500 and will go to a GSA Member

or Fellow between the ages of 30 and 65 who has published one or more significant papers on micropaleontology.

2006 application forms are available at [www.geosociety.org/grants/postdoc.htm](http://www.geosociety.org/grants/postdoc.htm). For more information, contact Grants, Awards, and Recognition, GSA, P.O. Box 9140, Boulder, CO 80301-9140, [awards@geosociety.org](mailto:awards@geosociety.org), or call +1-303-357-1028.

**Applications must be received via post on or before 1 February 2006.**



GEON



THE GEOLOGICAL SOCIETY OF AMERICA

# Geoinformatics 2006

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*Data to Knowledge*

Geoinformatics 2006 will focus on tools for the discovery, integration, management and visualization of geoscience data, with the ultimate goal of improving our understanding of the processes that have shaped the earth and our environment over time. The meeting will be co-hosted by the U.S. Geological Survey and GEON (Geosciences Network, NSF) and sponsored by the Geological Society of America. The conference provides a national forum for researchers and educators from the geosciences and information technology/computer science to present new data, data analysis or modeling techniques, visualization schemes, or technologies as they relate to developing the cyberinfrastructure for the Geosciences.

For additional information, registration, and abstract submission please visit:  
<http://www.geongrid.org/geoinformatics2006/>

U.S. Department of the Interior  
U.S. Geological Survey

Co-Hosted by USGS and  
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19th Annual

# SAGEEP

*Symposium on the Application  
of Geophysics to Engineering  
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## Geophysical Applications for Environmental and Engineering Hazards - Advances and Constraints

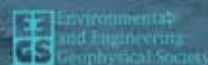
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- Ice Breaker Reception/  
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Celebration
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Washington Dinner Train
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AND SAVE MONEY!**

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



# Call for Applications and Nominations

## GSA SCIENCE EDITORS

---

GSA's internationally recognized journals and books rely on the expertise of dedicated science editors who ensure stringent peer review, maintain excellent content, and provide leadership in determining the future course of GSA publications. Desirable characteristics for successful candidates include:

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

If you wish to be considered, please submit a curriculum vitae and a brief letter describing why you are suited for the position. If you wish to nominate another, submit a letter of nomination and the individual's written permission and CV. Send nominations and applications to Jon Olsen, Director of Publications, GSA, P.O. Box 9140, Boulder, CO 80301, jolsen@geosociety.org, by 23 February 2006. Questions regarding the positions also may be directed to Mr. Olsen.

**GSA is currently soliciting co-editor applications and nominations for these upcoming openings.**

### GSA Bulletin

Publishing definitive works related to all aspects of geoscience, *GSA Bulletin* marks its 118th year of publication in 2006.

Term: January 2007–December 2010. A phased transition should begin in the fall of 2006. GSA provides funding for a part-time assistant, pays the costs of maintaining an editorial office, and reimburses journal-related travel expenses. Discretionary funds also are available. The editor will work out of his/her current location at work or home as part of a two-editor team.

### Geology

Undoubtedly the most popular and widely read earth science journal in print, *Geology* publishes about 22 articles each month that are current, concise, and thought provoking.

Term: January 2007–December 2010. A phased transition should begin in the fall of 2006. GSA provides funding for a part-time assistant, pays the costs of maintaining an editorial office, and reimburses journal-related travel expenses. Discretionary funds also are available. The editor will work out of his/her current location at work or home as part of a three-editor team. A co-editor with expertise and broad interests in paleoclimatology, paleoceanography, sedimentary geochemistry, and stratigraphy would best complement the continuing editors' strengths, but fields are flexible.

### GSA Today

GSA's science and news magazine for members and the earth-science community worldwide, *GSA Today* features a "hot-topic" science article most months.

Term: January 2007–December 2010. A phased transition should begin in the fall of 2006. GSA provides a small stipend and funds for mail, telephone, and online access. The editor will work out of his/her current location at work or home as part of a two-editor team.

### Environmental & Engineering Geoscience

This quarterly journal is jointly published with the Association of Engineering Geologists and focuses on human interactions with hydrologic and geologic systems. In addition to the above-listed characteristics, the successful candidate will have broad interest and experience in hydrogeology and/or geomorphology.

Term: July 2006–June 2010. GSA provides funding for a part-time assistant, pays the costs of maintaining an editorial office, and reimburses journal-related travel expenses. Discretionary funds also are available. The editor will work out of his or her current location at work or home as part of a two-editor team. In addition, the GSA co-editor is an ex-officio member of the journal's Editorial Board, which sets policies and meets once per year, and is a member of the GSA Publications Committee, which meets twice per year.

### GSA Books

As part of its mission to advance the science of geology, GSA publishes scholarly books—both state-of-the-art treatments of rapidly evolving subjects and works likely to remain authoritative references for a number of years.

Term: January 2007–December 2010. A phased transition should begin in the fall of 2006. GSA provides funding for a part-time assistant, pays the costs of maintaining an editorial office, and reimburses journal-related travel expenses. Discretionary funds also are available. The editor will work out of his/her current location at work or home as part of a two-editor team.

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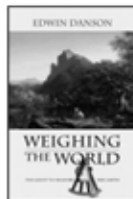
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### WEIGHING THE WORLD

The Quest to Measure the Earth  
**Edwin Danson**

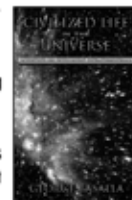
Danson takes us on a journey telling the story of an experiment that measured the "weight of the world". In a global tour de force, *Weighing the World* recounts the 100-year quest to discover enigmatic natural energy—the capability that mountains have to bend gravity—and of an extraordinary experiment that transformed our understanding of the world. Written to appeal to general readers interested in popular science and geographic intrigues, this book will also be greeted enthusiastically by surveyors, historians of science, physicists, teachers, and other specialist audiences.  
2005 304 pp.  
0-19-518169-7 \$29.95



### CIVILIZED LIFE IN THE UNIVERSE

Scientists on Intelligent Extraterrestrials  
**George Basalla**

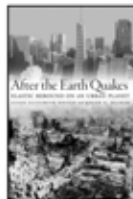
This book is a selective and fascinating history of scientific speculation about intelligent extraterrestrial life. Basalla traces the influence of one speculation on the next, showing an unbroken but twisting chain of ideas passed from one scientist to the next, and from science to popular culture. He questions the common modern scientific reasoning that life converges on intelligence, and intelligence converges on science valid everywhere.  
December 2005 224 pp.  
0-19-517181-0 \$29.95



### AFTER THE EARTH QUAKES

Elastic Rebound on an Urban Planet  
**Susan Elizabeth Hough and Roger G. Bilham**

Elastic rebound is one of the most basic tenets of modern earthquake science, the term that scientists use to describe the build-up and release of energy along faults. It is also the best metaphor for societal responses to major earthquakes in recent historic times. *After The Earth Quakes* focuses on this theme, using a number of pivotal and intriguing historic earthquakes as illustration. The book concludes with a consideration of projected future losses on an increasingly urbanized planet, including the near-certainty that a future earthquake will someday claim over a million lives.  
2005 336 pp.  
0-19-517913-7 \$39.95



### CATASTROPHES AND LESSER CALAMITIES

The Causes of Mass Extinctions  
**Tony Hallam**

In this book, renowned geologist Tony Hallam takes us on a tour of the Earth's history, and of the cataclysmic events, as well as the more gradual extinctions, that have punctuated life on Earth throughout the past 500 million years.  
2005 240 pp.  
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*Geosphere* science editor: G. Randy Keller,  
University of Texas at El Paso.

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THROUGH 28 FEB. 2006**

The U. S. Geological Survey invites applications for the following position. This position is in the Eastern Energy Resources Team, Geologic Discipline, located in Reston, VA. The Team has responsibility for planning and conducting research relating to the oil, gas, and coal resources of the United States and for the application of the results of these investigations to the exploration, development, and assessment of the resources. Applicants must apply online on the Online Automated Recruitment Service (OARS): <http://www.usgs.gov/ohr/oars>.

The Energy Resources Team has oil and gas, and coal resource volume and quality assessment responsibilities as well as research responsibilities relating to effects of fossil fuel combustion and carbon sequestration. The incumbent will serve as a member of a multidisciplinary team (geologist, geochemists, geophysicists, and economists.) to design assessment methods and participate in the preparation of assessments. In addition, the incumbent will be responsible for design, analysis, interpretation of laboratory experiments, and in the sampling design of field data collection programs in support of ongoing team research activities.

**FLORIDA STATE UNIVERSITY  
SCHOOL OF COMPUTATIONAL SCIENCE  
TENURE TRACK POSITION  
COMPUTATIONAL GEOSCIENCES**

The School of Computational Science (<http://www.csit.fsu.edu>) at the Florida State University invites applications for a tenure-track faculty position in the broadly defined area of Computational Geosciences. The position, to start August 2006, will be filled at the assistant professor level and tenure-earning status will be in the Department of Geological Sciences (<http://www.gly.fsu.edu>).

The School seeks candidates who are developing new computational tools for the geosciences, utilize a computer-based approach to solve geological problems, and are interested in interdisciplinary research. The area of research interest within geosciences is not restricted. Areas such as surface processes (including surface hydrology), geophysics (including seismology), biogeochemical modeling, basin and reservoir analyses, and others will be considered.

Faculty and students are housed in the Dirac Science Library building and have free access to two powerful IBM supercomputers (<http://www.csit.fsu.edu/super-computer/fsu-sp.html>) and a top of the line visualization laboratory. Excellent opportunities for collaboration exist with many other centers, institutes, and departments on the FSU campus. The Dirac Science Library is in close proximity to the departments of Geological Sciences, Oceanography, Meteorology, Physics, Statistics, Mathematics, and the institutes of Geophysical Fluid Dynamics and Molecular Biology.

Those interested in being considered for the position should apply electronically to <http://www.csit.fsu.edu/jobs.php> by 31 January 2006, at which time the review of applications will begin; the electronic submission of a

The University of Texas at Austin  
invites applications and nominations for the position of

## Dean, John A. and Katherine G. Jackson School of Geosciences

Effective September 1, 2006

The Jackson School is a newly founded academic unit that includes one of the largest geoscience programs in the country. With an endowment of over \$366 million, the school provides an unprecedented opportunity for its leader to have a major impact on the field of geoscience well into the future. The school includes the Department of Geological Sciences, the Institute for Geophysics and the Bureau of Economic Geology and employs 33 full-time faculty and approximately 100 research scientists. The department currently serves just under 200 undergraduate majors and approximately 170 graduate students.

We seek a visionary leader with proven scientific and administrative skills who will work with the faculty and research scientists to develop the Jackson School to its full potential as one of the world's top institutions in the geosciences and who will represent the school effectively to the university administration, to the state and national political leadership, and to the public.

Preferred qualifications include: (1) distinguished scholarship, with a strong research record and experience in academia, including teaching; (2) administrative experience that demonstrates vision, managerial ability, communication skills and ability to develop programs; (3) creative leadership capable of creating synergy within the school and interfacing with other programs within the university; and (4) commitment to balancing academic and research excellence with the diverse broader missions of units within the school.

Applications and nominations should include a letter describing the applicant's qualifications and potential interest in the position. Applicants should also include a description of relevant experience and accomplishments, *curriculum vitae*, and the names and addresses of six references (references will not be contacted without the candidate's permission).

**Send applications and nominations to:**  
Dr. Sharon Mosher, Chair, *Dean Selection Committee*  
Department of Geological Sciences  
Jackson School of Geosciences  
1 University Station C1100  
University of Texas at Austin  
Austin, TX 78712-0254

THE UNIVERSITY OF TEXAS AT AUSTIN  
**JACKSON**  
SCHOOL OF GEOSCIENCES

Review of applications will begin December 1, 2005, but applications will be accepted until the position is filled.

The University of Texas at Austin is an Affirmative Action/Equal Employment Employer. Women and minorities are encouraged to apply.

curriculum vita and research and teaching statements is required as are the names and email addresses of four references, one of which should address the candidate's qualifications for teaching.

Florida State University is an EO/AA employer, committed to diversity in hiring, and a public records agency.

**PHYSICAL GEOLOGY/PHYSICAL GEOGRAPHY  
VISITING ASSISTANT PROFESSOR  
DENISON UNIVERSITY**

The Dept. of Geosciences at Denison University invites applications for a one-year position to begin in the Fall of 2006. We seek a teacher/scholar to teach Physical Geology or Physical Geography and a course in the applicant's area of expertise and to enhance the diversity of our existing program. We are most interested in applicants with expertise in the broadly defined area of Surficial Processes, but all applicants will be

considered. This temporary position is separate from the sabbatical replacement position we advertised in September 2005 and is the result of a new tenure track position in Surficial Processes/Physical Geography that will begin in Fall 2007.

We seek a colleague who is committed to teaching excellence in the liberal arts tradition, is field-oriented, has broad interests beyond their specialty, and will provide a balance of classroom, field and laboratory experiences for our majors. We will consider ABD candidates, but we prefer candidates with a Ph.D. at the time of appointment. Denison is a highly selective liberal arts college strongly committed to, and supportive of, excellence in teaching and active faculty research that involves undergraduate students.

Please submit a letter of application and a discussion of your approach to teaching and research in a liberal arts setting, along with a *vitae*, copies or

originals of academic transcripts, and three letters of recommendation to: David Hawkins, Department of Geosciences, Denison University, Granville OH 43023; +1-740-587-5788; hawkins@denison.edu. Application materials should arrive by 17 Feb., although the search will remain open until the position is filled. Denison University is an Affirmative Action, Equal Opportunity Employer. In a continuing effort to diversify our Campus Community, we strongly encourage women and people of color to apply.

**TENURE-TRACK INSTRUCTOR POSITION  
GEOLOGY AND OCEANOGRAPHY  
MIRACOSTA COMMUNITY COLLEGE**

The Physical Sciences Department invites applications for a tenure-track position to teach geology, oceanography, and earth science at MiraCosta Community College in north coastal San Diego County, California. The position is teaching-oriented, involving lower division courses in a diverse community, with ample opportunities for field activities. The starting date is August 2006, and the application deadline is 31 January 2006. Please visit the college website at <http://www.miracosta.edu> for general information about the college. For particulars about the position, application procedure, and salary, please visit <http://www.miracosta.edu/info/admin/HR/jobs>. Or leave a message on the MiraCosta job line at +1-760-795-6868 or toll free at +1-888-201-8480, ext. 6868. MiraCosta College is an equal opportunity employer and is committed to an educational environment which affirms and supports a diverse faculty and staff.

**ASTROBIOLOGY—ASSISTANT PROFESSOR  
UNIVERSITY OF WASHINGTON**

The Astrobiology Program (<http://depts.washington.edu/astrobio>) at the University of Washington invites applications for a tenure-track Assistant Professor position to begin in September 2006. The Program has 20 graduate students from six different departments.

This faculty position will be placed in one of the following four departments: Astronomy, Atmospheric Sciences, Biology, Earth & Space Sciences. In exceptional circumstances, appointment as Associate Professor or Professor may be considered for candidates who have demonstrated a commitment to mentoring underrepresented students in the sciences.

Applicants must have a Ph.D. in a field relevant to Astrobiology by the date of appointment. We will consider strong candidates in any area bearing on Astrobiology, either providing new astrobiological expertise to our Program or strengthening areas of current research, which include: early solar system dynamics, habitability of planets, Martian surface features and atmospheric processes, extrasolar planets, comets and interplanetary dust particles, magnetospheres, mass extinctions, life and the early Earth, evolution of metabolic processes, microbial life under extreme conditions, and life detection techniques.

Duties for the new position will include undergraduate and graduate teaching, vigorous independent research, and service. A strong record of published research and a demonstrated commitment to interdisciplinary research and education are essential.

Applications must include curriculum vitae and list of publications, a statement of research and teaching experience and interests, and three letters of reference (sent directly to the search committee by the referees). Electronic application is strongly preferred and must be in PDF format and sent to [astrobio-search@ess.washington.edu](mailto:astrobio-search@ess.washington.edu), with subject line "ASTROBIO-Application, (your name)." Hard-copy applications, including reference letters, may be sent to: Astrobiology Search Committee, c/o Dept. of Earth and Space Sciences, University of Washington, Box 351310, Seattle, WA 98195-1310.

Priority will be given to applications, including recommendations, received by 31 January 2006. The University of Washington is an affirmative action, equal opportunity employer. Women and minorities are encouraged to apply.

**UNIVERSITY OF WYOMING  
GEOHYDROLOGIST**

The Department of Geology and Geophysics at the University of Wyoming invites applications for a tenure-track position in geohydrology at the assistant professor level. Higher rank (associate professor) is possible for individuals with an established research program and demonstrated ability to secure external funding. Ph.D. is required at time of appointment, August 2006. We seek an individual who shows the potential to develop an internationally recognized, externally funded research program and who will be involved in the undergraduate and graduate teaching mission of the department. We welcome applicants with any specialization within the general field of geohydrology, including those who will build on departmental

strengths in sedimentation, energy research, seismology, tectonics and structural geology. Additional information on the Department can be obtained on our web page (<http://home.gg.uwyo.edu/>).

Applications should include a statement of research and teaching interests and accomplishments, curriculum vitae, graduate transcripts, and the names and contact information of three references. Review of completed applications will begin January 3, 2006. Send an electronic copy of your application to: Ms. Carol Pribyl at [cpribyl@uwyo.edu](mailto:cpribyl@uwyo.edu); if you have additional application materials to send, please direct them to the Geohydrology Search Committee, Prof. Carol Frost, Chair, Department of Geology and Geophysics, University of Wyoming, 1000 E. University Ave., Dept. 3006, Laramie, WY 82071.

The University of Wyoming is an equal opportunity/affirmative action employer.

**THE DENVER MUSEUM OF NATURE & SCIENCE  
SEEKS A CURATOR OF GEOLOGY AND CHAIR  
OF THE DEPARTMENT OF EARTH SCIENCES**

This person will lead an effort to create an innovative specimen- and technology-based exhibit that integrates large-scale Earth System processes with the regional geology of the Rocky Mountains.

The successful Earth scientist will lead grant-funded research focused in the Rocky Mountains; curate and improve the mineral, rock, meteorite, and gemstone collections; build on the region's geological story to deliver and support innovative science education and exhibits; and supervise students and adult volunteers.

Applicants must have a Ph.D., strong interest in museum-based science, a record of grants and peer-reviewed publications, strong leadership and management skills and experience. Send application including letter of interest, curriculum vitae, names of three references, and sample publication via email by Feb. 1, 2006 to Kirk Johnson, Chief Curator, DMNS, Denver, Colorado 80205 at [geology.job@dmns.org](mailto:geology.job@dmns.org). No calls. EOE.

For additional information about the museum: <http://www.dmns.org/main/en/General/AboutTheMuseum/Jobs/>.

**OLIVET NAZARENE UNIVERSITY**

Geologist. Olivet Nazarene University seeks applicants for a faculty position. Hydrogeology/geophysics expertise is preferred. See <http://geology.olivet.edu> for details.

**CENTRAL CONNECTICUT STATE UNIVERSITY  
ASSISTANT PROFESSOR  
STRATIGRAPHY/SEDIMENTOLOGY/  
HYDROGEOLOGY**

The Physics and Earth Sciences Department at Central Connecticut State University invites applications for a tenure-track position at the Assistant Professor level beginning August 2006. We are seeking a candidate with experience in the broad areas of Stratigraphy/Sedimentology and Hydrogeology. Primary teaching responsibilities will be introductory courses in geology and advanced undergraduate courses depending upon their field of specialty. Our department stresses a balance of classroom, field and laboratory experiences for our majors, and we seek a colleague who will contribute to all of these components of our undergraduate curriculum. In addition, the individual will direct undergraduate research projects and conduct an active research program. The successful candidate will also participate in the design, development, and growth of the geology program at CCSU. Teaching experience and a Ph.D. in the above area at the time of appointment are required. Demonstrated ability to work with a diverse student body also required.

Applicants should send curriculum vita, statements of undergraduate teaching philosophy and research interests, along with three letters of reference to Ali Antar, Chair, Department of Physics and Earth Sciences, Central Connecticut State University, New Britain, CT 06050. Deadline for application is 23 January 2006.

CCSU aggressively pursues a program of equal employment and education opportunity and affirmative action. Members of all underrepresented groups, women, veterans, and persons with disabilities are invited and encouraged to apply.

**DISTINGUISHED PROFESSOR OF INVERTEBRATE  
PALEONTOLOGY AND TREATISE EDITORSHIP  
THE UNIVERSITY OF KANSAS**

The Department of Geology at The University of Kansas seeks applications for an academic year, tenured faculty position at the level of distinguished professor to fill the position of Director of the Paleontological Institute and editor of the *Treatise on Invertebrate Paleontology*. The successful candidate will be a paleontologist who uses fossil invertebrates or microfossils to study evolution, taxonomy, paleobiology, or paleoecology and who has a well-established, internationally recognized program involving teaching, research, and service. The person

should also have administrative and editorial ability and experience. The successful candidate will be expected to: edit the *Treatise on Invertebrate Paleontology*; establish and maintain an externally funded post-doctoral or visiting scientist program; fundraise to support the Paleontological Institute; seek and obtain external funding for their own program of research and actively publish results of research; teach courses in the area of specialty at all levels; and supervise graduate students.

Refer to [www.geo.ku.edu](http://www.geo.ku.edu) and links for additional information about the department and the University of Kansas. Appointment will begin 18 August 2006 or later. Review of completed applications will begin 1 February 2006 and will continue until the position is filled. Applicants must have the academic qualifications, including an earned Ph.D., to meet the criteria appropriate for appointment as a Distinguished Professor with tenure as defined by the University of Kansas (see <http://www.ku.edu/~unigov/fachand1998.html>). Applicants should submit with their letter of application a Curriculum Vitae, statements outlining teaching and research interests, a long-term vision for the *Treatise on Invertebrate Paleontology*, and the names and contact information of at least three persons who can be contacted for letters of reference if the search committee so desires. All materials should be sent to: Chair, Invertebrate Paleontology Search, Department of Geology, 1475 Jayhawk Blvd., 120 Lindley Hall, University of Kansas, Lawrence, KS 66045-7613 (tel. +1-785-864-2743; fax +1-785-864-5276, email: [blieber@ku.edu](mailto:blieber@ku.edu)). EO/AA Employer. The University of Kansas is committed to increasing the ethnic and gender diversity of its faculty and we strongly encourage applications from underrepresented group members. Paid for by KU.

**ASSISTANT PROFESSOR—  
PALEOBIOGEOCHEMISTRY  
UNIVERSITY OF KANSAS**

The Department of Geology at the University of Kansas seeks applications for an academic year, tenure-track faculty position at the assistant professor level in the field of paleobiogeochemistry. We seek an outstanding colleague who applies geochemical techniques such as isotopes, compound analysis, and biomarkers for the detection and identification of organisms or organismal activity in the geologic record. Priority consideration will be given to individuals whose research emphasizes the origin and evolution of life and paleoenvironmental reconstructions. This is a new position in our growing program in Geobiology. The successful candidate is expected to complement the existing expertise in paleobiology and geomicrobiology. The successful candidate will be expected to establish an externally funded interdisciplinary research program, direct graduate students, and participate in teaching graduate and undergraduate students. Women, minorities and candidates who will contribute to the climate of diversity in the College, which includes a diversity of scholarly approaches, are especially encouraged to apply. Refer to [www.geo.ku.edu](http://www.geo.ku.edu) and links for additional information about the department and the University of Kansas. Appointment will begin 18 August 2006, or later.

Applicants should arrange for at least three letters of recommendation to be sent directly to search committee chair and send the following information to the search committee chair: (1) statement of research interests; (2) statement of teaching interests; (3) Curriculum Vitae. Send all material to Paleobiogeochemistry Search; Attention: Luis A. González, Department of Geology, 1475 Jayhawk Blvd., 120 Lindley Hall, University of Kansas, Lawrence, KS 66045-7613 (tel. +1-785-864-2743; fax +1-785-864-5276, e-mail [lgonzalez@ku.edu](mailto:lgonzalez@ku.edu)). Review of completed applications will begin January 6, 2006, and will continue until the position is filled.

The University of Kansas is an equal opportunity, affirmative-action employer. The university encourages applications from underrepresented group members. Federal and state legislation prohibits discrimination on the basis of race, religion, color, national origin, ancestry, sex, age, disability, and veteran status. In addition, university policies prohibit discrimination on the basis of sexual orientation, marital status, and parental status. Paid for by KU.

**TEMPORARY RESEARCH-TEACHING POSITION  
IN TECTONICS, UNIVERSITY OF MINNESOTA**

The Department of Geology & Geophysics at the University of Minnesota-Twin Cities invites applications for a non-tenure track research-teaching position for the 2006–2007 academic year. Teaching responsibilities are an undergraduate course in structural geology (fall semester) and an upper level course or seminar in the individual's area of expertise (spring semester). The position may be renewable for a second year. Type and level of research activities are up to the individual, but ideally will involve interaction with one or more research

groups in the department, e.g., tectonics, metamorphic geology, rock and mineral physics, surface processes, geofluids, experimental petrology, the Institute for Rock Magnetism, or the National Center for Earth-surface Dynamics; additional information is at [www.geo.umn.edu](http://www.geo.umn.edu). Review of applications will begin 17 January 2006. A Ph.D. by the time of appointment is required.

Applicants should send their curriculum vitae (including a list of publications), a statement of research and teaching experience and interests, and names and contact information of 3 references by mail or email to Professor Donna Whitney, Geology & Geophysics, University of Minnesota, 310 Pillsbury Dr. S.E., Minneapolis MN 55455 USA ([dwhitney@umn.edu](mailto:dwhitney@umn.edu)). The University of Minnesota is an equal opportunity educator and employer.

**ASSISTANT PROFESSOR  
WATERSHED MANAGEMENT AND MODELING  
COLORADO STATE UNIVERSITY  
DEPARTMENT OF FOREST, RANGELAND, AND  
WATERSHED STEWARDSHIP**

**Description:** Tenure track, 9-month academic faculty position.

The Department of Forest, Rangeland, and Watershed Stewardship at Colorado State University invites applications for a tenure track Assistant Professor in watershed management and modeling beginning in August 2006. A complete job description and general information about the Department can be found at <http://www.warnernr.colostate.edu/frws/>.

CSU is an EO/AA Employer.

**TWO TENURE-TRACK POSITIONS  
WRIGHT STATE UNIVERSITY**

The Department of Geological Sciences invites applications for the following positions:

**WATERSHED PROCESSES.** Preference will be given to candidates whose research focuses on watershed processes through interdisciplinary approaches. The candidate's own discipline might include (but is not limited to): surface and subsurface hydrology, process geomorphology, Quaternary studies, or biogeochemistry. Example focus areas are groundwater and surface water interaction, dynamics of watershed evolution (landscape, climate and ecosystems), and nutrient and metal dynamics. We prefer candidates who use GIS and other spatial modeling/visualization tools. The candidate will complement and broaden existing strengths in hydrology, environmental geochemistry, sediment transport, GIS, remote sensing, and geophysics within the department, and complement existing strengths in aquatic toxicology and watershed ecosystems within the broader Environmental Sciences Ph.D. program. We seek candidates who will establish an active research program that supports Environmental Sciences Ph.D. students. The candidate will also contribute to well-established M.S., B.S., and B.A. degree programs in geological sciences. Departmental space is undergoing a multimillion dollar renovation. The candidate will have the opportunity to establish a laboratory which links with existing, technician supported facilities for remote sensing and GIS, organic and inorganic environmental analysis, field data acquisition, aquatic toxicology, and which utilizes nearby experimental watersheds. Candidates should have earned a Doctorate in Geological Sciences or related field.

**GEOSCIENCE EDUCATOR.** This is a joint appointment between the Department of Geological Sciences in the College of Science and Mathematics (5/6) and the Department of Teacher Education in the College of Education and Human Services (1/6). Teaching will include undergraduate classes in Earth Science, science methods courses for pre-service K-12 teachers, and/or courses in an area of specialization. Participation in program development for, and teaching in, an established Master's program for in-service K-12 teachers in the Department of Geological Sciences is expected. Experience in developing and facilitating on-line courses and K-12 teaching experience are highly desirable. The successful applicant will be expected to develop an active program of scholarship in science education, including publications and external funding. Candidates should have earned a Doctorate in Geological Sciences or related field or a Doctorate in Science Education with a strong emphasis in Geological Sciences.

Successful candidates should have a doctorate by August 2006 and sufficient research experience to establish and maintain an independent, extramurally funded research program. Competitive start-up packages will be tailored to individual needs. WSU has 17,000 undergraduate and graduate students. Send letter of application, CV, statement of research and teaching interests, and names and contact information for three references to: Search Committees, Department of Geological Sciences, Wright State University, Dayton

OH 45435-0001. Electronic applications can be sent to [cindy.harrison@wright.edu](mailto:cindy.harrison@wright.edu). Review of applicants will begin 3 January 2006 and continue until the positions are filled. *Wright State University is an Affirmative Action/Equal Employment Opportunity Employer.*

**SURFACE HYDROLOGIST  
UNIVERSITY OF WISCONSIN-MILWAUKEE**

The Department of Geosciences invites applications for a full-time, tenure-track position in surface hydrology at the rank of Assistant Professor beginning in August 2006. We seek candidates with an expertise in surface hydrologic systems, especially (1) river-channel stability and sediment transport, (2) their relation to riparian wetlands, and (3) the effects of human actions on water systems. The successful candidate is expected to develop a vigorous research program, supervise graduate students, attract external funding and participate in the Geosciences' undergraduate and master's programs, as well as in a new multidisciplinary Ph.D. in Earth and Freshwater Sciences (offered jointly by Geosciences and the WATER Institute), and to conduct a water resources course for the interdisciplinary, undergraduate Conservation and Environmental Sciences Program.

The successful candidate will be encouraged to interact with groundwater hydrogeologists, sedimentologists, limnologists, river and wetland restoration ecologists and a wide range of scientists in the Geosciences, Geography, Atmospheric Sciences, the WATER Institute, Engineering, Urban Planning, Biological Sciences, among others.

Applicants should send a cover letter, CV, three letters of recommendation, and a statement of professional goals, research interests, and teaching philosophy to Dr. Timothy J. Grundl ([grundl@uwm.edu](mailto:grundl@uwm.edu)), Chair, Surface Hydrologist Search Committee, Department of Geosciences, The University of Wisconsin-Milwaukee, P.O. Box 413, Milwaukee, WI 53201-0413. Review of applications will begin 30 January 2006 and will continue until the position is filled. The University of Wisconsin-Milwaukee is an equal opportunity/affirmative action employer.

**PROFESSOR/RESEARCH SCIENTIST AND  
DIRECTOR**

**WATER QUALITY RESEARCH CENTER  
UNIVERSITY OF CALIFORNIA, RIVERSIDE**

**Position:** Associate or full Professor of Environmental Sciences/Environmental Research Scientist and Director, UC Riverside Water Quality Research Center. Date Available: 1 July 2006.

**Responsibilities:** Applications and nominations are invited for the tenured position of Associate or full Professor of Environmental Sciences and Environmental Scientist at the University of California, Riverside. This 9-month tenured appointment is 50% Instruction and Research; 50% Organized Research in the Department of Environmental Sciences, University of California, Riverside and the University of California Agricultural Experiment Station. Candidates should have a record of outstanding and internationally recognized research productivity in the general area of water science or water policy, and to have a demonstrated commitment to teaching excellence. The successful candidate will be expected to maintain an active and highly visible research program while providing leadership as Director of the UC Riverside Water Quality Research Center (WQRC). The WQRC is a newly formed research center at the University of California Riverside addressing water quality issues of regional, national, and global importance. The position includes appointment in the University of California Agricultural Experiment Station, and requires that the individual create an experiment station project relevant to the mission of the Division of Agriculture and Natural Resources of the University of California. The candidate filling this position will play a lead role in developing integrated studies of important processes as they affect water resources and water quality at the watershed to regional scales. These integrated studies should consider the source and fate of contaminants and develop efficient water quality and resource management methodologies taking into account these natural processes. As a senior scientist, this individual is expected to be the catalyst for large multi- and interdisciplinary studies that address critical water-quality and water resource issues in the United States and other regions facing water problems. This individual will facilitate the creation of needed linkages to address critical regional-scale issues concerning land use, urban and suburban development, agricultural practice, wetland management, and sustainability. This person will be expected to participate actively in the graduate Environmental Sciences program, and to develop a graduate class in an area related to his or her particular research area.

**Qualifications:** It is required that the successful candidate hold a Ph.D. or equivalent degree in a discipline relevant to the study of water quality, and have a research emphasis in some area of water science or policy. He or she will be expected to maintain an active and highly visible research program while providing leadership as Director of the WQRC, and to contribute to the graduate teaching program in Environmental Sciences.

**Application Procedures:** Applicants should send a complete resume, a statement of research interests and a statement of teaching interests, in addition to the names of five individuals who may be contacted for letters of reference, to Water Quality Search Committee Chair, c/o Department of Environmental Sciences, Room 2208 Geology, University of California, Riverside, CA 92521-0424. Evaluations of applications will begin 15 January 2006, but applications will be accepted until the position is filled. Salary is commensurate with education and experience.

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The Department of Geological Sciences and Geological Engineering, Queen's University, which has a tradition of research excellence in the fields of crustal processes and mineral-deposits geology, seeks individuals with outstanding research and teaching capabilities to apply for an Assistant Professor position at the interface between petrology and economic geology. We especially seek individuals whose research explores the physical or geochemical processes that contribute to the origin of mineral deposits.

The successful candidate is expected to carry on an active, externally funded research program of international caliber and to supervise graduate students at the M.Sc. and Ph.D. levels. An ability to contribute to the undergraduate and graduate teaching needs in the science and engineering programs offered by the Department, and a willingness to engage in collaborative research with Departmental colleagues, will be considered in the selection process. For more information about faculty research interests, the full range of undergraduate and graduate teaching programs, and our laboratory facilities, visit [www.geol.queensu.ca](http://www.geol.queensu.ca).

The University invites applications from all qualified individuals. Queen's is committed to employment equity and diversity in the workplace and welcomes applications from women, visible minorities, aboriginal people, persons with disabilities, and persons of any sexual orientation or gender identity. All qualified candidates are encouraged to apply; however, Canadian citizens and Permanent Residents will be given priority. The academic staff at Queen's University is governed by a collective agreement, the details of which are posted at <http://www.queensu.ca/qufa>.

Applicants should send a current curriculum vitae, a statement of research interests and future plans, a statement of teaching experience and interests, and samples of research writing to the following address. Individuals who intend to apply should arrange for three persons of high standing to provide letters of reference to the undersigned as soon as possible. Review of complete applications will begin on 15 February 2006.

Robert W. Dalrymple, Head, Department of Geological Sciences and Geological Engineering, Queen's University, Kingston, ON K7L 3N6, Canada, Telephone: 613-533-2598, Fax: 613-533-6592, e-mail: [zarichny@geol.queensu.ca](mailto:zarichny@geol.queensu.ca).

**TWO TENURE TRACK POSITIONS  
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OCEANOGRAPHY AND SEDIMENT DYNAMICS**

The Marine Sciences Program of the University of North Carolina at Chapel Hill seeks to fill two (2) tenure-track faculty positions: one in Geological Oceanography (MASC) and one in Sediment Dynamics (IMS).

**Department of Marine Sciences (MASC) Position:** All aspects of geological oceanography/marine geology will be considered. We encourage applicants whose research complements existing strengths in the Department and/or cuts across traditional disciplinary boundaries (see [www.marine.unc.edu/MASC.html](http://www.marine.unc.edu/MASC.html) for further information). The candidate filling the MASC position will be expected to teach courses at the undergraduate and graduate levels.

**Institute of Marine Sciences (IMS) Position:** IMS seeks an individual investigating physical processes of sediment transport either in estuaries or the nearshore zone (see [www.marine.unc.edu/IMS.html](http://www.marine.unc.edu/IMS.html) for more information). The IMS position carries no formal teaching requirement, although undergraduate and graduate teaching opportunities exist.

The selected individuals will be expected to develop externally funded research programs, pub-

lish in peer-reviewed journals, and direct graduate students. Qualifications include a Ph.D. in Geological Oceanography, Marine Geology, Geology, Engineering or a related field. Post-doctoral experience is preferred. The positions will be filled at the Assistant Professor level. Nine months salary support will be provided for each position.

Applicants should submit a CV, a statement of research interests, and a statement of teaching interests (for MASC only). Also, arrange to have four reference letters sent to: for the MASC position—Chair, Geological Oceanography Search Committee, UNC—Chapel Hill, Dept. of Marine Sciences, Venable Hall CB #3300, Chapel Hill, NC 27599; for the IMS position—Chair, Sediment Dynamics Search Committee, UNC—CH Institute of Marine Sciences, 3431 Arendell St., Morehead City, NC 28557. We will consider applications beginning 2 January 2006. The University of North Carolina at Chapel Hill is an equal opportunity employer.

**MINERALOGY, PETROLOGY, and GEOCHEMISTRY**  
 The Department of Geology at Marshall University invites applications for a tenure track teaching position beginning 14 August 2006. The position will be filled at the Assistant or Associate Professor level. We seek a student-oriented individual who will teach upper level courses in mineralogy, petrology, and geochemistry as well as services courses in General Geology and/or Physical Geology and Earth Materials Lab. A Ph.D. is required and post secondary teaching experience is preferred. A vigorous, externally supported research program that involves undergraduate research is expected and a research focus on environmental geochemistry is desirable. Departmental recourses include an extensive rock and mineral collection, thin and polished section preparation lab, X-ray diffractometer, ICP-AA Spectrometer, and SEM with EDS.

Candidates should submit a letter of application, curriculum vitae, undergraduate and graduate transcripts, a statement of teaching and research interests, and the names of contact information (including e-mail addresses) for three references. All application materials should be sent to Dr. Dewey Sanderson, Chair, Department of Geology, Marshall University, Huntington, WV 25755. Review of applications will begin early January and continue until the position is filled.

Marshall University is an EO/AA employer. Women and minorities are encouraged to apply. For additional information about the Department of Geology and Marshall University, please visit the website [www.marshall.edu](http://www.marshall.edu).

## Opportunities for Students

**Ph.D. Students Wanted. Program in Infrastructure and Environmental Systems.** University of North Carolina—Charlotte. The interdisciplinary program in Infrastructure and Environmental Systems at UNC Charlotte is accepting applications for Ph.D. students. Full funding, including tuition waivers and health care coverage, is available as early as January 2006. Areas of student research include: biogeochemistry, applied climatology, coastal processes, contaminant transport, engineering geology, environmental geology, fluvial processes, geochemistry, geotechnical engineering, GPS, surface and groundwater hydrology, landfill design, tropical meteorology, mineralogy, petrology, Quaternary geology, remote sensing, sedimentology, stratigraphy, site remediation, slope stability, soil geomorphology, structural geology, surficial processes, vadose zone processes, watershed analysis and numerical weather prediction. Students have access to extensive field and analytical equipment and facilities including IC, ICP-MS, XRD, XRF, GPR, grain size analysis and GIS laboratories. We are located in the beautiful Piedmont of North Carolina close to pristine beaches and the Blue Ridge Mountains. Application deadline: 15 February 2006 for the 2006–2007 academic year. Applications for January 2006 admission are encouraged. For more information contact [jadiemer@uncc.edu](mailto:jadiemer@uncc.edu) or visit <http://www.ce.uncc.edu/INES/>.

**Ph.D. Student Assistantships. Oregon State and Portland State Universities** are offering ten Ph.D. research assistantships to explore all aspects of the Earth's subsurface microbial biosphere. Tuition and stipend are provided by the NSF IGERT program and the two universities. Students will work in interdisciplinary teams of engineers, oceanographers, microbiologists, microbial ecologists, geologists, soil scientists, and chemists to solve environmental problems, to

understand global chemical cycles, and to determine the impact of subsurface microorganisms on surface ecosystems. More information can be found at: <http://oregonstate.edu/dept/igert>, or Martin R. Fisk, College of Oceanic and Atmospheric Sciences, Oregon State University, [mfisk@coas.oregonstate.edu](mailto:mfisk@coas.oregonstate.edu) Students from all scientific backgrounds are encouraged to apply to departments represented by IGERT faculty at either institution. U.S. citizens or permanent residents can be supported by IGERT funds however students of all nations can participate in the program. Review of applications starts 1/15/06. Oregon State and Portland State Universities are committed to equality in education.

**Graduate Fellowships at Indiana University.** The Department of Geological Sciences at Indiana University (Bloomington) solicits applicants for at least five graduate fellowships in the following areas: Geobiology/Stratigraphy, Geophysics, Geomorphology, Petroleum Geology, and Clay Mineralogy. The fellowships offer up to \$18,000 per year plus tuition waiver. The duration of the fellowship varies but Ph.D. and M.Sc. students are guaranteed 4 and 2 years of support within the Department, respectively. Applicants for the 2006–2007 academic year should contact: Dr. Mark Person, Director of Graduate Studies, Indiana University, Department of Geological Sciences, [maperson@indiana.edu](mailto:maperson@indiana.edu), +1-812-855-4404.

**NASA Planetary Biology Internships.** The Marine Biological Laboratory, Woods Hole, Massachusetts, invites applications from graduate students and seniors accepted to graduate programs for rewards of \$2800 plus travel to participate in research in NASA centers and collaborating institutions for approximately 8 weeks. Typical intern programs include: global ecology, remote sensing, microbial ecology, biomineralization, and origin and early evolution of life. Application deadline: 1 March 2006. For information/applications, contact: Michael Dolan, Planetary Biology Internship, Department of Geosciences, Box 3-5820, University of Massachusetts, Amherst, MA 01003-5820. E-mail: [pbi@geo.umass.edu](mailto:pbi@geo.umass.edu). Tel +1-413-545-3223. An Equal Opportunity/Affirmative Action Employer.

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# Caribbean–South American Plate Interactions, Venezuela

edited by Hans G. Avé Lallemant and Virginia B. Sisson

Rocks in plate boundary zones are generally strongly deformed. Rocks in the Mesozoic–Cenozoic Caribbean–South American plate boundary zone in Venezuela are no exception. The first of four major deformation events occurred in Jurassic to Early Cretaceous time and is expressed by normal faults recognized in seismic reflection lines and by extensional mylonites in the Tinaquillo alpine-type peridotite. Subsequently, Early Cretaceous subduction created high-pressure–low-temperature mélanges that were exhumed in the Late Cretaceous to Eocene. Next, north-south contraction resulted in an Eocene fold and thrust belt. The final event from Eocene to Recent resulted in west to east diachronous, right-oblique convergence and collision of the Leeward Antilles arc. All of

this is documented with new geochronology, geochemistry, petrology, sequence stratigraphy, structural geology, and reflection seismology.

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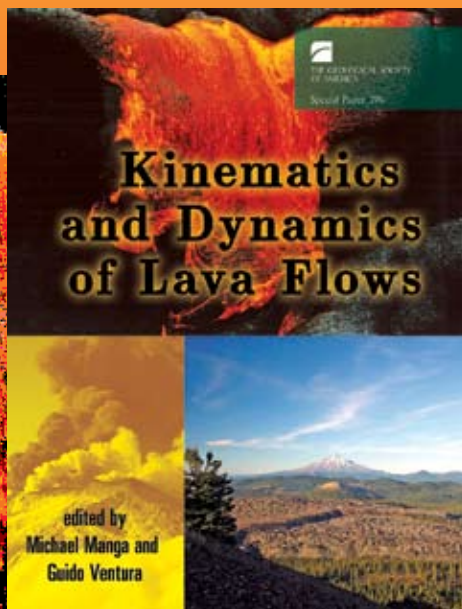
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edited by Michael Manga  
and Guido Ventura

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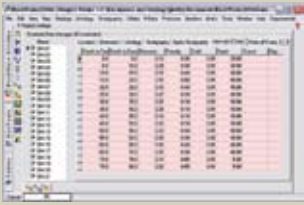
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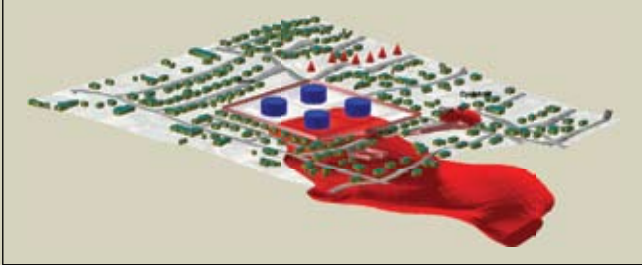
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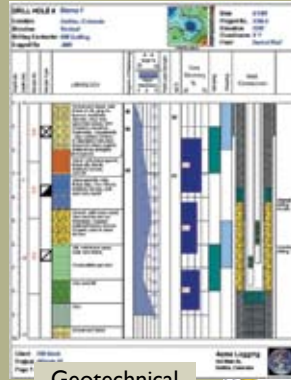


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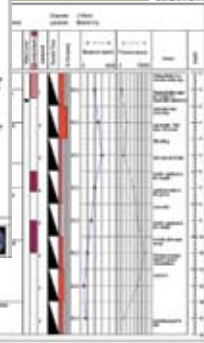
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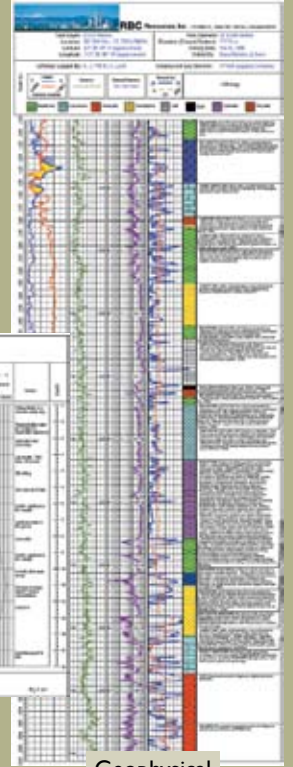
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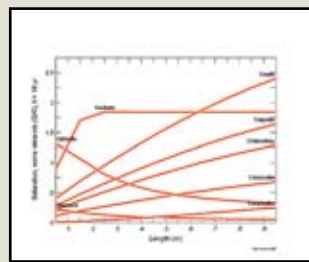
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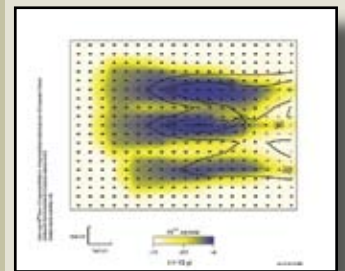
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