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Errata:
The April/May 2008 issue of GSA Today (v. 18, no. 4/5, p. 13) identifies a picture as “Horseshoe Canyon of the Colorado River” when in fact the photo is Horseshoe Bend, downstream of Glen Canyon Dam in the Colorado River. Horseshoe Canyon is in an arid location area west of Green River in Utah, USA.

The September GSA Today Foundation Update (v. 18, no. 9, p. 68) attributed the “Digging Up the Past” experience relayed there to Monte D. Williams. The experience, which was paraphrased and edited for length, was that of GSA Senior Member Monte D. Wilson of Boise, Idaho, USA.

GSA Today regrets these errors.
The significance of sheeted dike complexes in ophiolites

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ABSTRACT

Sheeted dike complexes, in which dike intrudes dike without intermediate screens of gabbro or pillow lava, have long been considered key features of oceanic lithosphere and ophiolites formed in extensional environments. The presence of a sheeted complex implies an approximate balance between spreading rate and magma supply, such that there is just enough melt to fill newly formed fractures produced by spreading. Such a balance appears to exist at mid-ocean ridges, where both the spreading rate and magma supply are probably linked to mantle convection, and thus sheeted dikes appear to be a major part of the ocean crust. In contrast, ophiolites, which are formed or modified in suprasubduction zone environments, rarely have large, well-developed sheeted dike complexes, because magma supply and spreading rate are not linked in the same way. In suprasubduction zone environments, the spreading rate is controlled largely by the rate of subduction rollback, whereas the magma supply is controlled by the local temperature profile, the lithology of the subducting crust and mantle wedge, the history and degree of melting of the mantle source, and the abundance and nature of fluids. Because spreading rate and magma supply are rarely balanced in these environments, we suggest that sheeted dikes, rather than being key elements of ophiolites, may instead be unusual features in such bodies. Thus, care must be exercised in using ophiolites to investigate spreading processes at mid-ocean ridges.

INTRODUCTION

Ophiolites are fragments of oceanic crust and upper mantle that have been uplifted and emplaced on continental margins or in accretionary prisms and island arcs. According to a 1972 GSA Penrose Conference, an idealized, complete ophiolite contains, from the base upward, mantle peridotites, layered ultramafic rocks and gabbros, isotropic gabbros, a sheeted dike complex, and an extrusive sequence, composed of pillowed and massive lavas, overlain by radiolarian chert and/or pelagic limestone (Anonymous, 1972; Dilek, 2003). The presence of a sheeted dike complex has been interpreted as an essential component of ophiolites, as exemplified by the Troodos ophiolite of Cyprus (Fig. 1A), where such complexes were first recognized (Gass, 1968). Sheeted dikes, which are tabular intrusions of magma with no intervening screens of other host rock (Fig. 1B), are believed to form in extensional environments where the faults and fractures produced by seafloor spreading are filled with new magma flowing laterally and vertically along a narrow axial zone beneath the spreading center (Vine and Matthews, 1963; Gass, 1968; Kidd and Cann, 1974; Dilek et al., 1998). In 1968, when Gass correctly identified the sheeted complex in Troodos, mid-ocean ridges were the only environment where such spreading was known to occur; thus, he suggested a mid-ocean ridge environment for the formation of this ophiolite.

Figure 1. Sheeted dikes of the Cretaceous Troodos ophiolite, Cyprus. (A) A typical outcrop of sheeted dikes in which dike intrudes dike without intervening host rock. Individual dikes range from a few centimeters to ~0.5 m in this outcrop (Baragar et al., 1989). Note the inclined dikes on the right side of the picture. These earlier dikes were probably tilted by listric faulting along the spreading axis (Varga and Moores, 1985) and then intruded by the younger vertical dikes in the center. (B) Close-up view of sheeted dikes in Troodos showing contact relationships. Arrows point to one-sided chilled margins.
Sheeted dikes similar to those in ophiolites have since been observed in the walls of oceanic fracture zones (e.g., at Hess Deep; Stewart et al., 2002, 2003) and have been drilled at Deep-Sea Drilling Project–Ocean Drilling Project (DSDP-ODP) Hole 504B south of the Costa Rica Rift (e.g., Alt et al., 1996; Bach et al., 1996; Dilek et al., 1996; Dilek, 1998). Although not widely exposed on the seafloor, such dikes are believed to be a major component of the ocean crust, forming the lower part of seismic layer 2 and perhaps the upper part of layer 3 (Detrick et al., 1994), where they are interpreted to form the plumbing system between sub-rift magma chambers and the overlying extrusive rocks.

Oceanic lithosphere is produced at different rates along modern spreading centers, leading to different structural architectures (Karson, 1998). Fast-spreading mid-ocean ridges are generally characterized by a voluminous magma supply and have well-defined convex axial highs, whereas slow-spreading ridges have a lower magma supply and are characterized by axial grabens and extensive tectonic disruption (Phipps Morgan et al., 1994; Cannat et al., 1995). Based on these observations, many workers have interpreted ophiolite complexes in the same manner. Thus, well-developed sheeted complexes showing little tectonic disruption have been interpreted as the products of fast-spreading centers, whereas poorly developed complexes with extensive disruption were thought to have formed at slow-spreading ridges (e.g., Nicolas et al., 1999).

We suggest that such a generalization is probably not valid and that direct correlations between in situ oceanic lithosphere and ophiolites are rarely possible. Although probably well developed in modern ocean crust, sheeted dikes are rare in ophiolites. Large, well-developed sheeted complexes are found only in a few bodies, such as the Troodos ophiolite of Cyprus (Gass, 1968; Baragar et al., 1989), the Semail ophiolite of Oman (Searle and Cox, 1999; Umino et al., 2003), the Kizildag ophiolite of Turkey (Dilek and Thy, 1998), and examples from Newfoundland (Church and Riccio, 1974; Strong and Malpas, 1975); most other ophiolites lack sheeted dikes entirely or contain only small, discontinuous bodies. Some ophiolites contain sills complexes rather than dikes (Hopson et al., 2008). The paucity of sheeted dikes in many ophiolites implies either that they did not form originally as part of the ancient oceanic lithosphere or that they were selectively removed during tectonic disruption of the crust, either during seafloor spreading or during ophiolite emplacement. However, ophiolites that lack sheeted dike complexes commonly have the other characteristic lithologies included in the Penrose Conference (Anonymous, 1972) definition, such as ultramafic rocks, gabbrons, lavas, and pelagic-hemipelagic sedimentary rocks, and display no significant strain associated with emplacement tectonics. Because it is difficult to envisage the widespread, selective tectonic removal of the portion of an ophiolite that originally existed between the volcanic and plutonic rocks, we suggest that well-developed sheeted dike complexes rarely form in such bodies because the tectonic environment of formation of many ophiolites is different from that of mid-ocean ridges.

In this paper, we discuss the evidence for the formation of ophiolites in suprasubduction zones, consider the processes involved in the development of sheeted dikes, and show why such complexes are rare in ophiolites. We suggest that sheeted dikes, rather than being considered necessary elements of ophiolites, should be viewed as possible—but not essential—features in such bodies.

**FORMATION AND EMPLACEMENT OF OPHIOLITES**

Increasingly detailed tectonic and geochemical studies over the past 30 years have shown that most ophiolites contain volcanic and plutonic rocks with clear suprasubduction zone geochemical signatures (Pearce, 2003, and references therein). For example, ophiolitic lavas are dominated by arc tholeiites, back-arc basalts, andesites, dacites, and depleted lavas resembling boninites, most of which are distinctly different from mid-ocean ridge and ocean island basalts (Table 1) and are found only in modern suprasubduction zone environments. Some tholeiitic basalts erupted in suprasubduction zone environments have major oxide contents similar to those of mid-ocean ridge lavas but can easily be distinguished on the basis of their trace element compositions (Fig. 2). Compared to typical mid-ocean ridge basalt (MORB), suprasubduction zone magmas are characterized by significant enrichment in large ion lithophile elements (LILE: K, Rb, Cs, Th) and light rare earth elements (LREE) (Pearce, 1982) and depletion in high field strength elements (Ti, Nb, Ta, Hf) (Pearce, 1982; Shervais, 1982). Island arc basalts, for example, are easily recognized on mantle-normalized trace element spider diagrams by their marked negative Nb and Ta anomalies (Fig. 2). Many ophiolites also contain high MgO–high SiO₂ lavas, such as boninites, that in modern environments are restricted to forearc regions.

A few rare occurrences of lavas with arc signatures are currently being erupted at modern ridge axes, such as in the Woodlark Basin (Perfit et al., 1987) and on the southern Chile Ridge (Klein and Karsten, 1995; Karsten et al., 1996), however, these are anomalous features in the ocean basin. The arc-like lavas being erupted in the Woodlark Basin are due to subduction reversal, so that seafloor spreading is now taking place in what used to be a backarc basin above a subduction zone dipping SW beneath the Solomon islands (Abbott and Fisk, 1986; Johnson et al., 1987). The collision of the Ontong Java Plateau with this subduction zone at about the middle or late Miocene halted the subduction and caused a subduction jump and polarity reversal beneath the Solomon Islands (Weissel et al., 1982). The southern Chile Ridge is being subducted beneath

---

**Table 1. Average compositions of common oceanic basaltic rocks**

<table>
<thead>
<tr>
<th></th>
<th>N-MORB</th>
<th>E-MORB</th>
<th>OIB</th>
<th>Alk-Oliv</th>
<th>Arc Thol</th>
<th>Bon</th>
</tr>
</thead>
<tbody>
<tr>
<td>SiO₂</td>
<td>50.4</td>
<td>51.2</td>
<td>49.2</td>
<td>47.6</td>
<td>51.7</td>
<td>53.6</td>
</tr>
<tr>
<td>TiO₂</td>
<td>1.36</td>
<td>1.69</td>
<td>2.57</td>
<td>3.23</td>
<td>1.36</td>
<td>0.26</td>
</tr>
<tr>
<td>Al₂O₃</td>
<td>15.2</td>
<td>16</td>
<td>12.8</td>
<td>15.7</td>
<td>16.57</td>
<td>13.5</td>
</tr>
<tr>
<td>Fe₂O₃</td>
<td>9.31</td>
<td>8.46</td>
<td>11.4</td>
<td>13.4</td>
<td>8.4</td>
<td>8.6</td>
</tr>
<tr>
<td>MnO</td>
<td>0.18</td>
<td>0.16</td>
<td>0.17</td>
<td>0.19</td>
<td>0.16</td>
<td>0.15</td>
</tr>
<tr>
<td>MgO</td>
<td>9.5</td>
<td>6.9</td>
<td>10</td>
<td>5.6</td>
<td>6.6</td>
<td>10.2</td>
</tr>
<tr>
<td>CaO</td>
<td>11.4</td>
<td>11.5</td>
<td>10.8</td>
<td>7.9</td>
<td>10.8</td>
<td>12.2</td>
</tr>
<tr>
<td>Na₂O</td>
<td>2.3</td>
<td>2.7</td>
<td>2.1</td>
<td>4.0</td>
<td>3.0</td>
<td>0.92</td>
</tr>
<tr>
<td>K₂O</td>
<td>0.09</td>
<td>0.4</td>
<td>0.5</td>
<td>1.5</td>
<td>0.34</td>
<td>0.41</td>
</tr>
<tr>
<td>P₂O₅</td>
<td>0.14</td>
<td>0.15</td>
<td>0.25</td>
<td>0.35</td>
<td>0.18</td>
<td>0.04</td>
</tr>
<tr>
<td>Total</td>
<td>99.38</td>
<td>99.16</td>
<td>99.79</td>
<td>99.47</td>
<td>99.11</td>
<td>99.88</td>
</tr>
</tbody>
</table>

*Note: N-MORB—normal mid-ocean ridge basalt; E-MORB—enriched mid-ocean ridge basalt; OIB—oceanic island basalt; Alk-Oliv—alkaline olivine basalt; Arc Thol—arc tholeiitic basalt; Bon—boninite.*
the South American continent, and this process may account for the anomalous trace element signatures (i.e., weak Nb anomaly, slight enrichment of LILE) and modest variations in the Pb, Sr, and Nd isotope ratios (consistent with contamination of its mantle source by subducted terrigenous sediment and altered oceanic crust) of the erupted lavas (Sturm et al., 2000).

These isolated examples cannot explain the widespread occurrence of suprasubduction zone lavas in ophiolites. For example, the Troodos ophiolite of Cyprus, long considered to be a fragment of normal oceanic lithosphere, contains only arc tholeiites, andesites, dacites, and rhyodacites accompanied by boninitic lavas (Robinson et al., 1983; McCulloch and Cameron, 1983; Malpas and Langdon, 1984; Robinson and Malpas, 1990; Bednarz and Schmincke, 1994; Dilek and Flower, 2003); the Oman ophiolite contains a range of lava compositions, most with suprasubduction zone signatures (Alabaster et al., 1982; Ishikawa et al., 2002), and the rocks of the Bay of Islands ophiolite of Newfoundland have trace element signatures typical of suprasubduction zone environments (Jenner et al., 1991; Suhr and Edwards, 2000).

Some ophiolites also contain remnants of volcanic and plutonic rocks comparable to those found in modern ocean crust, suggesting a compound origin (e.g., Shervais and Kimbrough, 1985; Batanova and Sobolev, 2000; Zhou et al., 2000; Malpas et al., 2003). In such cases, it is generally postulated that fragments of oceanic lithosphere that formed originally at mid-ocean ridges were trapped above intraoceanic subduction zones, where they were invaded by, reacted with, and partially replaced by, suprasubduction zone melts (Dilek and Flower, 2003; Malpas et al., 2003). In other cases, such as in the Coast Range ophiolite of California and the Josephine ophiolite of Oregon, MORB lavas intrude suprasubduction rocks, possibly as the result of ridge collision and/or rift propagation into an arc or forearc region (Shervais et al., 2004; Harper, 2003). However, it is now generally accepted that the majority of ophiolites are both formed and emplaced in suprasubduction zone environments (e.g., Stern and Bloomer, 1992; Shervais, 2001; Pearce, 2003).

Moores (1982) classified ophiolites into Cordilleran and Tethyan types (now referred to as Sierran and Mediterranean types,
respectively—see Dilek, 2003) based on their emplacement mechanisms. Sierran-type ophiolites occur in accretionary-type orogenic belts where they structurally overlie subduction-accretion complexes and are incorporated into active continental margins through the growth and uplift of the underlying accretionary prisms. Mediterranean ophiolites structurally overlie passive continental margins and micro- and ribbon continents and are emplaced by partial subduction of these buoyant crustal entities beneath them. Ophiolites that evolved in restricted Mediterranean-type marginal basins may have a typical Penrose Conference-type (Anonymous, 1972) pseudodstratigraphy, and the time difference between their igneous accretion and tectonic emplacement is commonly short, perhaps >10 m.y. (Dilek et al., 2005). In contrast, Sierran-type ophiolites are believed to have formed in active margins facing large ocean basins, such as the modern western Pacific region, where continuous subduction persisted for prolonged periods. Such ophiolites display a highly heterogeneous internal structure with igneous ages spanning 50 m.y. or more. However, many of these differences may simply reflect different stages of evolution of the ophiolites rather than fundamental differences in their formation. What is apparent is that most Sierran-type ophiolites lack sheeted complexes entirely; others may have isolated dike swarms or small enclaves of sheeted dikes (Dilek et al., 1991; Beccaluva et al., 2004). Sheeted dikes are commonly better developed in Mediterranean-type ophiolites, but even in these bodies, large, well-developed sheeted complexes, such as those observed in Cyprus and Oman, are rare. Why do sheeted dikes occur in some ophiolites and not in others, and why are such complexes rare?

Sheeted dikes form when magma is intruded into cracks and fissures produced by tensile stresses. These magma-filled fractures propagate vertically and laterally beneath narrow rift axes. When the roof of the magma chamber ruptures because of reservoir replenishment from a buoyant melt zone near the Moho, mafic melt that has accumulated along the neutral buoyancy region (dike-gabbro boundary) starts ascending to form dike injections (Ryan, 1994). Thus, for a large, well-developed sheeted complex to form, there must be an approximate balance for an extended period between spreading rate and magma supply so that sufficient melt is available to keep pace with spreading. If the rate of spreading exceeds the rate of magma supply, the crust will be disrupted tectonically via magmatic extension, and few or no sheeted dikes will form. If the magma supply exceeds the spreading rate, excess melt may form plutons underplating the extrusive sequence and the sheeted dikes may cause local thickening of the crustal section by magmatic inflation.

In mid-ocean ridge environments, the rate of spreading appears to be approximately related to the rate of magma supply. Thus, fast-spreading ridges (e.g., portions of the East Pacific Rise) produce voluminous magma over a wide area beneath the ridge (Fig. 3A) (Phipps Morgan et al., 1994). The high magma supply rates produce an axial rift zone that is marked by the existence of a temporally continuous magma lens (Sinton and Detrick, 1992) and a topographically well-defined ridge crest reminiscent of shield volcanoes (e.g., Macdonald et al., 1993a, 1993b; Scheirer and Macdonald, 1993). On the other hand, slow-spreading ridges are associated with more restricted melting, and the magma supply is greatly reduced, creating an environment in which tectonic extension via crustal stretching and faulting predominates, so that the axial zone is marked by a deep graben. At ultrasmall-spreading ridges, such as the Southwest Indian Ridge or the Gakkel Ridge, magma supply is small and episodic, and the crust is tectonically disrupted by detachment faulting, leading to exposures of the lower crust and upper mantle on the seafloor (Dick, 1989; Dick et al., 1991; Michael et al., 2003; Jokat et al., 2003). There appears to be, therefore, an approximate balance between spreading and magma supply rates at modern mid-ocean ridges. Such a balance is also suggested by the relatively uniform seismic thickness of in situ oceanic crust (~6 km), although it is clear that the seismic Moho and petrologic Moho (i.e., crust-mantle lithologic boundary) do not always correlate with one another, as determined in some ophiolitic complexes (Malpas, 1973; Malpas and Stevens, 1978) and in modern oceanic lithosphere (Muller et al., 1997; McClain, 2003).

The correlation between spreading rate and magma supply at mid-ocean ridges probably reflects the relatively simple
nature of the system. Mid-ocean ridge lavas are sourced from a dry, relatively homogeneous mantle with a constant geotherm in which melting is almost entirely dependent on decompression.

It is difficult to apply a spreading-rate-controlled model of igneous accretion to ophiolites that form in suprasubduction zone environments. In such environments, the spreading rate and magma supply are not so clearly linked. Suprasubduction zone spreading rate is controlled largely by subduction rollback, which is the major cause of lithospheric extension at a convergent plate boundary (Hamilton, 1995). The edge force of “trench suction” places the overriding lithosphere in a state of tension as the subduction zone moves oceanward under the influence of the negative buoyancy of the cold, dense descending slab. The rate of slab rollback may be related to a number of factors (see summaries by Forsyth and Uyeda, 1975; Jarrard, 1986), amongst which the most important may be the angle of subduction; steeply dipping zones such as those of the western Pacific Ocean might be expected to retreat more rapidly than the more shallow-dipping zones of the eastern Pacific (Schellart et al., 2006). The angle of subduction must itself be related to the age and density of the subducted oceanic lithosphere, with younger, hotter material being more buoyant than older, colder material (Stern and Bloomer, 1992). However, the overall rate of convergence and the absolute speed of the overriding plate (Gross and Pilger, 1982) may also be controlling factors—shallow-dipping subduction is invariably associated with high convergence rates. Whatever the specific mechanisms of subduction rollback may be, the multitude of competing forces present along a convergent margin negate the likelihood of rollback being as regular and steady-state as mid-ocean ridge spreading.

FORMATION OF SHEETED COMPLEXES

While the rate of spreading in the upper plate within subduction environments is linked directly to the rate of subduction rollback, the magma supply rate is not. Suprasubduction zone magma supply rates are related to the local temperature profile, the lithology of the subducting crust and mantle wedge, the history and degree of melting of the mantle source, and the abundance and nature of fluids (Kincaid and Hall, 2003). The paucity of sheeted dikes in many ophiolites suggests that spreading rates in suprasubduction zone environments are commonly not matched by equal rates of magma supply. This inference is consistent with the thin nature of ophiolitic crust compared to modern oceanic crust in present-day major ocean basins (Coleman, 1977); that is, spreading in suprasubduction zones is dominated by tectonic extension, which results in crustal thinning.

Although magma supply in suprasubduction zones can be voluminous, eruptions are concentrated in the arc portions of the zones and are focused on individual volcanoes. Magma supply rates are generally lower in fore-arc and backarc regions, which are characterized by high extensional strain. These are the regions in which most ophiolites are believed to form, because ophiolites rarely contain the explosive volcanic materials characteristic of arc volcanoes.

Many ophiolites lack a coherent internal structure due to tectonic disruption during their formation and emplacement, and in some cases, pillow lavas rest directly in eruptive contact on mantle peridotites with no intervening gabbros or sheeted dikes (Dilek and Thy, 1998), a situation similar to that at modern ultraslow-spreading axes (e.g., Gakkel Ridge). In these cases, the pillow lavas must have been fed from magma sources, perhaps represented by gabbroic rocks in the mantle sequence (cf. Cannat et al., 1995), resulting in the appearance of individual dikes. Recognition of consanguineous magmatism and tectonic disruption is difficult, and synmagmatic deformation might not be as obvious as in those cases where dismemberment of the crustal sequence took place later—i.e., during emplacement of the ophiolite. The recognition of undeformed magmatic intrusions that cut deformed and extended crustal sequences in some ophiolites confirms the timing of deformation and structural omission as intra-oceanic and pre-emplacement on land.

CONCLUSIONS

The presence of large and well-developed sheeted dike complexes, such as those in Cyprus and Oman, is not a common feature of ophiolites. Indeed, it can be argued that the recognition of a sheeted complex should not be a requirement for the definition of this suite of rocks. The formation of a sheeted complex requires a balance between spreading rate and magma supply over a period of millions of years, a situation that is probably unusual in suprasubduction zone environments, where the two are at least partly decoupled.

Ophiolites were once considered direct analogues of oceanic lithosphere developed at mid-ocean ridges, but this view is incompatible with the geochemical characteristics of ophiolitic rocks, which indicate a strong subduction component in their melt evolution. However, it has been argued that even though ophiolites form in an anomalous spreading environment above subduction zones, they record structural and igneous processes similar to those occurring at mid-ocean spreading centers and can be considered proxies for studies of some aspects of in situ ocean crust. Such comparisons cannot be pursued too far, however. The relationship between tectonic and magmatic activities in suprasubduction spreading is controlled by different factors than those operating at mid-ocean ridge spreading centers. Care must be exercised when using features like sheeted dike complexes in ophiolites to investigate spreading processes at mid-ocean ridges.

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REFERENCES CITED


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John C. Frye Environmental Geology Award

*Supported by endowment income from the GSA Foundation’s John C. Frye Memorial Fund.*

In cooperation with the Association of American State Geologists, GSA makes an annual US$1,000 cash prize award for the best paper on environmental geology published either by GSA or by one of the state geological surveys.

Nomination deadline: **31 March 2009.**

2009 National Awards

GSA Members are invited to nominate colleagues for the following awards, which are coordinated by the American Geological Institute (AGI).

- William T. Pecora Award
- National Medal of Science
- Vannevar Bush Award
- Alan T. Waterman Award

Nomination deadline: **1 February 2009.**

2009 Student Research Grants

Grants applications may be made online only; no paper applications or letters will be accepted. Go to www.geosociety.org/grants/gradgrants.htm to apply beginning the end of November.

Submission deadline: **11:59 p.m. (MST) on Sunday, 1 February 2009.**

2009 Post-Doctoral Research Awards

The following research awards are managed by the GSA Foundation. Learn more at www.geosociety.org/grants/postdoc.htm.

- **The Gladys W. Cole Memorial Research Award** for research on the geomorphology of semiarid and arid terrains in the United States and Mexico is awarded annually to a GSA Member or Fellow between 30 and 65 years of age who has published one or more significant papers in geomorphology. 2009 award: US$9,900.

- **The W. Storrs Cole Memorial Research Award** for research in invertebrate micropaleontology is awarded annually to a GSA Member or Fellow between 30 and 65 years of age who has published one or more significant papers on micropaleontology. 2009 award: US$9,100.

Deadline for application: **1 February 2009.**
Preliminary Announcement and Call for Papers

NORTH-CENTRAL

43rd Annual Meeting
Rockford, Illinois, USA

2–3 April 2009

CALL FOR PAPERS
Abstract Deadline: 30 December 2008

Technical Sessions
Please submit your abstract online at www.geosociety.org/meetings. An abstract submission fee of US$10 will be charged. If you cannot submit the abstract online, please contact Nancy Wright, +1-303-357-1061, nwright@geosociety.org.

Symposia Sessions
1. Hydrogeology in Fractured Rocks.
2. Water Resources in Karst Terranes of the Midwestern U.S.
5. Central American Volcanism.

LOCATION
We will meet in Rockford, Illinois, USA, on the campus of Northern Illinois University (NIU). The third largest city in Illinois, Rockford was originally named Midtown in 1834 but was renamed ca. 1837 because of its location at a rock outcrop popular for fording the Rock River. Our welcoming reception will be held at the Burpee Museum of Natural History, which has an ongoing paleontologic research program with NIU centered on the Hell Creek Formation in Montana and the Morrison Formation in Utah. This program led to the excavation and restoration of Jane, a juvenile *Tyrannosaurus rex*, on display in the museum, and Petey, another juvenile *T. rex*, now being restored. A museum-sponsored excavation this year near Hanksville, Utah, USA, unearthed a number of Late Jurassic dinosaur specimens, including *Camarasaurus* and *Allosaurus*, and some of these finds are also on display.
Theme Sessions
1. Applied Geology: Environmental, Hydrogeological, and Geotechnical.
3. Quaternary Research in Wisconsin.
4. Medical Geology.
5. Polar Climate Change.
8. Easy-to-Incorporate Inquiry-Based Activities for the K–16 Classroom. Cosponsored by the National Association of Geoscience Teachers.
10. Issues in Geoscience Education. Cosponsored by the National Association of Geoscience Teachers.
12. Sedimentary Event Histories and Controls on Timing and Patterns of Deposition in North American Phanerozoic Basins. Cosponsored by the Great Lakes Section, SEPM.
13. Climate Change: Causes, Consequences, and Adaptations.

REGISTRATION
Early Registration Deadline: 2 March 2009
Cancellation Deadline: 9 March 2009
Online registration begins in January 2009. Details on field trips, workshops, student opportunities, the guest program, and symposia and theme sessions for this meeting will be online at www.geosociety.org/sectdiv/Northc/09mtg/.

For further information, or if you have special requirements, please contact the local committee chair, Eugene Perry, t60ecp1@wpo.cso.niu.edu, +1-815-753-7935, or technical program chair, James Walker, t60jaw1@wpo.cso.niu.edu, +1-815-753-7936.

FIELD TRIPS
If you’d like to propose a field trip, please contact field trip co-chairs Michael Konen, mkonen@niu.edu, +1-815-753-6849, and Steve Simpson, steve.simpson@highland.edu, +1-815-599-3474.
2. Geology and Geo-Engineering along the Chicago Lakefront. Sat., 4 April.
4. The Upper Mississippi Valley Pb-Zn District Revisited: Mining History, Geology, Reclamation and Environmental Issues 30 Years after the Last Mine Closed. Sat., 4 April.

SHORT COURSES
1. Introduction to Basic Map Making Using ArcGIS and Spatial Analyst.
2. Improving Boring Logs at Glaciated Sites.

STUDENT OPPORTUNITIES
Mentor Programs
Questions? Contact Jennifer Nocerino, jnocerino@geosociety.org, or go to www.geosociety.org/mentors/.
Mann Mentors in Applied Hydrogeology Program. Sponsored by the GSA Foundation. Thurs., 2 April, 11:30 a.m.–1 p.m. This FREE luncheon presents mentoring opportunities for students and recent graduates with a declared career interest in applied hydrogeology.
Roy J. Shlemon Mentor Program in Applied Geoscience. Sponsored by the GSA Foundation. Fri., 3 April, 11:30 a.m.–12:30 p.m. and 12:30–1:30 p.m. These FREE luncheons are designed to extend the mentoring reach of professionals from applied geology to geoscience students.

Travel Grants
Find information and applications for student travel grants at www.geosociety.org/sectdiv/.

Volunteers
We rely on student volunteers to help meetings run smoothly, and are pleased to offer student volunteers free registration for the meeting in return for ~6 hours of work. Contact student volunteer coordinator Mark Frank, t60mrf1@wpo.cso.niu.edu, for more information.
Preliminary Announcement and Call for Papers

ROCKY MOUNTAIN
61st Annual Meeting
Orem, Utah, USA
11–13 May 2009

Orem, Utah, USA, is located in the foothills of Mount Timpanogos, the second highest mountain in Utah’s Wasatch Range at 11,749 feet (3,582 m) above sea level. Photo courtesy Utah Valley Convention and Visitors Bureau.

Reaching for Greater Heights: Geology in the Rocky Mountains
This meeting will cover a broad range of topics of specific interest to geoscientists in GSA’s Rocky Mountain region. Our venue will be the new library at Utah Valley University. The library features large, comfortable open spaces, sweeping views of the Wasatch Range and Utah Valley, and a full-service café, and was recognized by Utah Governor Jon Huntsman Jr. as the most energy-efficient building in the Utah higher education system.

CALL FOR PAPERS
Abstract Deadline: 3 February 2009

Technical Sessions
We plan to have three to four sessions running concurrently each day, along with a poster session, and will have general sessions in addition to the following.

Theme Sessions

Stratigraphy, Sedimentology, Paleontology
1. Neoproterozoic Geology of the Rocky Mountains. Paul Link, Idaho State University, linkpaul@isu.edu; Carol Dehler, Utah State University, chuaria@cc.usu.edu.
2. New Developments and Discoveries in Paleozoic Stratigraphy and Paleontology in the Rocky Mountains and Basin and Range. Scott Ritter, Brigham Young University, scott_ritter@byu.edu; Forest Gahn, Brigham Young University–Idaho, gahnf@byui.edu.

Hydrology, Surficial Geology, and Engineering Geology
4. Hydrologic Studies in the Basin and Range and Rocky Mountains. Lucy Jordan, Utah Geological Survey, lucyjordan@utah.gov; John Bradford, Boise State University, johnb@cgiss.boisestate.edu; Stephen Nelson, Brigham Young University, stn@geology.byu.edu.
5. Getting a Better Handle on the “Dirt” Covering the Bedrock—Mapping and Dating of Surficial Deposits. Grant Willis, Utah Geological Survey, grantwillis@utah.gov; Joel Pederson, Utah State University, joel.pederson@usu.edu.
6. Quaternary Tectonics and Earthquake-Hazard Characterization in the Rocky Mountain Region. Chris DuRoss, Utah Geological Survey, cbduross@hotmail.com; Greg McDonald, Utah Geological Survey, gregmcdonald@utah.gov; Ivan Wong, URS Corp., ivan_wong@urscorp.com; Mike Bunds, Utah Valley University, bundsmi@uvsc.edu.
7. Geologic Hazards in the Rocky Mountain Region and Their Impacts on Development: A Tribute to the Career of Gary Christensen. Danny Horns, Utah Valley University, hornsda@uvsc.edu.

Structure and Tectonics
8. Compression and Extension—Thrusts and Normal Faults and Their Interplay in the Rocky Mountains and Basin and Range. Adolph Yonkee, Weber State University, ayonkee@weber.edu.

Energy and Economic Geology
10. Energy Resources and Developments in the Rocky Mountain Region. Michael Vanden Berg, Utah Geological Survey, mvandenberg@mines.utah.edu; Bill Keach, Brigham Young University, bill_keach@byu.edu.
11. **Ore Deposits in the Great Basin and Rocky Mountains.** Ken Krahulec, Utah Geological Survey, kenkrahulec@utah.gov.

12. **Industrial Mineral Deposits of the Rocky Mountains Region.** Bryce Tripp, Utah Geological Survey, brycetripp@utah.gov.

**Igneous and Metamorphic Rocks**

13. **Volcanic and Plutonic Activity from the Mesozoic to the Present in the Rocky Mountains Region.** Eric Christiansen, Brigham Young University, eric_christiansen@byu.edu.

14. **New Developments in Understanding Metamorphic Rocks in the Rocky Mountains and Great Basin.** Bill Dinklage, Utah Valley University, dinklawi@uvsc.edu; Mark Colberg, Southern Utah University, colberg@suu.edu.

**Other Theme Sessions**

15. **Geologic Mapping Supported by EDMAP and STATEMAP in the Rocky Mountains Region.** Bart Kowallis, Brigham Young University, bkowallis@byu.edu; Grant Willis, Utah Geological Survey, grantwillis@utah.gov.

16. **Geological Studies in National Parks and Monuments of the Rocky Mountains Region.** David Wilkins, Boise State University, dwilkins@boisestate.edu.

17. **Geoinformatics.** Walt Snyder, Boise State University, wsnyder@boisestate.edu.


19. **Undergraduate Research (Posters).** Cosponsored by the Council on Undergraduate Research. Bill Dinklage, Utah Valley University, dinklawi@uvsc.edu.

**REGISTRATION**

Early Registration Deadline: 6 April 2009
Cancellation Deadline: 13 April 2009

Find complete and up-to-date information at www.geosociety.org/meetings. If you have questions or special requirements, please contact the general meeting co-chairs, Bart Kowallis, +1-801-422-2467, bkowallis@byu.edu, and Daniel Horns, +1-801-863-8064, hornsda@uvsc.edu.

Continued on p. 18

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FIELD TRIPS
1. **Hot Springs of Utah Valley and the Wasatch Range.** Sun., 10 May. Steven H. Emerman.
2. **Stratigraphy and Correlation of Lower and Middle Jurassic Rocks, Utah: Transition from a Sand Sea to Marine Embayment and Back.** Fri.–Sun., 8–10 May. Doug Sprinkel, Helmut Doelling, Bart Kowallis.

WORKSHOP
**Climate Change: Causes, Consequences, and Adaptations.** Cosponsored by National Association of Geoscience Teachers. Allen Macfarlane, dowser@kgs.ku.edu; Sallie Greenberg, greenberg@isgs.illinois.edu.

ACCOMMODATIONS
Rooms have been reserved at the following hotels. Please call the hotel directly to make reservations, and reference the 2009 GSA Rocky Mountain Section Meeting for the group rate.


OPPORTUNITIES FOR STUDENTS
**Mentor Programs**
Questions? Contact Jennifer Nocerino, jnocerino@geosociety.org or go to www.geosociety.org/mentors/.

- **Roy J. Shlemon Mentor Program in Applied Geoscience.** Sponsored by the GSA Foundation. Mon., 11 May, 11:30 a.m.–1 p.m. This FREE luncheon is designed to extend the mentoring reach of professionals from applied geology to geoscience students.
- **The John Mann Mentors in Applied Hydrogeology Program.** Sponsored by the GSA Foundation. Tues., 12 May, 11:30 a.m.–1 p.m. This FREE luncheon presents mentoring opportunities for students and recent graduates with a declared career interest in applied hydrogeology.
WE COVER THE EARTH

The Encyclopedia of Earth
A Complete Visual Guide
MICHAEL ALLABY, ROBERT COENRAADS, STEPHEN HUTCHINSON, KAREN McGHEE, JOHN O’BYRNE and KEN RUBIN
This sumptuously illustrated encyclopedia presents the most up-to-date information about planet Earth. With thousands of illustrations and maps and a text by a team of international experts, it presents an impressive overview of our globe—beginning with the history of the universe and ending with today’s conservation issues.
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“A popular, imaginative, and scientific evocation of sand as the creator of the world we experience and seek to understand. Sand is a timely meditation on things both large and small that simultaneously opens the door to the oldest geology and our most recent history.”
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DAVID R. MONTGOMERY
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Darkening Peaks
Glacier Retreat, Science, and Society
BEN ORLOVE, ELLEN WIEGANDT, AND BRIAN H. LUCKMAN, EDITORS
“Glaciers play a major role in teaching us about our planet’s past, and in warning us about its future. They inspire fear, awe, and fascination. Whatever your interest in glaciers, you will find this rich, broadly ranging volume exciting.”
—Iared Diamond, author of Guns, Germs, and Steel and Collapse
$45.00 hardcover

Nature’s Clocks
How Scientists Measure the Age of Almost Everything
DOUG MACDOUGALL
“Rich in historical tidbits, this book is a delightful study of how scientists figured out analytical techniques that revealed the history of the earth.”—New Scientist
$24.95 hardcover

Dead Pool
Lake Powell, Global Warming, and the Future of Water in the West
JAMES LAWRENCE POWELL
“Offers a powerful epitaph to the era of big dams. Carefully researched and cogently argued, it shows how the self-serving promoters of the Colorado River’s dams have consistently ignored natural limits imposed by water supply, silt, and salt, creating a long-term crisis that may make ghost towns out of many of the overpopulated cities of the American West.”
—Jacques Leslie, author of Deep Water
$27.50 hardcover

The California Deserts
An Ecological Rediscovery
BRUCE M. PAVLIK
“I’ve been waiting for a book like this, one that captures the very essence of the desert rather than simply cataloging and describing it. Pavlik is a consummate integrator and storyteller. He makes this ‘rediscovery’ of the desert as exciting as its initial discovery.”
—Jeff Lovich, Deputy Director, U.S. Geological Survey, Southwest Biological Science Center
$27.50 paperback, $60.00 hardcover

At bookstores or www.ucpress.edu
The majority of my time at Rocky Mountain National Park was spent helping researchers with their field work. In many cases, I was the only person who knew anything about geology, so I frequently stressed the connection between geology and other field sciences. Working with so many kinds of researchers was good preparation for working on a collaborative scientific investigation. —Ansel Bubel

As a geology education specialist at Rocky Mountain National Park, my responsibility was to develop and deliver education programs within the park and the surrounding school districts. This involved doing research, writing outlines (modified lesson plans), designing appropriate hands-on activities, and presenting the program. I found that no matter the age, it was important to have a related hands-on activity that truly engaged the students. —Nancy Dickinson

The Florissant Fossil Beds National Monument protects and preserves countless fossil specimens preserved in lake shale and mud flows from 34 million years ago. Working as the paleontologist this summer, I was fortunate enough to work closely with these fossils and in some cases I was able to participate in test excavations to discover more specimens. One of the most exciting things about my summer was the discovery of the first-ever fossilized ginkgo leaf for the monument; I unearthed it during one of the paleontology crew’s test excavations. To be the first to discover a ginkgo here at the monument has been quite exhilarating and has only served to fuel my passion for paleontology. —Bret Buskirk

GeoCorps™ America places geoscientists of all levels—university students, professionals, and retirees—in short-term science projects at public lands throughout the country. These projects, hosted by the National Park Service, the U.S. Forest Service, and the Bureau of Land Management (BLM), range from geology, hydrogeology, and paleontology, to mapping, GIS, soils, geohazards, and interpretation. This year, 66 highly qualified individuals worked on geoscience projects in 25 National Parks, 13 BLM Units, and 11 National Forests.

GeoCorps™ America is proudly supported by the ENVIRON Foundation and the America Institute of Professional Geologists.
My benefit from the program is indisputable. I will forever carry the experience gained while working in the park, preparing me for a future career in paleontology. Working in Denali National Park has had many moments of awe and inspiration that I could never capture from any book or detailed account. Out of every course I have taken on natural history, no lesson hits harder than the one you witness yourself silently, with no instructor other than Mother Nature herself. —Todd Jacobus

Badlands National Park staff had begun the process of inventorying and assessing fossil localities within park boundaries to gain a better understanding of stratigraphic position, depositional environment, degree of preservation, and vulnerability to poachers and visitors. The goal of completing a park paleontological inventory database continues; vulnerable fossil localities are identified during the assessment, allowing park management to protect the localities from poachers. —Darrin Strosnider

Special thanks to all of this year’s GeoCorps™ America participants!

Justy Alicea
Evan Batton
Sabrina Belknap
Glenda Besana-Ostman
Ansel Bubel
Bret Buskirk
Kathleen Compton
Peter Dennehy
Meagan DeRaps
Margie DeRose
Nancy Dickinson
Dylan Duverge
Lisa Fay
Catherine Foley
Hilton Freed
Logan Fusso
Lynn Galston
Gilbert Garcia
Connie Garrett
Dianah Grubb
Wheeler
Sarah Hanson
Benjamin Haring
Kristin Harms
Anthony Harper
Zoe Harrold
Joel Hartmann
Rory Hunter
Justin Hynicka
Nick Inzinna
Raymond Jacobus
Erich Junger
Sophia Kast
Any Kircher
Justin Knudson
Hillary Kruger
Adam Lee
Hugh Lewis
Bradley Markle
April Mattox
Brian McDonald
Katy McGuire
Brina Mocsny
Patrick Moran
Gary Motz
Nellie Olsen
Kyle Rybacki
Robert Sas Jr.
Christine Saulsbury
Anne Schumacher
Barry Shaulis
Kevin Stack
Lydia Staisch
Katie Stehli
Kirsten Stokes
Darrin Strosnider
Nicholas Sullivan
Lidia Tarhan
Teagan Tomlin
Justin Tweet
Zachary Walter
Adam Wanta
Anna Weber
Stephanie Welch
Adam Willett
Rayna Winters
One of the main impacts of global warming is accelerated sea-level rise: Intergovernmental Panel on Climate Change predictions suggest that the rate of rise could reach as high as 5–10 mm/yr by the end of this century. While it is generally recognized that accelerated sea-level rise will severely impact low-gradient coastlines, scientists are still ill prepared to predict coastal response. A study of seven Gulf Coast estuaries (Mobile Bay and Mississippi Sound, Weeks Bay, Calcasieu Lake, Sabine Lake, Galveston Bay, Matagorda Bay, and Corpus Christi Bay) was aimed at examining their response to past changes in the rate of sea-level rise and climate. The rates of change are of the same magnitude as those predicted for this century. The estuarine response to change has been one of abrupt landward retreat and major reorganization of estuarine environments at decadal time scales. This book should be of interest to scientists and policy makers concerned with future impacts of global warming.

SPE443, 146 p., ISBN 9780813724430, list price $60.00

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Renew securely online: www.geosociety.org/members
As you plan your “end of year” gifts, I want to remind you of some easy ways to make your donation to the GSA Foundation:

- Use the coupon below.
- Donate when you renew your GSA Membership.
- Visit the Foundation’s Web site, gsafweb.org. You’ll find a complete list of Foundation funds on the “Make a Donation” page. Online donation is easy, secure, and takes just a few minutes!

I encourage you to donate to the Foundation’s Greatest Needs Fund—this fund has been a source of support for many GSA programs and projects over the years, and its flexibility allows contributions to be used in a wide variety of ways.

Perhaps you’re interested in donating to a more specific fund? We’re happy to send you a detailed list describing each Foundation Fund and its purpose—just contact me, Donna Russell, at drussell@geosociety.org or +1-303-357-1054.

The GSA Foundation exists to promote the science of geology and to provide funds for programs of the Geological Society of America that are consistent with the Society’s mission. Thus, the Foundation seeks to fund education, research, publications, student opportunities, public outreach, and other GSA geoscientific programs that the Foundation, in consultation with the Society, considers necessary to accomplish GSA’s purposes of advancing the geosciences, enhancing the professional growth of its members, and promoting the geosciences in the service of humankind.

**Most memorable early geologic experience:**

In 1964 I experienced first-hand the Alaska Good Friday Earthquake in Anchorage, and in the following couple of weeks I participated in a volunteer preliminary survey of the quake’s local geologic effects.

—Glen L. Faulkner
Position Statement

To improve the scientific basis for land-use decisions, The Geological Society of America (GSA) supports the integration of geoscience information with land-use planning processes. Government agencies have a special responsibility to integrate geoscience information with land-use planning to address such issues as natural hazards (e.g., earthquakes, floods, or droughts), natural resources (e.g., energy, water and mineral resources), environmental issues (e.g., climate change and pollution), and human-induced hazards. The geosciences provide a unique contribution to land-use issues because they address the origin and character of materials at or near Earth’s surface and the varied natural and human-induced processes that have redistributed these materials over time.

Purpose

This position statement (1) summarizes the consensus views of GSA regarding the integration of geoscience into the land-use decision-making process; (2) provides information that can raise awareness among policy makers and land managers of the important contributions that geoscientists can make in crafting sustainable land-use policies, implementing those policies, and evaluating their short- and long-term consequences; and (3) encourages geoscientists to participate in land-use decision-making at local, regional, state, and national levels.

Rationale

Earth’s water, air, and land are essential natural resources. Land affords humanity with places to build communities and associated infrastructure, generates most of its food resources, serves as a major carbon sink, and provides mineral and soil resources vital for society. The land surface also imparts both aesthetic satisfaction and habitat value to humanity. Water sources for domestic, municipal, industrial, and agricultural uses include lakes, rivers, and groundwater, and lakes and rivers also provide water for transportation, recreation, and ecosystem habitat. The quality of the air we breathe is determined by interactions between activities on Earth’s surface and the atmosphere. Water, air, and land resources are inherently linked. These resources must be sustained for society’s future generations and the health of the planet.

Human land-use practices affect Earth’s vital resources, and the ecosystems supported by these resources. Land-use practices are wide-ranging and include, but are not limited to, agriculture, ranching, logging, mining, river management (including dam and levee building and water diversion and storage), waste disposal, and urban/suburban development. Land-use practices affect hydrologic and biogeochemical cycles, as well as fundamental ecosystem structure. Changes in these highly dynamic cycles and structures affect all living things.

Because land use is so diverse, land management decisions are inherently multifaceted and interdisciplinary. The geosciences provide a unique contribution to land-use issues because...
they address the origin and character of materials at or near Earth’s surface and the varied natural and human-induced processes that have redistributed these materials over time. The geosciences provide an understanding of potential short- and long-term changes to Earth’s surface that can result from past, present, and future land-use practices. Human activity interacts daily with Earth’s natural processes, and these processes are threatened constantly by expanding populations, pollution, and natural hazards. Geoscience-based information must be integrated with land-use planning so that various, often conflicting, land-use scenarios are evaluated on the basis of sustaining natural resources as well as for socioeonomic purposes.

Land resources, and our ability to manage and protect them, inevitably will be affected by climate change. For example, a rise in sea level could result in the displacement of millions of people from coastal regions. Increasing temperatures have already led to thawing permafrost in arctic regions, which affects wildlife and infrastructure and diminishes the suitability of these lands for human habitat. Climate change also affects the water cycle, including the amount, type, and seasonal and spatial distribution of precipitation, as well as the magnitude of extreme events. These changes have the potential to increase the risk of extreme flooding, drought, and wildfires, alter groundwater recharge patterns and availability, and intensify many other problems due to ecosystem interconnectedness.

Public Policy Aspects of Integrating Geoscience with Land-Use Decision Making

Land-use planning and management decisions should (1) reflect a comprehensive understanding of the potential impacts on resources that sustain communities; (2) provide measures to avoid the over-allocation of depleted resources and to decrease competition for remaining resources; and (3) consider the wider community and future populations to avoid widespread disruption of and damage to natural systems that may be difficult, expensive, or even impossible to restore. Without careful planning and integrated resource management, inappropriate land-use practices may proceed on an unsustainable course and at an accelerated rate even without the threat of climate change.

Scientific understanding, using the best available geological, hydrological, ecological, and biogeochemical information on the long-term effects of land-use change on the environment, is essential for improving management of land resources. It is this understanding that allows decision makers in industry and government to evaluate the location, extent, and availability of present and future soil, water, mineral, and energy resources and to concurrently optimize resource utilization while minimizing land-use conflicts and potential environmental problems.

As the human population continues to grow, the demand for land resources will increase, as will the need for science-based land-management decisions to support future populations in a sustainable manner. Geoscience research contributes to the further understanding of past natural changes and better prediction of future changes, including natural hazards affecting the land surface. The geosciences have an important and unique role to play in understanding the potential long-term consequences associated with past and future land-use changes and evaluating strategies for the mitigation of detrimental changes.

Recommendations

- To improve the scientific basis for land-use decisions, appropriate geoscience information should be integrated with land-use planning processes.
- Government agencies at local, state, national, and international levels have a special responsibility to integrate geoscience information with land-use planning to address such issues as natural hazards (e.g., earthquakes, floods, droughts, landslides, subsidence, and erosion), natural resources (e.g., energy, water and mineral resources), environmental issues (e.g., climate change and pollution), and human-induced hazards (e.g., siting industrial and waste facilities).
- Private developers and community groups should have access to reliable geoscience information to reduce potential future liabilities in areas of known natural or human-induced hazards.
- Strong and growing public investments in geoscience research are needed to improve the scientific basis for land-use decisions. Appropriate geoscience information should be made available to policy makers, developers, community groups, and land managers in a useful and timely manner.
- Increased public investment in geoscience education is needed to improve the public’s ability to make informed land-use decisions, such as construction of housing developments close to fault zones or along eroding coasts.

Opportunities for GSA and GSA Members to Help Implement Recommendations

To facilitate implementation of the goals of this Position Statement, GSA recommends the following actions to increase the involvement of geoscientists in local, regional, statewide, and federal land-use policy decisions.

- We should seek opportunities to communicate effectively the value of integrating geoscience with sustainable land management to international, national, state, and local legislative bodies and government agencies, private developers, economic development corporations, professional land-use planners, chambers of commerce, and other local decision makers. GSA members are encouraged to work with print, electronic, and broadcast media in promoting the value of science-based approaches for addressing critical land-use issues. Members who participate in land-use planning are encouraged to share their experiences at GSA meetings and with GSA’s Director for Geoscience Policy (DGP). Local examples of how geoscience has contributed information to a land-use planning or decision-making effort are essential to this effort. What also must be made clear is how the lack of geoscientific information might have prevented or lessened the effect of a costly adverse land-use activity or the devastating consequences of a natural disaster.
- We should seek opportunities to communicate effectively to community groups the value of integrating geoscience
with sustainable land management. The public must be able to respond in an informed manner to land-use decision making that potentially can have detrimental effects on their community and personal property; thus, there is a growing need for the public to be educated about the value of geoscientific information for land-use planning. As above, it is beneficial to provide the DGP with local examples of how geoscientific information has either contributed to land-use planning efforts or its lack resulted in costly adverse land-use activities or increased the devastating consequences of a natural disaster.

- We should participate in professional forums and town hall meetings for open community discussions on the role that geoscience plays in effective land-use planning. Our discussions should emphasize the value of geoscientific information for land-use planning and decision making and its sustainability outcomes and enable GSA members to be better-informed advocates for requesting funding for geoscientific information in support of land-use planning.

- GSA should provide readily accessible print, Web, and personnel resources to members that support geoscientists’ communications with decision makers regarding the value of integrating geoscience with sustainable land management. Considerable expertise and resources are available to members through GSA’s Geology and Public Policy Committee (GPPC), GSA’s Geology and Society Division, and GSA’s DGP in Washington, D.C. GSA expertise can help members participate in land-use policy decisions by creating talking points on common land-use problems and providing examples of how they can participate in land-use decisions by becoming members of relevant decision-making bodies. It is important that GSA and its members identify legislation that affects land use and alert the GPPC, the Geology and Society Division, and GSA’s Associated Societies if action by the GSA membership and affiliated organizations can help improve the scientific base for land-management decisions. The GPPC, Geology and Society Division, and the DGP, often working with GSA members, can also bring this Position Statement to the attention of lawmakers when legislation affects land use.

- GSA can raise awareness of land-use issues by publishing articles on both the links between geoscience and land-use planning and management decisions and the successful integration of geoscience with sustainable land management.

Apocalypse brings the latest scientific evidence to bear on biblical accounts, mythology, and the archaeological record to explore how ancient and modern earthquakes have shaped history—and, for some civilizations, seemingly heralded the end of the world. Through earthquakes the book explores also societal and philosophical issues related to natural disasters and catastrophes. Amos Nur bridges the gap that for too long has separated archaeology and seismology. He examines tantalizing evidence of earthquakes at some of the world’s most famous archaeological sites in the Mediterranean and elsewhere, including Troy, Jericho, Knossos, Mycenae, Armageddon, Teotihuacán, and Petra. As Nur shows, recognizing earthquake damage in the shifted foundations and toppled arches of historic ruins is vital today because the scientific record of world earthquake risks is still incomplete. Apocalypse explains where and why ancient earthquakes struck—and could strike again.

Amos Nur is the Wayne Loel Professor of Earth Sciences and professor of geophysics at Stanford University. Dawn Burgess is a writer and editor based in Bar Harbor, Maine. She earned a PhD in geophysics from Stanford.

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ASSISTANT PROFESSOR IN EARTH SCIENCE MORAVIAN COLLEGE
The Dept. of Physics and Earth Science at Moravian College invites applications for a tenure-track appointment at the level of assistant professor beginning in August 2009. The candidate should have experience in teaching earth science (geology and either meteorology, climatology, or oceanography) and geographic information science. The candidate should have experience with GIS and proficiency in teaching science education and astronomy will be considered a plus. Applicants must have a Ph.D. and a demonstrated potential for excellence in teaching and research involving undergraduates. Applications must include a letter of application, curriculum vitae, a detailed description of teaching philosophy and research interests, and contact information for three references; sent to Prof. Kriebel, Dept. of Physics and Earth Science, Moravian College, 1200 Main St., Bethlehem, PA 18018-6650 or via e-mail to kriebelm@moravian.edu. Application deadline is January 19, 2009. Moravian College is an equal opportunity employer. We value diversity and encourage applications from underrepresented populations to apply.

ASSISTANT PROFESSOR, GEOLOGY DEPT. OF GEOLOGY, UTAH STATE UNIVERSITY UNIVERSITY OF WISCONSIN-MADISON
The Dept. of Geology and Geophysics invites applications for the position of Assistant Professor of Geology begining in August 2009. We seek outstanding candidates within the broad area of sedimentary geology, including both near surface and subsurface systems, paleoecology, low temperature geochemistry, and for the multi-collector and quadrupole ICP-mass spectrometers in areas such as, but not limited to, U-Pb, and for the multi-collector and quadrupole ICP-mass spectrometers in areas such as, but not limited to, U-Pb, Pb-Pb, Sm-Nd, Rb-Sr, isotopic and elemental analysis of a variety of materials. The position will also involve overseeing the application of laser ablation isotopic and elemental analysis using the two existing NewWave 213nm UV lasers. The incumbent will play a significant role in grant and contract development, and is expected to support the development of new technologies generally in geochemistry. The incumbent is also responsible for the administrative organization of the research lab including supervision of laboratory technicians, scheduling, budgeting and costing of services.

ASSISTANT PROFESSOR, GEOLOGY DEPARTMENT OF EARTH AND ATMOSPHERIC SCIENCES UNIVERSITY OF ALBERTA
The Dept. of Earth and Atmospheric Sciences requires a research scientist to manage its Geochemistry research laboratories and develop, through research, new techniques to enhance the department’s analytical capabilities in geochemistry. The incumbent reports to the Chair of the department. The appointment is an academic position at the Faculty Service Officer level. The position will involve overseeing the development and implementation of new technology and techniques in geochemistry and for the multi-collector and quadrupole ICP-mass spectrometers in areas such as U-Pb, Lu-Hf, Sm-Nd, Rb-Sr, isotopic and elemental analysis of a variety of materials. The position will also involve overseeing the application of laser ablation isotopic and elemental analysis using the two existing NewWave 213nm UV lasers. The incumbent will play a significant role in grant and contract development, and is expected to support the development of new technologies generally in geochemistry. The incumbent is also responsible for the administrative organization of the research lab including supervision of laboratory technicians, scheduling, budgeting, and costing of services.

ASSISTANT PROFESSOR, GEOLOGY DEPARTMENT OF EARTH AND ATMOSPHERIC SCIENCES UNIVERSITY OF WISCONSIN-MADISON
The Dept. of Geology and Geophysics invites applications for a faculty position in Geochronology beginning in August 2009. We seek outstanding candidates within the broad area of sedimentary geology, including both near surface and subsurface systems, paleoecology, low temperature geochemistry, and for the multi-collector and quadrupole ICP-mass spectrometers in areas such as, but not limited to, U-Pb, Pb-Pb, Sm-Nd, Rb-Sr, isotopic and elemental analysis of a variety of materials. The position will also involve overseeing the application of laser ablation isotopic and elemental analysis using the two existing NewWave 213nm UV lasers. The incumbent will play a significant role in grant and contract development, and is expected to support the development of new technologies generally in geochemistry. The incumbent is also responsible for the administrative organization of the research lab including supervision of laboratory technicians, scheduling, budgeting, and costing of services.

ASSISTANT PROFESSOR, GEOLOGY DEPARTMENT OF EARTH AND ATMOSPHERIC SCIENCES UNIVERSITY OF WISCONSIN-MADISON
The Dept. of Geology and Geophysics invites applications for a tenure-track position in sedimentary geology beginning in August 2009. We seek outstanding candidates within the broad area of sedimentary geology, including both near surface and subsurface systems, paleoecology, low temperature geochemistry, and for the multi-collector and quadrupole ICP-mass spectrometers in areas such as, but not limited to, U-Pb, Pb-Pb, Sm-Nd, Rb-Sr, isotopic and elemental analysis of a variety of materials. The position will also involve overseeing the application of laser ablation isotopic and elemental analysis using the two existing NewWave 213nm UV lasers. The incumbent will play a significant role in grant and contract development, and is expected to support the development of new technologies generally in geochemistry. The incumbent is also responsible for the administrative organization of the research lab including supervision of laboratory technicians, scheduling, budgeting, and costing of services.

ASSISTANT PROFESSOR, GEOLOGY DEPARTMENT OF EARTH AND ATMOSPHERIC SCIENCES UNIVERSITY OF WISCONSIN-MADISON
The Dept. of Geology and Geophysics invites applications for a tenure-track position in sedimentary geology beginning in August 2009. We seek outstanding candidates within the broad area of sedimentary geology, including both near surface and subsurface systems, paleoecology, low temperature geochemistry, and for the multi-collector and quadrupole ICP-mass spectrometers in areas such as, but not limited to, U-Pb, Pb-Pb, Sm-Nd, Rb-Sr, isotopic and elemental analysis of a variety of materials. The position will also involve overseeing the application of laser ablation isotopic and elemental analysis using the two existing NewWave 213nm UV lasers. The incumbent will play a significant role in grant and contract development, and is expected to support the development of new technologies generally in geochemistry. The incumbent is also responsible for the administrative organization of the research lab including supervision of laboratory technicians, scheduling, budgeting, and costing of services.

ASSISTANT PROFESSOR, GEOLOGY DEPARTMENT OF EARTH AND ATMOSPHERIC SCIENCES UNIVERSITY OF WISCONSIN-MADISON
The Dept. of Geology and Geophysics invites applications for a tenure-track position in sedimentary geology beginning in August 2009. We seek outstanding candidates within the broad area of sedimentary geology, including both near surface and subsurface systems, paleoecology, low temperature geochemistry, and for the multi-collector and quadrupole ICP-mass spectrometers in areas such as, but not limited to, U-Pb, Pb-Pb, Sm-Nd, Rb-Sr, isotopic and elemental analysis of a variety of materials. The position will also involve overseeing the application of laser ablation isotopic and elemental analysis using the two existing NewWave 213nm UV lasers. The incumbent will play a significant role in grant and contract development, and is expected to support the development of new technologies generally in geochemistry. The incumbent is also responsible for the administrative organization of the research lab including supervision of laboratory technicians, scheduling, budgeting, and costing of services.

ASSISTANT PROFESSOR, GEOLOGY DEPARTMENT OF EARTH AND ATMOSPHERIC SCIENCES UNIVERSITY OF WISCONSIN-MADISON
The Dept. of Geology and Geophysics invites applications for a tenure-track position in sedimentary geology beginning in August 2009. We seek outstanding candidates within the broad area of sedimentary geology, including both near surface and subsurface systems, paleoecology, low temperature geochemistry, and for the multi-collector and quadrupole ICP-mass spectrometers in areas such as, but not limited to, U-Pb, Pb-Pb, Sm-Nd, Rb-Sr, isotopic and elemental analysis of a variety of materials. The position will also involve overseeing the application of laser ablation isotopic and elemental analysis using the two existing NewWave 213nm UV lasers. The incumbent will play a significant role in grant and contract development, and is expected to support the development of new technologies generally in geochemistry. The incumbent is also responsible for the administrative organization of the research lab including supervision of laboratory technicians, scheduling, budgeting, and costing of services.

ASSISTANT PROFESSOR, GEOLOGY DEPARTMENT OF EARTH AND ATMOSPHERIC SCIENCES UNIVERSITY OF WISCONSIN-MADISON
The Dept. of Geology and Geophysics invites applications for a tenure-track position in sedimentary geology beginning in August 2009. We seek outstanding candidates within the broad area of sedimentary geology, including both near surface and subsurface systems, paleoecology, low temperature geochemistry, and for the multi-collector and quadrupole ICP-mass spectrometers in areas such as, but not limited to, U-Pb, Pb-Pb, Sm-Nd, Rb-Sr, isotopic and elemental analysis of a variety of materials. The position will also involve overseeing the application of laser ablation isotopic and elemental analysis using the two existing NewWave 213nm UV lasers. The incumbent will play a significant role in grant and contract development, and is expected to support the development of new technologies generally in geochemistry. The incumbent is also responsible for the administrative organization of the research lab including supervision of laboratory technicians, scheduling, budgeting, and costing of services.
education) and Earth Science (secondary education) majors. Additional teaching responsibilities may include introductory courses, upper-level general education theme courses, and/or courses for Geology majors in area of expertise.

The successful candidate is expected to develop courses and field experiences; conduct research with undergraduate students; advise pre-service teacher candidates; contribute to in-service teacher education; and act as the Geology Department liaison with the State Department of Education, the College of Education, and K-12 teachers. The Geology Department includes 10 tenure-track faculty and ~90 majors (geo and earth science) and serves ~200 integrated science majors (www.gsuv.edu/sci). The department values field experiences and collegial faculty-student interactions (www.gsuv.edu/geology).

Apply online at www.gsuvjobs.org. Attach a letter of application, vita, statements of teaching philosophy and research interests, and the names and contact information of at least three references familiar with your teaching and/or research potential. Review of applications to begin 1 December 2008 and continue until the position is filled. Grand Valley is an affirmative action, equal opportunity institution.

HYDROLOGIST—GEOHYDROLOGY SECTION KANSAS GEOLOGICAL SURVEY THE UNIVERSITY OF KANSAS, LAWRENCE Full-time position at faculty-equiv. rank of assistant or associate scientist for basin-scale, water-cycle studies. Requires Ph.D. with hydrology emphasis, research experience on processes relevant for semi-arid basins, and scientific leadership potential. Background in recharge, stream-aquifer interaction, remote sensing/GIS, and integrated water-cycle models is desirable. Individual expected to develop research program of national stature and relevance to Kansas. The Geohydrology Section has 9 full-time professionals with additional support personnel. Emphasis on cutting-edge science/field studies and completion of applicable theoretical research. Sabbatical-eligible position. Complete announcement/application info at www.kgs.ku.edu/General/jobs.html. First consideration deadline: 6 Feb. 2009. For further information contact Jim Butler (jbutler@kgs.ku.edu) or Marios Sophocleous (marios@kgs.ku.edu). KU is an EQUA employer.

DEPARTMENT OF EARTH SCIENCES ASSISTANT PROFESSOR BRIDGEWATER STATE COLLEGE The Dept. of Earth Sciences at Bridgewater State College invites applications for a tenure-track position in sedimentary geology/statigraphy to begin September 2009. The ideal candidate should be committed to excellence in teaching at the collegiate level, strongly field-oriented, and focused on integrative research in sedimentary geology and physical stratigraphy. The successful candidate will also have a strong background in invertebrate paleontology. The successful applicant will develop a junior level course in sedimentary geology/statigraphy, a senior level course in paleontology, advanced course(s) in the applicant’s area of expertise as well as introductory geology courses. The candidate is also expected to develop and mentor undergraduate research activities. Other responsibilities include academic advising and service on College-wide committees. This position will be filled at the assistant professor level; candidates should possess a Ph.D. by June of 2009.


Applicants should be strongly committed to excellence in teaching and advising, and to working in a multicultural environment that fosters diversity. They should also have an ability to use technology effectively in teaching and learning, the ability to work collaboratively, evidence of active research, and a commitment to public higher education.

TO APPLY: Please apply online at http://jobs.bridgewater.edu.

Please attach the following documents to your online application: Cover Letter; Resume; A Teaching Philosophy statement.

Bridgewater State College is an affirmative action/equal opportunity employer which actively seeks to increase the diversity of its workforce.

ASSISTANT RESEARCH SPECIALIST RESEARCH SPECIALIST I INTEGRATED OCEAN DRILLING PROGRAM WITH TEXAS A&M UNIVERSITY Assistant Research Specialist/Research Specialist I position [NOW0900005]. For review of the full position announcement, refer to our Web site www.ioudp-uso.org/Employment/default.html as well as the Texas A&M University Web site http://tamujobs.tamu.edu. The Integrated Ocean Drilling Program with Texas A&M University invites applications for the position of Research Specialist with the Tools & Analytical Services department. The responsibilities include the development of scientific equipment and methodology relevant to IODP. The specialist will focus in one of three major areas:

- geology, which includes stratigraphy, sedimentology, petrography, and paleontology,
- geophysics and physics, and
- geochemistry, chemistry, and microbiology.

The specialist will coordinate the activities of the laboratory working group assigned to the respective area as well as the application of this knowledge to the development, documentation, instruction, operation, and maintenance of methods and equipment related to these areas. This includes the collection, compilation, and analysis of data. In addition, the specialist will be expected to sail on IODP expeditions approximately twice per year, approximately 2 months apiece, and will be responsible for support, operation, and maintenance of specialized laboratory systems on-board the research vessel as well as continuing ongoing development projects while at sea. The successful applicant will be required to pass a new employee physical exam and annual sea-going exams, and must be able to obtain a passport and travel visas on a continuing basis.

The applicant must have a bachelor’s degree in a science- or engineering-related field with five years experience in a relevant field and proficiency in at least one relevant laboratory measurement technique. We...
prefer a B.S. degree or an advanced degree, especially in a science or engineering-related field. The applicant must have a demonstrated fluency in written and spoken English, be able to work professionally, harmoniously, and collaboratively with other technical and visiting scientists, and must be detail-oriented, be able to work independently, and be able to multi-task and prioritize their work.

This position is a permanent position and is contingent upon the continuation of funding of this program. Interested candidates should apply to the IDDP and TAMU employment sites listed above. Applicants may access the TAMU application the TAMU jobsite and may apply online with a cover letter and resume. Please attach the names and addresses of three references (required). If available, please also attach a resume, a curriculum vita, a statement of teaching and research interests, and names and contact information of at least three current references. Examples of published papers and letters of recommendation will be included in the application process.

The application deadline is February 16, 2009. To apply, please go to www.jobs.uwm.edu/applicants/ Central/?quickFind=50518. Candidates will upload a cover letter, a curriculum vitae, a statement of teaching philosophy and research interests, and names and contact information of at least three current references. Examples of published papers and letters of recommendation will be included in the application process.

The University of Wisconsin–Milwaukee is an Equal Opportunity / Affirmative Action Employer.

ASSISTANT PROFESSOR
DEPT. OF GEOLOGICAL SCIENCES
MINERALOGY/PETROLOGY
BALL STATE UNIVERSITY, MUNCIE, INDIANA
Tenure-track position with specialty in mineralogy/petrology with a secondary area of igneous, metamorphic, sedimentary, economic geology, or oceanography. Preferred qualifications: college teaching experience, experience with extramural funding, and potential for future academic leadership. Experience required: college teaching experience in their field of expertise, and ability to conduct research. Applications will begin immediately and will continue until the position is filled. Send letter of application, curriculum vitae, statement of teaching and research interests, and names and contact information for at least three professional references to Dr. Kevin E. Ditcher, Search Committee Chair, Dept. of Geological Sciences, 1000 North Kilgore, Muncie, IN 47306. Ball State University is an Affirmative Action/Equal Opportunity Employer.

ASSOCIATE PROFESSOR / HYDROGEOLOGY
DEPT. OF GEOLOGICAL SCIENCES
MILLER COLLEGE JUNIOR COLLEGE
BALL STATE UNIVERSITY, MUNCIE, INDIANA
Tenure-track position with specialty in suburface hydrogeology, preferably with an associated area such as environmental science, geophysics, engineering geology, computational geology/modeling, water quality, or earth science education available August 21, 2009. Responsibilities: college teaching, research, extramural funding, master's/certiﬁcate courses in their field of expertise, and advise undergraduates in an active research program. The successful candidate will have a Ph.D. in hydrogeology, engineering geology, or a related area and be capable of leading extramural funded research program. The successful candidate will be expected to teach, advise undergraduates, serve on departmental committees, and contribute to the growth and quality of the graduate program. Send letter of application, curriculum vitae, statement of teaching and research interests, and names and contact information for at least three professional references to Dr. Kevin E. Ditcher, Search Committee Chair, Dept. of Geological Sciences, Ball State University, Muncie, IN 47306. Ball State University is an Equal Opportunity / Affirmative Action Employer.
The Department of Geology and Geophysics at Texas A&M University invites applications for two tenure-track faculty positions in sedimentary geology, broadly defined. Areas of interest include but are not limited to fundamental and applied problems in sedimentary processes ranging from pore to basin scale, depositional environments, sequence stratigraphy, basin architecture, sea level change and coastal evolution, and energy and natural resource science. At least one position will be offered to an individual working at the basin scale. We will consider applicants at all academic ranks. Successful applicants will be expected to develop and maintain vigorous, externally funded research programs and contribute to undergraduate and graduate teaching. We are a collaborative broad-based department within the College of Geosciences, which includes the Departments of Oceanography, Atmospheric Science, Geography, and the Integrated Ocean Drilling Program. Opportunities for collaboration also exist within the Department of Petroleum Engineering.

Interested candidates should submit electronic versions of a curriculum vita, statement of research interests and teaching philosophy, the names and email addresses of at least three references, and up to four reprints by email attachments, to the Chair of the Sedimentary Geology Search Committee, sedsearch@geo.tamu.edu. Screening of applications will begin October 31, 2008 and will continue until positions are filled. A Ph.D. is required at the time of employment.

The Department of Geology and Geophysics (geoweb.tamu.edu) is part of the College of Geosciences, which also includes the Departments of Geography, Oceanography, and Atmospheric Sciences, Sea Grant, the Geochemical and Environmental Research Group (GERG), and the Integrated Ocean Drilling Program (IODP). Texas A&M University, a land-, sea-, and space-grant university, is located in a metropolitan area with a dynamic and international community of 152,000 people. Texas A&M University is an affirmative action/equal opportunity employer committed to excellence through the recruitment and retention of a diverse faculty and student body and compliance with the Americans with Disabilities Act. We encourage applications from minorities, women, veterans, and persons with disabilities. Texas A&M University also has a policy of being responsive to the needs of dual-career partners (hr.tamu.edu/employment/dual-career.html).
To apply send a vita, statement of teaching interests, proposals for undergraduate courses, and contact information for three references to R.E. Hanson, Chair, Dept. of Geology, Box 298830, Fort Worth, TX 76129. Review of applications is ongoing and will continue until the position is filled. A Ph.D. in meteoritics or related fields is required at the time of appointment. Women, minorities, and persons with disabilities are encouraged to apply. A Ph.D. is required at the time of appointment. TCU is an EEO/AA employer and encourages a diversity of applicants.

SEDIMENTARY GEOLOGY/PETROLEUM GEOLOGY
TEXAS CHRISTIAN UNIVERSITY

The Dept. of Geology invites applications for a tenure-track assistant professor position in sedimentary geology/petroleum geology beginning in Fall, 2009. This person will be responsible for teaching introductory geology and advanced courses such as fluids in reservoirs. They will also be responsible for teaching introductory geology and advanced courses such as fluids in reservoirs. They will also continue until the position is filled. A Ph.D. in meteoritics or related fields is required at the time of appointment. Women, minorities, and persons with disabilities are encouraged to apply. A Ph.D. is required at the time of appointment. TCU is an EEO/AA employer and encourages a diversity of applicants.

ASSISTANT PROFESSOR—GEOMORPHOLOGY
ST. LAWRENCE UNIVERSITY

The Geology Department at St. Lawrence University invites applications for a tenure-track Assistant Professor position. We desire an individual with expertise in Geomorphology and, ideally, Hydrology/Hydropedolog, who will complement our existing strengths in Structural Geology, Sedimentology, Paleoentomology, Petrology and Geochemistry. The successful candidate will be expected to teach Geomorphology, Hydrology/ Hydropedolog, and to assist in the teaching of our entry courses to the Geology program, in addition to advanced courses within their interest area. The successful candidate will be expected to teach Geomorphology, Hydrology/ Hydropedolog, and to assist in the teaching of our entry courses to the Geology program, in addition to advanced courses within their interest area. The successful candidate will be expected to teach Geomorphology, Hydrology/ Hydropedolog, and to assist in the teaching of our entry courses to the Geology program, in addition to advanced courses within their interest area.

For a detailed job description, requirements and application instructions, please visit www.stlawu.edu/resources/job.html.

Review of applications will begin February 1, 2009, and all materials will be considered until the position is filled. A Ph.D. is required at the time of appointment. TCU is an EEO/AA employer and encourages a diversity of applicants.

SENIOR GEOLOGIST
INSTITUTE OF EARTH SCIENCE AND ENGINEERING
AUCKLAND, NEW ZEALAND

The Institute of Earth Science and Engineering (IESE) at the University of Auckland is recruiting a Senior Geologist. The ideal candidate will provide expertise in earth science research and the application of this research to projects with industry, community, government, and other universities. The backbone of IESE is its engagement in pure, applied, and relevant research and professional training focused on the accessible earth. IESE is seeking to employ an experienced Geologist with applied research interests in the geological factors that control hydrocarbon reservoirs, and several key aspects of the earth’s crust. In this role, you will join a growing team of IESE earth scientists engaged in multi-disciplinary applied research with the University of Auckland, providing a new dimension to the Institute of Earth Science and Engineering’s research space.

For more information contact either Prof. Peter Malin, Vice Dean of Earth Science and Engineering, or Rebecca Mowat, Senior HR Advisor, on + 64 9 373 7522 or e-mail Director IESE p.malin@auckland.ac.nz or Rebecca Mowat, Senior HR Advisor, on + 64 9 373 7522 or e-mail Director IESE p.malin@auckland.ac.nz. Application deadline is January 2, 2009, and all mate-


tials must be received by that date.

S. Lawrence University is an Affirmative Action/ Equal Opportunity employer. Women, minorities, and persons with disabilities are encouraged to apply.

ASSISTANT PROFESSOR, SEDIMENTARY PETROLOGY/GEOCHEMISTRY OR NEOTECTONICS
BOONE PICKENS SCHOOL OF GEOLGY
AT OKLAHOMA STATE UNIVERSITY (OSU)

The Boone Pickens School of Geology at Oklahoma State University (OSU) seeks applications for a tenure-track faculty position in Sedimentary Petrology or Geochemistry or Neotectonics. The appointment will be at the assistant professor level and effective August 16, 2009. A Ph.D. in geology or related field at the time of appointment. The successful candidate will be expected to teach courses such as petrology, earth materials, and advanced undergraduate and graduate courses in their area of specialty. The successful candidate will be expected to teach courses such as petrology, earth materials, and advanced undergraduate and graduate courses in their area of specialty. The successful candidate will be expected to teach courses such as petrology, earth materials, and advanced undergraduate and graduate courses in their area of specialty.
petrography. The successful applicant will possess a Ph.D. in geology, be committed to excellence in teaching at both the undergraduate and graduate level, develop a strong research program supported by external funding, and augment our planetary and structural/metamorphic expertise. Candidates must have outstanding leadership, management, and interpersonal skills to relate to a wide diversity of faculty, staff, students and community members.

Ohio University is a Research-Extensive institution, enrolling 19,900 students on the Athens campus and more than 8,000 students on five regional campuses. The College of Arts and Sciences includes 340 tenured and tenure-track faculty members and contains 19 departments, 8 of which offer the doctoral degree. Further information about Ohio University may be found at the University’s Web site: www.ohio.edu.

Applicants must apply online via the Quicklinks site (www.ohiouniversityjobs.com/applicants/ CentralJobQuickFind-04688) and attach a vita, description of research interests, statement of teaching philosophy, and the names and addresses of three referees. An electronic copy of the most recent paper may be attached.

Applications to the Search Committee Chair, Dept. of Geological Sciences, 316 Clippinger Laboratories, Athens, OH 45701-2979. Postmarked applications, if necessary, may be mailed to: Search Committee Chair, Dept. of Geological Sciences, 316 Clippinger Laboratories, Athens, OH 45701-2979. Positions will remain open for full consideration, apply by December 1, 2008. Ohio University is an affirmative action/equal opportunity employer. For further information concerning the department and its faculty, visit www.ohiou.edu/geology.

**TENURE TRACK POSITION**

**EARTH SYSTEM SCIENTIST**

**SEDIMENTARY PROCESSES—BOSTON COLLEGE**

The Dept. of Geology and Geophysics at Boston College seeks to hire an Assistant Professor in the broad area of Earth System Science with a focus in Sedimentary Processes and/or geochemical processes in sedimentary systems. Areas of expertise to include (but are not limited to): basin analysis, reflection seismology, sediment transport, global environmental change, and/or geochemical processes in sedimentary systems. The successful candidate will be expected to develop a vigorous externally funded research program integrated with excellence in teaching within the geology-geophysics-environmental geoscience curriculum at both the undergraduate and graduate levels, including teaching a course in Sedimentology and Stratigraphy for majors. Information on the department, faculty, and research strengths can be viewed at www.bc.edu/geosciences. Applicants should send a curriculum vitae, statements of teaching and research interests, and the names and contact information of at least three references as a single PDF-file e-mail attachment to sed_position@bc.edu. Review of applications will begin on November 14, 2008. Dept. faculty will be available at the GSA and AGU fall meetings to meet with applicants. Boston College is an academic community whose doors are open to all residents, employees without regard to race, religion, age, sex, marital or parental status, national origin, veteran status, or handicap.

**Opportunities for Students**

Ph.D. Opportunity in Alaskan paleoclimate, University of Nevada–Las Vegas. We are seeking a Ph.D. student to complete field and laboratory research on Alaskan paleoclimate using stable isotopes in ground ice of permafrost near Fairbanks, Alaska, in the context of their stratigraphy, sedimentology and age, with lab work in the Las Vegas Isotope Science (LVIS) Lab. Previous experience in paleoclimateology/or stable isotope geochemistry is preferred. Contact Matthew Lachniet (matthew.lachniet@unlv.edu) or Daniel Lawson (lawson@cc.rensselaerproject.army.mil) and see geosciences.unlv.edu for more info.

Graduate Research Assistantships in Near-Surface Geophysics at the University of Tennessee. The first project (sponsored by the DOD and ORNL) involves utilizing time-lapse electrical resistivity tomography with a 3.2 MHz full cadence for analyzing natural recharge and contaminant remediation processes through time (days, weeks, months). The second project (sponsored by NSF) involves promoting diversity in the geosciences by providing unique opportunities to underrepresented student populations through the East Tennessee Geosciences Program (ETGP). The third project (currently pending funding through NSF) is a multi-university collaborative project to identify surface subsurface processes (144 channels available for 48 3C stations) and azimuthal seismic refraction tomography (ASRT) for analyzing bedrock anisotropy and associated hydrologic structures in the Centennial Valley to assess stress field switching associated with the interaction between the Yellowstone Hotspot and Basin and Range extension. The successful applicant will possess a Ph.D. degree and augment our structural/metamorphic expertise. Application packages (consisting of a curriculum vitae, list of publications, statement of research and teaching interest, and the names of 3 references) to: ENS@tnu.edu by 1st December 2008.

For further information about the Earth Observatory of Singapore, please refer to: http://www.ntu.edu.sg/EarthObservatory

www.ntu.edu.sg

Earth Observatory of Singapore

**Principal Investigators**

The Earth Observatory of Singapore has been established at Nanyang Technological University to study tectonic, volcanic and climatic processes, three arenas of earth science with particular relevance to the future of societies and civilization.

We plan to make about 15 tenure-track appointments over the next few years. Most will be at the assistant-professor level, but a few will be more senior.

If being part of a new earth-science research team in tropical Asia intrigues you, please email your application package (consisting of a curriculum vitae, list of publications, statement of research and teaching interest, and the names of 3 references) to: EOS@ntu.edu.sg by 1st December 2008.

For additional information contact: Dr. Gregory Baker, Director, Environmental Geophysics Research Lab, Dept. of Earth & Planetary Sciences, e-mail: gbaker@ntu.edu.sg. For more information, please see http://geophysics.tennessee.edu.

**Graduate Student Opportunities, Ohio University.**

The Dept. of Geological Sciences at Ohio University is seeking qualified students for its graduate program beginning September 1, 2009. The department offers programs leading to an MS degree in Geological Sciences with areas of emphasis including paleontology, stratigraphy, sedimentology, hydrogeology, geochemistry, geomorphology, planetary geology, geophysics, and tectonics. Prospective students are encouraged to contact faculty directly to discuss potential research topics. Qualified students are eligible to receive teaching assistantships that carry a full tuition scholarship and a stipend. For program and application information, visit the department Web site at www.ohiou.edu/geology/ or contact the graduate chair, Greg Springer (springeg@ohio.edu), for additional information.

**Earth Sciences Graduate Fellowship (Kottlowski/Bureau Fellowship)**

The New Mexico Bureau of Geology and Mineral Resources, a division of New Mexico Tech, is soliciting candidates for the Kottlowski/Bureau Fellowship. The fellowship, for an incoming Ph.D. candidate in the Dept. of Earth and Environmental Science, offers a 12-month, $23,000 stipend plus full coverage of tuition. The fellowship is renewable for up to three years. Additional funding is available to cover some laboratory and field expenses. All Ph.D. applicants to the department will be considered for the fellowship. The successful candidate may have interests in any earth or environmental science specialty, but will be expected to do a project within the state or of particular interest to the state, under the direction of advisors from both the Bureau and the Department. Application deadline is January 15, 2009. Applicants will automatically be considered for other support within the department.

New Mexico Tech is a highly rated science and engineering university with more than 60 earth science...
Ph.D. Assistantships—Soil Carbon-Mineral Geochemistry. We seek Ph.D. candidates to join our USDA funded project investigating the acceleration of organic nutrient release and mineral-organic matter association by biophysical soil mixing along an earthworm invasion chronosequence. This position will require strong understanding of the ecology of earthworm invasion in the Chippewa National Forest in Minnesota with two major biogeochemical processes: mineral weathering and carbon cycling. For more information, visit http://udel.edu/~kyoo/worm.html. Accepted students will be mentored by an interdisciplinary team of scientists—Hyungsoo Yoo at University of Delaware, Anthony Aufdenkampe at UD and Stroud Water Research Center, and Cindy Hale at the University of Minnesota. Degrees will be granted by the UD’s Dept. of Plant and Soil Sciences, with coursework customized from extensive offerings throughout UD. We seek students who might start as soon as February 2009. We encourage interested students to e-mail Yoo (kyoo@udel.edu) and Aufdenkampe (aufdenkampe@stroudcenter.org) for details while preparing a CV, statement of academic interest, and contact information of two references. Official applications are due at UD’s Graduate Office (www.udel.edu/gradoffice/applicants/) on Dec. 1 2008 for Spring 2009 admission and 1 April 2009 for Summer 2009 admission. New Mexico Highlands University, Graduate Assistantship. Graduate assistantships are available for students wishing to pursue an MS in Geology beginning Fall 2009 term. The NMHU Environmental Geology Program offers a field-intensive curriculum emphasizing earth materials, mineral-rock-water interactions, environmental geophysics, and natural geologic hazard assessment. Program strengths are in mineralogy, petrology, geochemistry, rock-paleomagnetism, structural geology, volcanology, and collaborative endeavors with the Forestry Program and the New Mexico Forest and Watershed Restoration Institute. New NSF-Funded Paleomagnetic-Rock Magnetism and Water Chemistry laboratories allow for numerous student and collaborative research opportunities. Nestled in the foothills of the Sangre de Cristo Mountains, Highlands’ campus has been cited as one of New Mexico’s best-kept secrets. A low student-faculty ratio, state-of-the-art laboratory facilities, and committed faculty provide students with a superior learning experience. The graduate assistantship includes a stipend of $10,000 and tuition waiver per academic year. Application review begins 01/15/08. For more information, contact Dr. Michael Petronis, Environmental Geology, Natural Resource Management Department, New Mexico Highlands University, Box 9000, Las Vegas, New Mexico 87701, mpetron@nmhu.edu. For disabled access or services call +1-505-454-3513 or TDD +1-505-454-3003. AA/EOE Employer. Ph.D. Opportunity at Louisiana State University. We seek highly qualified, motivated, and academically strong students with a bachelor’s or masters degree in geoscience or a closely related field for the Marathon Geosciences Diversity Enrichment program (Marathon GeoDE). Individuals must possess a strong desire to become leaders in a Ph.D. program that emphasizes scholarship, research, service, diversity, and mentorship. The program provides a $30,000, 9-month stipend, a full tuition waiver, and additional annual support for research and travel. This program is intended to create an inclusive, respectful, and intellectually challenging climate that embraces individual diversity and enhances the participation of underrepresented groups (including but not limited to race, ethnicity, and gender) in the sciences. For additional information, visit www.geol.lsu.edu/marathongeoede.html or contact Dr. Laurie Anderson at glande@lsu.edu. Houston Energy Fellow and Flagship Graduate Research Assistantship in Isotope Biogeochemistry and Geomicrobiology. A four-year Ph.D. assistantship is available in the Dept. of Geology and Geophysics, Louisiana State University. The research project will utilize multiple stable isotopes to study denitrifying and sulfate-reducing microorganisms to understand modern and ancient metabolic processes. The applicant should have a strong academic background in geology, aqueous geochemistry, and/or microbiology. Excellent oral/written communication skills and teamwork spirit are essential. The assistantship includes a stipend of $25,000, summer support, and $3000 for additional research expenses. Funding is in place to begin work as early as January 2009. Please contact Dr. Annette Engel (aengel@lsu.edu) or Dr. Huiming Bao (bao@lsu.edu) for more information. Visit http://geol.lsu.edu/aengel/ Flagship%20Assistantship.htm and www.geol.lsu.edu/ for details about our department.
Generational and Cyclical Demographic Change in The Geological Society of America

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**INTRODUCTION**

The Geological Society of America’s (GSA) membership is a demographic aggregate of individuals who join the Society, age as members, and eventually leave it either voluntarily or through death. GSA’s population structure bears the imprint of the major events that have shaped the geosciences during the past 85 years (the lifetimes of its membership). The current population structure also anticipates future changes in the Society’s membership.

GSA provided the birth year, gender, and location (state or country) of active members in July 2006; the data analyzed here include only members residing in the United States (15,224 members; 85.4% of the Society’s total) to minimize demographic variations resulting from the varied social, political, and economic histories of multiple nationalities.

**DEMOGRAPHIC CHARACTERISTICS OF THE MEMBERSHIP**

Figure 1 illustrates the age and gender composition of the 2006 GSA membership sample. Members of each gender are organized into cohorts of individuals born within 5-year intervals.

**Gender Imbalance**

The most striking feature of GSA’s population structure is the small percentage of women members—only 27.6%. The gender imbalance is especially notable among those born prior to 1945, when men outnumber women by more than 14 to 1. Cohorts born after 1969 have many more female members, and the number has increased with each successive 5-year cohort. This change reflects the near equity of the genders in geoscience degrees now being awarded in the United States (Holmes and O’Connell, 2007).

**Post–World War II Expansion**

The bulge in GSA’s membership corresponding to the timing of the Baby Boom (1946–1964) is one of the Society’s most pronounced demographic features. The bulge is strongly asymmetric, with men in every cohort outnumbering women by more than 3 to 1 (30.8% to 9.5%).

Unusually large cohorts born during the Baby Boom are not observed in all academic disciplines. The membership of the Association of American Geographers, for example, does not have particularly large cohorts from the Baby Boom years. In fact, the increase in the national birthrate that led to the Baby Boom appears to be only coincidentally associated with the large number of geoscientists born during those years. Federal programs to enhance the sciences and science education appear to have been far more important.

**Petroleum Boom-and-Bust Cycles**

Petroleum exploration in the United States is a story of “boom-and-bust” cycles (Deffeyes, 2001), and the two twentieth-century cycles had profound effects on GSA’s membership. The first cycle began in August 1945, when the United States ended gasoline rationing. The boom, resulting from higher gas
prices, continued until 1957, when “famine had replaced feast in the exploration business” (Friedman, 1978) and employment opportunities dwindled (Fig. 2).

The effects of the boom in oil prices are reflected by the bulge in the 1930–1934 birth-year cohort (Fig. 1). After the price bubble burst in 1957, employment opportunities for the following (1935–1939) cohort were significantly reduced.

The second and most prominent gap in GSA’s membership resulted from the petroleum boom and bust of 1973–1986 driven by the Organization of Petroleum Exporting Countries (OPEC) and political unrest in the Middle East. The boom was initiated when the “oil weapon” was employed as part of the Arab strategy for the 1973 Yom Kippur War. The Iranian Revolution (begun Jan. 1978) and the Iran-Iraq War (begun Sept. 1980) drove the crude oil market price in “real” (uninflated) 2007 dollars to an historic high (www.wtrg.com/prices.htm) that was not exceeded until March 2008 (Fig. 2).

Writing for Science in 1978, Gerald Friedman proclaimed the years ahead to be “The Golden Age of the Geoscientist.” Record oil prices produced the “greatest boom of them all” (Yergin, 1991), and employment opportunities for earth scientists had never been brighter (Rossbacher, 1983). Unfortunately, this “Golden Age” was short-lived, ending only three years after Friedman’s prediction.

In the early 1980s, OPEC began to lose its power to dictate the world’s petroleum prices. Saudi Arabia broke ranks with OPEC in 1981 and increased production to regain its market share and income. The price of petroleum fell immediately and continued to plummet until 1986, by which time the price in real dollars had returned to pre-embargo levels (Fig. 2). The impacts of this change on employment opportunities and education in the geosciences were immediate and devastating (Fig. 2).

The 1965–1969 birth cohort was college age (18–23) when the Middle East Petroleum Bust reached its nadir. Undergraduate enrollment in geoscience programs across the country plunged as jobs disappeared (AGI, 2001). In 1981, more than 7,000 geoscience undergraduate degrees were conferred in the United States, but by 1991, fewer than 2,000 were earned (Fig. 2).

The Base of the Pyramid: After The Bust

The disastrous decline in enrollment following the most recent bust placed many academic geoscience departments in jeopardy (Feiss, 1996). With students no longer drawn to the field by the prospect of large salaries, geoscience departments began to change in order to survive. New employment opportunities for geoscientists, driven largely by environmental issues, required a new curriculum.

In concert with curricular changes, academic departments and the geosciences at large began to accept pedagogy as a legitimate research area. GSA acknowledged this important change in 1991 with the creation of the Geoscience Education Division. Pressed by regional institutional accreditation, assessment in all its varied forms, budget constraints, and simple survival, many geoscience professors have focused on the scholarship of teaching and on finding ways to make the science more accessible.

Members added to GSA since the most recent petroleum bust mark a major demographic shift. The most important change is the decline in gender imbalance, reflecting increases in the number of women entering the geosciences (Fig. 2). Between 1974

and 2000, geoscience degrees awarded to women rose from ~17% to 45% (AGI, 2001). With substantially fewer men joining GSA now than during the Baby Boomers' undergraduate and post-graduate years, the growth in women members has prevented a substantial loss in overall GSA membership.

DISCUSSION

Nothing in the current GSA structure dictates the size or composition of future cohorts. Reasonable predictions can, however, be made as the extant cohorts continue to age.

First, as GSA's Baby-Boom generation moves into retirement and leaves the organization, the Society's membership will decline substantially unless new members are added more rapidly. In 2006, slightly more than 45% of the Society's membership was 50 or older. The three largest male cohorts (Fig. 1) will all reach retirement age in the next 15 years. This loss is inevitable and can be counterbalanced only by producing more U.S. geoscientists or by bringing in geoscientists from other countries.

Second, the 1980s Petroleum-Bust cohorts (born 1965–1975) are just entering their 40s and are assuming a much greater share of the responsibility for their profession. The small size of these cohorts means that there are fewer people to carry on the work of the science and the Society than in the past. Members of this group will, however, benefit from the increased opportunities for leadership. As well, some responsibilities that would usually be borne by this age group will probably be passed on to younger members.

Third, women are certain to play a larger role in the Society than ever before. It is critical, therefore, to retain as professionals women recruited as geoscience majors (de Wet et al., 2002).

For most of GSA's history, the societal value of geoscience has been defined by the ability of geologists to discover mineral and petroleum resources. The events of more than 50 years ago still have a recognizable imprint on GSA's membership, but the oil boom-and-bust cycles that largely shaped the geosciences throughout the twentieth century may be over (Keane, 2005). If these cycles have ceased, or at least ceased to be the most important influence on GSA, the class of events that may have this role in the future is by no means clear. Political, economic, and social changes are certain to have a profound impact on the Society and its membership.

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