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Fe isotopes: An emerging technique for understanding modern and ancient biogeochemical cycles

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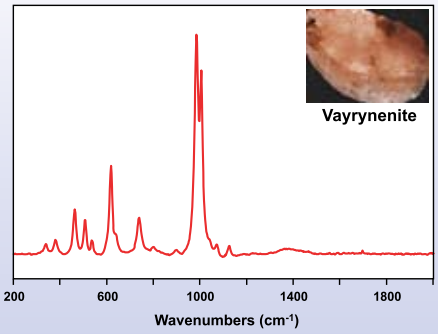

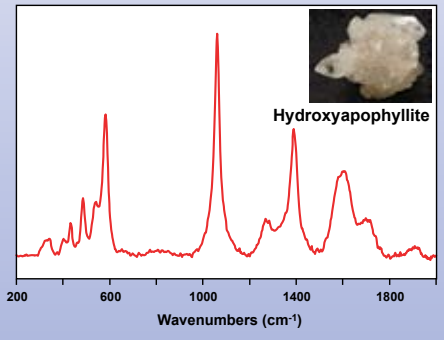

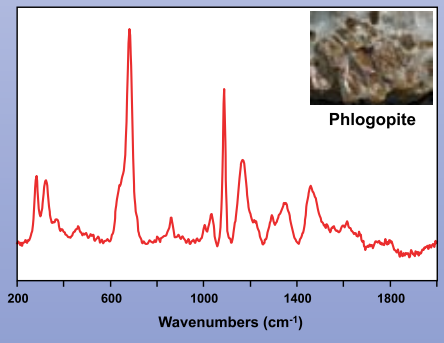

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Cover: Precambrian banded iron formation (BIF) at Jasper Knob, Upper Peninsula of Michigan. Iron isotope variations in BIFs and other Precambrian sedimentary rocks record major changes in the Fe cycle of ancient Earth, including development of microbial Fe^{3+} reduction. Photograph taken by John W. Valley. See "Fe isotopes: An emerging technique for understanding modern and ancient biogeochemical cycles" by C.M. Johnson and B.L. Beard, p. 4–10.

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SCIENCE ARTICLE

Fe isotopes: An emerging technique for understanding modern and ancient biogeochemical cycles

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ABSTRACT

Fractionation of the stable isotopes of Fe occurs through a combination of differences in bonding environments and separation of mobile Fe components. These fractionations are particularly large in low-temperature systems. The very low Fe contents of modern seawater make Fe isotopes exceptionally sensitive indicators of Fe sources and pathways in the oceans. Iron cycling at redox boundaries is a major means by which Fe isotope variations are produced. Bacteria, which commonly exploit redox gradients for energy, may strongly influence the associated isotopic fractionations, and this is particularly true for Fe^{3+}-reducing bacteria. Moreover, the Fe isotope fractionations associated with Fe sulfide, which may be produced by bacterial sulfate reduction, appear to be distinct from those produced by bacterial Fe reduction. The isotopic fingerprint for bacterial Fe reduction may be found in the rock record as far back as 2.9 Ga, and evidence for coupled bacterial sulfate reduction and Fe reduction is found in rocks that are 2.7 Ga. The ancient Fe isotope record requires the existence of an oxidant on Earth's surface since at least 3.8 Ga, but the nature of this oxidant (atmospheric O_2, anaerobic photosynthesis, UV-photo oxidation) remains unclear. Continued development of Fe isotope geochemistry depends critically on expanding the database for Fe isotope fractionation factors and increasing our understanding of the kinetic effects during redox transformations and mineral precipitation.

INTRODUCTION

The first-row transition metals (Sc to Zn) share a special combination of relatively high elemental abundance and a propensity for multiple oxidation states. Seven of these elements have multiple isotopes, ranging from two (V and Cu) to five (Ti, Ni, and Zn), and yet, up until several years ago, their isotopic variations in nature had been relatively little explored. Although the relative mass differences among the isotopes of the transition metals are small compared to the light stable isotopes (e.g., 5.9%/mass for O versus 1.5%/mass for Zn), the range in isotopic compositions measured in nature is 100 times analytical error using modern techniques. Of the over 100 papers that have been published on the isotopic variations of the first transition metals, approximately three-fourths have been on Fe isotopes, placing Fe prominently among the emerging "non-traditional" stable isotope systems (Johnson et al., 2004a).

Iron is the most abundant of the transition metals at 6.7 wt% in the continental crust (Rudnick and Gao, 2004). Fe^{3+} is generally insoluble at neutral pH, although it is soluble under acidic conditions. Fe^{2+} is soluble under near-neutral pH conditions only under low-Eh, anoxic conditions, such as might be found in reducing groundwaters, restricted marine basins, or when atmospheric O_2 contents were much lower than they are today. In the highest temperature portions of Earth (deep crust and mantle), Fe largely exists as Fe^{2+}, creating a large redox potential when mantle and deep crustal rocks are exposed to surface oxidizing conditions. In terms of biological processes, Fe^{3+} is an important terminal electron acceptor for iron-reducing bacteria as part of the electron transport chains they develop for adenosine triphosphate synthesis (e.g., Nealson and Saffarini, 1994). Fe^{2+} may provide a source of electrons for processes such as anaerobic photosynthetic Fe oxidation, which has been hypothesized to have been an important metabolic pathway in early Earth (e.g., Widdel et al., 1993). It is within this broad landscape of biogeochemical pathways and bonding environments, in part created through redox state and in part by ligand chemistry, that substantial isotopic fractionations may occur among the different isotopes of Fe. Here we focus on redox changes in low-temperature environments, modern and ancient, where the isotopic fractionations are relatively large. Recent in-depth reviews on Fe isotope geochemistry may be found in Anbar (2004), Beard and Johnson (2004), Johnson et al. (2004b), and Dauphas and Rouxel (2006).

NUTS AND BOLTS: DATA PRESENTATION AND FRACTIONATION FACTORS

There are four naturally occurring stable iron isotopes: ^{54}Fe (5.84%), ^{56}Fe (91.76%), ^{57}Fe (2.12%), and ^{58}Fe (0.28%), and isotopic data are typically reported using a standard δ notation in units of per mil (‰) (deviations in parts per 1000 relative to a reference ratio), using either $^{56}Fe/^{54}Fe$ or $^{57}Fe/^{54}Fe$ ratios. All of the data discussed here are reported in $\delta^{56}Fe$ values relative to the average for igneous rocks (Beard et al., 2003a):

$$\delta^{56}Fe = (^{56}Fe/^{54}Fe_{Sample}/^{56}Fe/^{54}Fe_{Ig\ Rxs} - 1) \times 10^3.$$

A common interlaboratory standard that allows comparison across labs is the Fe metal isotope standard IRMM-014, which is also used as a reference ratio in defining $\delta^{56}Fe$ and $\delta^{57}Fe$ values in a number of laboratories. The two reference frames for δ values may be related by

$$\delta^{56}Fe_{Ig\ Rxs} = \delta^{56}Fe_{IRMM\text{-}014} - 0.09‰$$

(Beard et al., 2003a). The reader should be aware that Fe isotope data are reported in the literature in a variety of ways, and a detailed discussion may be found in Beard and Johnson (2004). Details on the various analytical methods used for Fe isotope analysis may be found in Albarède and Beard (2004).

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Isotopic fractionation factors are key to understanding natural isotope variations. The Fe isotope fractionation between two species, *A* and *B*, may be defined as:

$$\Delta^{56}Fe_{[A]-[B]} = \delta^{56}Fe_{[A]} - \delta^{56}Fe_{[B]}$$

following standard convention. $\Delta^{56}Fe_{[A]-[B]}$ may reflect equilibrium or kinetic fractionations, and a process may reflect a combination of equilibrium and kinetic effects. Some of the largest Fe isotope fractionations occur between Fe^{3+} and Fe^{2+} species (e.g., Schauble, 2004). For example, the net Fe isotope fractionation that occurs during oxidation of Fe^{2+}_{aq} to Fe^{3+}_{aq}, followed by precipitation of Fe^{3+}_{aq} to ferric oxide, under equilibrium conditions, is $\Delta^{56}Fe_{[Fe\ Oxide]-[Fe^{2+}_{aq}]} = +3.0‰$ at room temperature, reflecting a Fe^{3+}_{aq}-Fe^{2+}_{aq} fractionation of +2.9‰ and a ferric oxide–Fe^{3+}_{aq} fractionation of +0.1‰ (Beard and Johnson, 2004); the equilibrium fractionation between ferric oxide and Fe^{3+}_{aq} is small because Fe does not change oxidation state or coordination. In most experimental and natural systems, however, the observed ferric oxide–Fe^{2+}_{aq} fractionation is much less, generally between +0.9 and +1.6‰, reflecting the combined effects of an equilibrium Fe^{3+}_{aq}-Fe^{2+}_{aq} fractionation (+2.9‰) and a kinetic ferric oxide–Fe^{3+}_{aq} fractionation (−1.3 to −2.0‰) upon precipitation (Beard and Johnson, 2004). Large gaps remain in our understanding of Fe isotope fractionations for the carbonate and sulfide mineral groups, which are critical for interpreting the geologic record; experimental studies of these groups are a high priority for future work.

THE Fe ISOTOPE CYCLE OF MODERN EARTH

We summarize Fe isotope variations in modern Earth in Figure 1. In surface environments, the existence of an O_2-bearing atmosphere provides an oxidant for Fe^{2+} but also produces a very low solubility for Fe^{3+}_{aq} at neutral pH, which generally restricts Fe isotope variations to environments where redox boundaries exist. Fe-S interactions are also important (although incompletely understood), and such interactions are also closely tied to redox boundaries. Significant Fe isotope variations may also occur in aqueous systems that are oxic, such as the oceans, where the aqueous Fe contents are so low that they are highly sensitive to changes in input fluxes over short time scales or geographic distance.

The major igneous fluxes that create oceanic and continental crust appear to have $\delta^{56}Fe$ values of zero (Beard et al., 2003a). Exceptions exist for some silicic granitic rocks and mantle xenoliths, but they are minor in terms of the overall Fe budget of the crust and mantle. In terms of Fe in the sedimentary cycle, an important observation is that the near-zero $\delta^{56}Fe$ values of the bulk continental crust are largely retained in bulk clastic sediments during weathering processes, despite a large increase in Fe^{3+}/Fe^{2+} ratios (Beard et al., 2003b). Although there are large equilibrium isotope fractionations between Fe^{3+} and Fe^{2+} aqueous species and minerals, conversion of Fe^{2+}-rich igneous or metamorphic rocks to insoluble Fe^{3+} weathering products under oxic conditions occurs without significant loss of Fe, producing little net change in Fe isotope compositions during formation of clastic sedimentary rocks. These observations indicate that in terms of Fe cycling, virtually all of the Fe in igneous, metamorphic, and clastic sedimentary rocks is isotopically homogeneous and has a $\delta^{56}Fe$ value of zero (Fig. 1). This provides an important reference frame for recognizing and understanding the processes and environments that produce Fe isotope variations.

Iron isotope variations in modern marine sediments are produced by diagenetic processes that reflect the interplay between Fe^{2+}_{aq} and ferric oxide during bacterial iron reduction (BIR), Fe^{2+}_{aq} and S^{2-}_{aq} during bacterial sulfate reduction (BSR), and ferric oxide–sulfide interactions. Both BIR and BSR may occur in the same sediment section, reflecting extensive cycling of Fe and S before they are ultimately sequestered in the rock record as pyrite (e.g., Canfield et al., 1993). Recent studies of shelf sediments from the California margin and the Arabian Sea demonstrate that reactive Fe pools may have highly variable Fe isotope compositions (Severmann et al., 2006; Staubwasser et al., 2006), but the bulk sediment has $\delta^{56}Fe$ values close to the average of clastic sedimentary rocks, indicating that Fe cycling largely occurs as a closed system within the sediment column or at most on the small basin scale (Staubwasser et al., 2006). Although porewater Fe^{2+} lost during marine diagenesis may be a significant flux to the oceans (Severmann et al., 2006), from the sediment perspec-

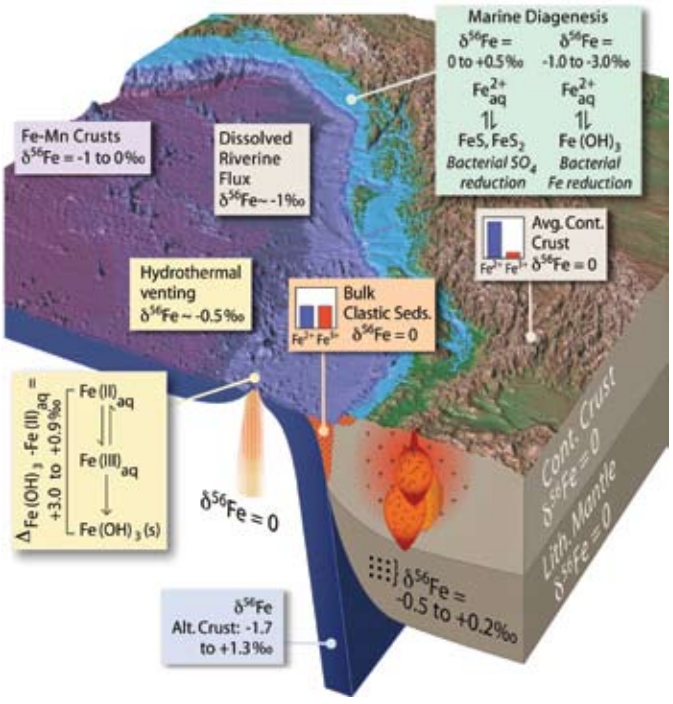

Figure 1. Illustration of the modern biogeochemical cycle for Fe isotopes (three-dimensional rendering of Pacific Northwest and British Columbia region). The oceanic and continental igneous flux has $\delta^{56}Fe$ = 0‰, indicating that the bulk of the mantle, with the exception of isolated domains that reside largely in the lithosphere (dot pattern), is isotopically homogeneous, as are bulk clastic rocks that have low-C and -S contents, despite an increase in Fe^{3+}/Fe^{2+} ratios. Marine diagenesis is in part driven by bacterial sulfate and iron reduction, and these two metabolisms appear to have distinct Fe isotope compositions. The dissolved riverine and marine hydrothermal fluxes have negative $\delta^{56}Fe$ values, and the hydrothermal flux may become increasingly negative through near-vent ferric oxide or hydroxide precipitation; isotopically heterogeneous seawater is expected due to the low residence time of Fe in modern seawater, and this is confirmed in Fe-Mn crusts that are used as a proxy for seawater Fe isotope compositions.

tive, the amount that is lost is small relative to the size of the Fe reservoir in the sediment column. Severmann et al. (2006) found that in suboxic sediment sections, where BIR was active, the reactive Fe pool was dominated by Fe^{2+}_{aq} and ferric oxides or hydroxides, which had negative δ^{56}Fe values of ~−1.0 to −3.0‰. In contrast, the reactive Fe pool in anoxic, sulfide-dominated sections consisted of Fe^{2+}_{aq} and FeS that had higher δ^{56}Fe values of 0 to +0.5‰. These observations highlight the distinct Fe isotope signatures that may be associated with BIR and BSR. Although the ultimate end product of Fe-S cycling in marine sediments is generally considered to be pyrite (e.g., Schoonen, 2004, and references therein), Severmann et al. (2006) noted that pyrite does not appear to be in Fe isotope equilibrium with Fe^{2+}_{aq} in the California margin sediments, and FeS and pyrite have dramatically different Fe isotope compositions. We are therefore far from understanding the factors that determine the Fe isotope compositions of sedimentary pyrite, in large part because experimental studies of Fe isotope fractionations in Fe-S systems have only just begun (Butler et al., 2005).

The quantity of *dissolved* Fe that exists under the oxic conditions of modern Earth is extremely small (ppb to ppt). The dissolved riverine Fe flux has low δ^{56}Fe values, perhaps ~−1‰ (Fantle and DePaolo, 2004). The major source of Fe to the upper oceans that are far from continental margins is atmospheric dust (e.g., Jickells and Spokes, 2001), which has a δ^{56}Fe value of zero (Beard et al., 2003b). Ligand-complexed Fe^{3+}_{aq} derived from partial dissolution of dust, however, may have negative δ^{56}Fe values, perhaps <−1‰, based on partial dissolution studies using organic ligands (Brantley et al., 2004). Direct emanations of Fe^{2+}_{aq} from marine hydrothermal vents have δ^{56}Fe ~−0.5‰ (Sharma et al., 2001; Beard et al., 2003b), and these may become more negative through near-vent oxidation and precipitation (Severmann et al., 2004). Altered oceanic crust may have a large range of δ^{56}Fe values (Fig. 1), but probably has an average δ^{56}Fe value near zero (Rouxel et al., 2003), consistent with only minor Fe loss via hydrothermal fluids. Finally, pore fluids emanating from marine sediments during bacterial reduction of iron oxides can have δ^{56}Fe values as low as −3‰ (Severmann et al., 2006). It is important to note that the dissolved Fe fluxes to the oceans under an O_2-bearing atmosphere are miniscule relative to the inventory of Fe in rocks, and therefore the isotopic compositions of the bulk "lithologic" inventory of Fe is largely unaffected under such conditions.

The Fe residence time in the oceans is estimated to be 70–140 yr (e.g., Bruland et al., 1994), which predicts that the Fe isotope composition of the modern oceans should be heterogeneous on short temporal and geographic scales (Beard et al., 2003b). The expected isotopic provinciality of modern seawater has been confirmed by Fe isotope studies of Fe-Mn crusts (Zhu et al., 2000; Levasseur et al., 2004; Chu et al., 2006), indicating that Fe isotopes may constrain Fe sources and pathways in the oceans. Temporal variations in Fe isotope compositions of Fe-Mn crusts, coupled with transition-metal abundances, may distinguish hydrothermal Fe sources from other sources of low-δ^{56}Fe components (Chu et al., 2006). In addition, time-series analysis of an Fe-Mn crust in the central Pacific suggests that Fe sources to the deep oceans far from continental margins may be decoupled from the dust-dominated sources in the surface ocean (Chu et al., 2006); such conclusions bear on Fe pathways in models for nutrient upwelling on continental margins (e.g., Mackey et al., 2002) or the effects of Fe fertilization on the surface ocean (e.g., Boyd et al., 2000). Iron cycling in the oceans is of great interest because phytoplankton productivity is linked to Fe availability, which in turn affects atmospheric CO_2 drawdown and global climate (e.g., Martin, 1990). It seems likely that future isotope research in modern marine systems will contribute greatly to tracing metal sources and pathways, although direct Fe isotope analysis of seawater is very difficult due to extremely low Fe contents.

IRON OXIDES AS RECORDS OF BIOLOGIC AND ABIOLOGIC Fe REDOX CYCLING

Using Fe isotopes to trace biological redox cycling has been debated since the initial papers appeared in the literature (e.g., Beard et al., 1999; Bullen et al., 2001). The isotopic compositions of Fe oxides are central to this discussion, and we first focus on oxidative processes. Abiologic oxidation of Fe^{2+}_{aq} by O_2 occurs in terrestrial and marine hydrothermal systems at circum-neutral pH, but in acidic systems (pH < 3), acidophilic Fe^{2+}-oxidizing bacteria are much more efficient at oxidation than abiotic reactions involving O_2 (e.g., Singer and Stumm, 1970). Under low-O_2 conditions, abiotic oxidative processes include UV-photo oxidation (Braterman et al., 1983), but anaerobic photosynthetic Fe^{2+} oxidation has been identified as a biologic pathway for oxidation in the absence of O_2 (Widdel et al., 1993); in both of these cases, oxidation is restricted to environments that have relatively high light intensities, such as the photic zone in marine settings. All of these processes involve two steps: oxidation of Fe^{2+}_{aq} to Fe^{3+}_{aq}, followed by precipitation of Fe^{3+}_{aq} to ferric oxide or hydroxide. The evidence at hand suggests that the Fe isotope fractionations between initial Fe^{2+}_{aq} and ferric oxide or hydroxide precipitate for all of these pathways are similar (Bullen et al., 2001; Croal et al., 2004; Balci et al., 2006; Staton et al., 2006), ranging from ~+1 to +3‰ (Fig. 2A), where the smaller fractionations are dominated by kinetic effects. Iron isotopes do not, therefore, appear to provide a clear distinction between abiologic and biologic pathways that involve *oxidation*. This does not mean, however, that Fe isotopes have limited value in tracing oxidation processes. As noted above, complete oxidation in situ, such as weathering under an oxic atmosphere, will produce no net isotopic change, and therefore ferric oxides or hydroxides that have positive δ^{56}Fe values must have formed through incomplete oxidation of Fe^{2+}_{aq}, suggesting close proximity to an aqueous anoxic-oxic boundary.

An unexpected finding in studies of ferric oxides or hydroxides has been the increasingly common occurrence of negative δ^{56}Fe values from terrestrial (Fig. 2B) and marine (Fig. 2C) environments. These isotopic compositions cannot be explained by partial oxidation of Fe^{2+}_{aq}, which would produce relatively high δ^{56}Fe values, but must reflect complete or near-complete oxidation of Fe that had low δ^{56}Fe values. Low δ^{56}Fe values in bulk analyses and acid extractions of soils have been interpreted to reflect a combination of organically bound Fe and Fe that has been cycled through multiple oxidation and reduction steps (e.g., Fantle and DePaolo, 2004; Emmanuel et al., 2005). Emmanuel et al. (2005) demonstrated, through mixing rela-

tions, that ferric oxides in semiarid and forest soils may have significantly negative δ^{56}Fe values, down to −1 or −2‰ (Fig. 2B). These compositions cannot be produced by a single oxidation step but instead appear to reflect isotopic fractionation during reductive dissolution of detrital oxide and silicate minerals and creation of a labile low-δ^{56}Fe Fe^{2+} pool, followed by complete oxidation. In addition, a labile low-δ^{56}Fe pool may be produced by complexation of Fe^{3+} by organic ligands.

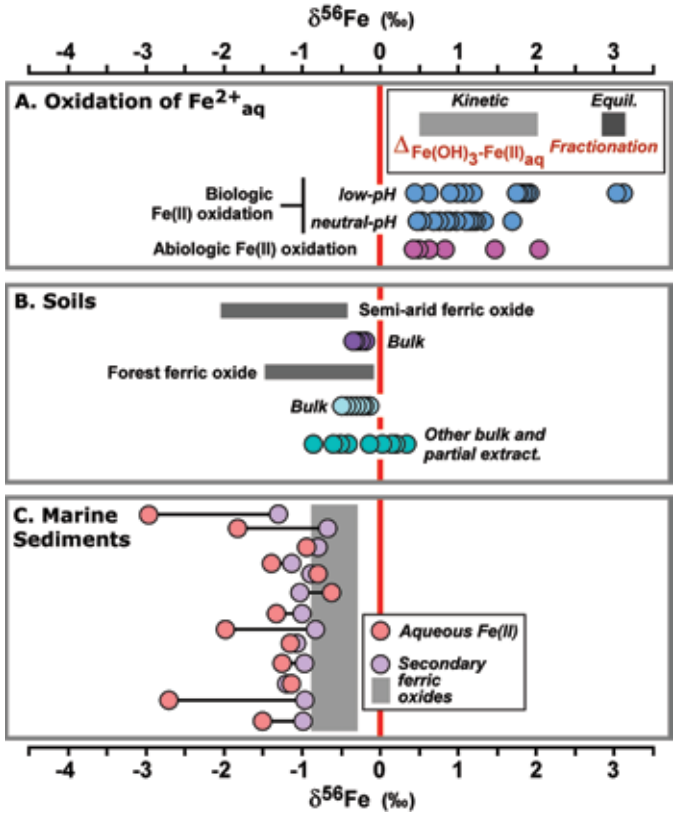

Figure 2. Fe isotope compositions for ferric oxides or hydroxide minerals from various environments that reflect oxidation or redox cycling. Vertical red lines indicate average isotopic composition of igneous and low-C and -S clastic sedimentary rocks, which serve as an isotopic mass-balance reference. (A) Experimental studies of biologic (blue symbols) and abiologic (pink symbols) oxidation of Fe^{2+}_{aq}. The maximum fractionation for the initial precipitate for the two-step reaction $Fe^{2+}_{aq} \rightarrow Fe^{3+}_{aq} \rightarrow Fe(OH)_3$, which is $\Delta_{[Fe(OH)_3] - [Fe^{2+}_{aq}]}$ = +3.0‰, occurs under equilibrium conditions, whereas kinetic fractionation upon precipitation decreases this to ~+0.9 to +1.6‰ for the initial precipitate under many conditions; this range can be increased depending upon the extent of reaction, as observed in experiments. Data from Bullen et al. (2001), Croal et al. (2004), and Balci et al. (2006). (B) Soils. Data from bulk or partial acid extractions, including inferred compositions for ferric oxides (gray bars) and associated bulk soils (purple and light blue symbols), as well as data from other soil samples (blue-green symbols). Data from Brantley et al. (2001); Fantle and DePaolo (2004); Emmanuel et al. (2005). (C) Marine environments. Data from the California coastal margin are shown in circles for Fe^{2+}_{aq} (light pink) and secondary ferric oxides or hydroxides (light purple) for samples where Fe^{3+}/Fe_{total} ratios exceed 0.3, reflecting an important influence by Fe^{3+}-reducing bacteria (Severmann et al., 2006). Grey box indicates range in secondary ferric oxides or hydroxides from modern marine sediments from the Arabian Sea (Staubwasser et al., 2006).

The low-δ^{56}Fe values for ferric oxides or hydroxides in modern marine sediments (Fig. 2C) have been interpreted to reflect oxidation of low-δ^{56}Fe Fe^{2+}_{aq} that was produced by BIR (Severmann et al., 2006; Staubwasser et al., 2006). Porewater Fe^{2+}_{aq} in sediments from the California margin that are dominated by BIR have δ^{56}Fe values equal to or lower than those of coexisting ferric oxides or hydroxides (Fig. 2C). We interpret the negative δ^{56}Fe values for ferric oxide or hydroxide minerals in marine sediments to ultimately be related to BIR followed by oxidation when anoxic porewaters encounter O_2-rich zones. Detailed experimental studies have shown that BIR produces low δ^{56}Fe values of −1 to −3‰ for Fe^{2+}_{aq} (Johnson et al., 2005a, and references therein), which occurs through reduction of ferric oxides and hydroxides via coupled electron and atom exchange between a secondary high-δ^{56}Fe Fe^{3+} surface layer in the oxide substrate and Fe^{2+}_{aq} (Crosby et al., 2005). We conclude that negative δ^{56}Fe values for Fe^{2+}_{aq}, either measured directly or inferred from ferric oxide or hydroxide minerals, appear to be signatures for biological iron *reduction*. Alternative explanations, such as sorption of Fe^{2+} to oxides, are unlikely (Crosby et al., 2005).

LOOKING INTO THE PAST

If the atmosphere of ancient Earth had significantly lower O_2 contents (e.g., Rye and Holland, 1998), the global Fe cycle illustrated in Figure 1 would have been significantly different than it is today. In particular, lower levels of oxidants for Fe would have kept Fe in solution in seawater for much longer periods; the estimated residence time for Fe in the Archean oceans is ~10^6 yr (Johnson et al., 2003). In the absence of an oxidant, the range in Fe isotope compositions of the fluxes to the Archean oceans would have been more restrictive than they are today, where, for example, both riverine and marine hydrothermal fluxes would have had a δ^{56}Fe of ~0‰ (Yamaguchi et al., 2005). In contrast, a wide range of mostly negative δ^{56}Fe values has been found in Proterozoic and Archean sedimentary rocks, spanning lithologies from oxide and carbonate layers in banded iron formations (BIFs), pyrite nodules and disseminated pyrite in shales, to black shales and graywackes with Fe budgets dominated by magnetite or Fe-rich carbonates (Fig. 3).

The contradictory prediction of small Fe isotope variations in an anoxic world and the observed variations in the rock record can be reconciled if Fe cycling in the Archean involved interaction between anoxic reservoirs and those that contained an oxidant. It is generally agreed that an oxidant is required to explain the occurrence of positive δ^{56}Fe values in Archean sedimentary rocks and minerals through oxidation of seawater Fe^{2+}_{aq} (Johnson et al., 2003; Dauphas et al., 2004; Rouxel et al., 2005; Yamaguchi et al., 2005). The nature of the Archean oxidant, however, is debated, and possibilities include atmospheric O_2 (e.g., Ohmoto, 1997), as well as UV-photo oxidation and anaerobic photosynthetic bacteria. The oxidant reservoir most likely existed in the upper ocean, because all oxidation mechanisms require proximity to either an O_2-bearing atmosphere or solar radiation, and such stratification is commonly invoked to explain sequences such as BIFs (e.g., Beukes et al., 1990).

Superimposed upon the isotopic compositions produced during oxidation are those produced during diagenesis under

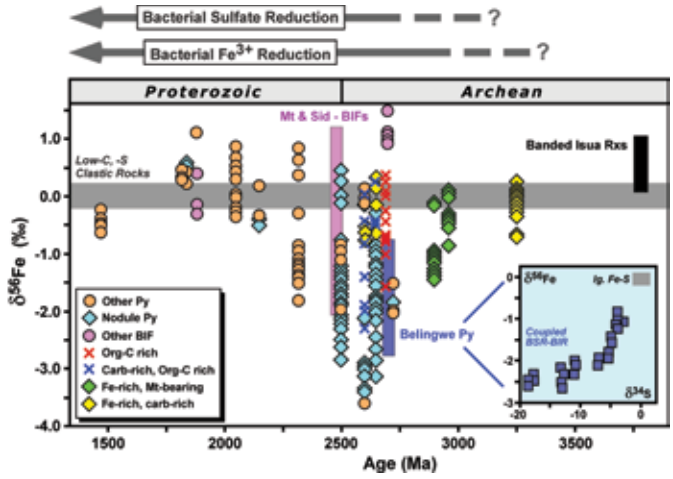

Figure 3. Iron isotope variations in Early Proterozoic to Archean sedimentary rocks and minerals. Range of low-C and -S clastic sedimentary rocks of Archean to modern age shown in horizontal gray band (Beard et al., 2003b; Yamaguchi et al., 2005), encompassing the range of igneous rocks and providing an isotopic mass-balance reference for the total crust. Isotopic data for high-grade metamorphosed banded rocks from Isua Supracrustal belt and adjacent regions shown in dark gray vertical box at right ("Banded Isua Rxs") (Dauphas et al., 2004). Bulk shale samples rich in Fe, C, and/or S are shown in blue and red "X" and green and yellow diamond symbols (Yamaguchi et al., 2005). Data for nodule and other pyrite (py) shown in tan circles and light blue diamonds (Rouxel et al., 2005). Compositions for magnetite and siderite (mt, sid) from the 2.5 Ga Kuruman and Brockman banded iron formations (BIFs) shown in vertical pink bar (n = 166, Johnson et al., 2003, 2005b; Rouxel et al., 2005). Additional data for oxide layers in BIFs (pink circles) from Rouxel et al. (2005). Coupled Fe and S isotope variations for pyrite from the Belingwe basin shown in inset; Fe isotope data shown in dark blue bar on main diagram (Archer and Vance, 2006). Shown along top of figure are the inferred times for the origin of bacterial sulfate reduction (Canfield, 2001) and bacterial Fe^{3+} reduction (Yamaguchi et al., 2005). BIR—bacterial iron reduction; BSR—bacterial sulfate reduction.

reducing conditions. Because the long residence time of Fe in the Archean oceans prevents rapid changes in Fe isotope compositions, the range in Fe isotope compositions in Figure 3 cannot directly reflect that of the Archean oceans. Low δ^{56}Fe values for magnetite in BIFs and shales have been interpreted to reflect equilibration with diagenetically produced Fe^{2+}_{aq} that had low-δ^{56}Fe values generated by BIR (Johnson et al., 2005a; Yamaguchi et al., 2005), providing a time marker for development of this important metabolism on Earth at 2.9 Ga or earlier. Archer and Vance (2006) discovered a remarkable correlation between Fe and S isotope compositions for pyrite from a 10-cm shale section from the 2.7 Ga Belingwe sedimentary basin (Fig. 3, inset). They interpret the covariation in Fe and S isotopes to reflect BIR and BSR during marine diagenesis, where the low-δ^{56}Fe and -δ^{34}S values were produced in shallower sections of the sediment column where BIR was supported by ferric oxide or hydroxide minerals and BSR was less likely to have been SO_4-limited, providing the maximum S isotope fractionation. The high-δ^{56}Fe and -δ^{34}S values are interpreted to have been produced at deeper levels in the sediment column where BIR was minor and SO_4 became limiting.

The abundance of low-δ^{56}Fe values that have been measured for Late Archean to Early Proterozoic sedimentary rocks and minerals is striking (Fig. 3), and we interpret these to dominantly reflect anoxic diagenetic processes, because such rocks are either rich in organic C, carbonate, and/or sulfide or reflect chemical precipitates such as magnetite- and siderite-rich layers in BIFs. Although low-δ^{56}Fe sedimentary pyrite is not restricted to the Archean (Severmann et al., 2006), as originally suggested (Rouxel et al., 2005), the low-δ^{56}Fe inventory in the Late Archean–Early Proterozoic record is clearly significant. It is important to note that low-C and -S clastic rocks have δ^{56}Fe = 0‰ through this time interval (Yamaguchi et al., 2005), indicating that the low-δ^{56}Fe values cannot reflect simple weathering and sediment transport processes. A logical question is, given the important mass-balance constraints provided by the δ^{56}Fe = 0‰ reservoirs of igneous, metamorphic, and low-C and -S clastic rocks, where are the positive δ^{56}Fe components? In a broad survey of sedimentary sulfides from Late Archean to Phanerozoic rocks, Rouxel et al. (2005) hypothesized that the high-δ^{56}Fe component may lie in oxide layers in BIFs or ferric oxides or hydroxides dispersed on continental shelves. Although it is true that oxide minerals (hematite and magnetite) from Late Archean to Early Proterozoic rocks may have high δ^{56}Fe values, this is not uniformly so. If we look at BIFs that have not been subjected to significant metamorphism, the δ^{56}Fe values for magnetite range from −1 to +1‰ but have an average value of +0.04‰ (n = 73; Johnson et al., 2003, 2005b; Rouxel et al., 2005). It is possible that the high-δ^{56}Fe component may not be preserved in the rock record. Important reservoirs that remain unknown are ancient altered oceanic crust and Late Archean–Early Proterozoic seawater.

Generally positive δ^{56}Fe values were measured for the 3.8 Ga banded Isua and Akilia rocks of SW Greenland (Fig. 3; Dauphas et al., 2004), some of which may have been BIFs. Because these rocks have been subjected to amphibolite- to granulite-facies metamorphism, there is some uncertainty regarding the effects of high-grade metamorphism. Dauphas et al. (2004) interpreted the high-δ^{56}Fe values to reflect partial oxidation of hydrothermally sourced Fe^{2+}_{aq}, which may have been caused by atmospheric O_2, anaerobic photosynthetic Fe oxidation, or UV-photo oxidation. Although Fe isotopes cannot, by themselves, distinguish among these possibilities, the isotopic data highlight the importance of an oxidant in the earliest period of Earth's history, and the positive δ^{56}Fe values require oxidation that did not run to completion, implying that the oxidant was limited. An important focus for future research will be investigation of a possible transition from the high-δ^{56}Fe values at 3.8 Ga to the low-δ^{56}Fe values at 2.7–2.5 Ga in the sedimentary rock record (Fig. 3), which could constrain the timing of development of iron-reducing metabolisms and the abundance of an oxidant on Earth's surface. Anaerobic photosynthesis preceded oxygenic photosynthesis (Xiong et al., 2000; Brocks et al., 2003), and although bacterial Fe reduction is also thought to be an ancient metabolism (Vargas et al., 1998), it must have formed after a significant oxidant developed on Earth (Nealson and Saffarini, 1994).

CONCLUSIONS

In the relatively short period since the field of Fe isotope geochemistry began, the expectation that measurable isotopic fractionations would be produced through differences in

bonding environments that accompany redox and mineral-fluid reactions has been realized in a wide variety of natural systems. The Fe isotope literature, reflecting nearly 80 publications through mid-2006 from roughly two dozen research groups, now contains several thousand isotopic analyses, attesting to the remarkable speed with which this new field has developed. Most of the Fe that is part of the modern Fe cycle has δ^{56}Fe values within one or two tenths per mil of zero, including the majority of the mantle, most igneous and metamorphic rocks, and low-C and -S clastic sedimentary rocks. The environments in which Fe isotope fractionations are produced on Earth today are therefore quite specific.

In modern aqueous environments, such as the oceans, dissolved Fe contents are so low that their isotopic compositions are sensitive indicators of Fe sources and pathways. Iron isotopes are exceptional indicators of Fe redox cycling, particularly in low-temperature environments where isotopic fractionations are relatively large and where significant pools of Fe^{2+} and Fe^{3+} may coexist. In modern Earth, such environments comprise a relatively small portion of the global Fe biogeochemical cycle, and in many cases these environments are populated by Fe^{2+}-oxidizing and/or Fe^{3+}-reducing bacteria that exploit redox gradients for energy. The evidence is clear that in many cases the observed Fe isotope fractionations reflect bacterially mediated redox cycling, and this is particularly true for bacterial Fe^{3+} reduction, where Fe isotopes appear to be most robust as a "biosignature." In addition, coupled Fe-S cycling induced by sulfide produced by bacterial sulfate reduction appears to produce Fe isotope compositions in Fe^{2+}_{aq} and FeS that are distinct from those of Fe^{2+}_{aq} and ferric oxides or hydroxides that are associated with bacterial iron reduction, providing a potential marker for the two metabolisms. Abiologic processes clearly fractionate Fe isotopes, but we contend that biologic and abiologic processes may be distinguished in many cases when the likely processes involved and mass balance issues are carefully considered.

We are only just beginning to study the Fe isotope cycle in early Earth. If a low-O_2 atmosphere and Fe^{2+}-rich ocean characterized the Archean, the global Fe isotope balance must have been significantly different than it is today. For example, Fe isotope compositions provide powerful evidence that bacterial iron reduction was established ca. 2.9 Ga, which in turn requires a mechanism to produce ferric oxide or hydroxide minerals. Major challenges involve understanding the connection between what is preserved in the rock record, which may be strongly affected by diagenesis and later alteration or metamorphism, and the ambient surface conditions in the past. Full understanding of the Fe isotope mass balance of ancient Earth, which is powerfully constrained by the near-zero δ^{56}Fe values of igneous and low-C and -S clastic sedimentary rocks, requires estimating the isotopic compositions and elemental inventories of important Archean reservoirs such as the "oxidized zone" or those that we cannot measure directly, such as ancient oceanic crust and seawater. Critical to the success of all of these studies will be careful theoretical and experimental determination of Fe isotope fractionation factors under kinetic and equilibrium conditions, as well as quantifying the rates of isotopic exchange in systems that are analogous to nature.

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Preliminary Announcement and Call for Papers

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Welcome to St. George!

We look forward to hosting you in St. George for the 2007 GSA Rocky Mountain Section Meeting, 7–9 May 2007. If you have never been to St. George, you'll be glad you came! This small but rapidly growing city of 70,000 retains its comfortable and friendly small-town feel, nestled amid sandstone and basalt-capped ridges and outcrops of the orange and deep red Early Triassic Moenkopi and Early Jurassic Moenave and Kayenta formations. St. George lies in a geologically fascinating area between the Basin and Range Province to the west and the Colorado Plateau to the east. Because of this unusual position, a broad spectrum of geological features is readily visible and available here, including the Virgin River Gorge (exposing much of the same strata visible in the Grand Canyon), the Hurricane Fault, the Virgin Anticline, hot springs, Plio-Pleistocene cinder cones and basalt flows, and the Pine Valley Mountains, one of the world's largest laccoliths, as well as fascinating series of Cambrian-Eocene (primarily Triassic-Jurassic in the immediate St. George area) marine and terrestrial strata.

Early May is a superb time to be in St. George: the weather is typically mild to warm, but it will not yet have achieved the kinds of searing temperatures typical of desert southwest summers, and tourist season will have only just begun. Evenings can be cool, however, and rain is not unknown, so please pack accordingly!

If your significant other and/or children are joining you on your trip but don't wish to attend the talks—or, if you would just like to extend your stay in St. George beyond the GSA meeting and get away from it all for a while—St. George is in close proximity to a wealth of national and state parks, including the St. George Dinosaur Discovery Site at Johnson Farm museum (in the city), Snow Canyon State Park (~15 minutes away), Zion National Park (45 minutes away), Bryce Canyon National Park (~1.5 hours away), Cedar Breaks National Monument (~1 hour away), Grand Staircase–Escalante National Monument (~1.5 hours away), the North Rim of the Grand Canyon (~3 hours away; the more crowded South Rim is ~5 hours away), Valley of Fire State Park and Great Basin National Park (both in Nevada; ~2 hours and ~3.5 hours away, respectively), and Lakes Powell and Mead (including the Hoover Dam; each ~2 hours away), all of which offer unparalleled geology, scenery, hiking, rock climbing, biking, photography, and natural history. If casinos and shows are your thing, Mesquite, Nevada, is nearby and Las Vegas is less than a 2-hour-drive away. St. George itself offers a wide variety of activities, including a myriad of golf courses, the Red Mountain and Green Valley spas (the latter is the third top-ranked spa in the world and popular with the Hollywood set), several museums and historical sites, fishing and bird-watching at Gunlock, Quail Creek, and Sand Hollow State Park reservoirs, restaurants, shopping, including the many unique art galleries and shops in St. George and the nearby villages of Kayenta and Springdale, and many other activities. Because St. George is, in large part, a tourist town, I highly recommend making reservations for hotels and any activities quite early—they get snapped up fast!

For more information on St. George and activities in Washington County, please visit these Web sites: www.sgcity.org, www.utahsdixie.com, and www.stgeorgechamber.com.

Travel to St. George is easy. By car: take I-15, which bisects the city and is less than two hours south of I-70. By air: fly directly in and out of the St. George Municipal Airport (airport code: SGU) on SkyWest Airlines, the world's largest independently owned regional airline (headquartered in St. George), a Delta and United partner. SkyWest has direct flights from Salt Lake City and Los Angeles; the route from Salt Lake City flies you directly over some great geology! The much larger McCarran Airport in Las Vegas (airport code: LAS) is about 2 hours away, and you can easily rent a car from there; there is also periodic shuttle service. The drive from Las Vegas takes you through the spectacular Virgin River Gorge.

Our meeting will be held at the Dixie Center, a fairly new and beautiful convention center located just off I-15; the Rosenbruch Wildlife Museum is directly attached to and accessible from the center. Several hotels and restaurants are within walking distance, and many others are within a few minutes' drive of the center. For the camping aficionado, beautiful campgrounds are available in Snow Canyon State Park, about 10–15 minutes northwest of St. George, and in the Virgin River Canyon Recreation Area in Arizona, about 20 minutes south of St. George in Arizona (take the Cedar Pocket exit [no. 18] of I-15 in the Virgin River Gorge).

As you make your plans to come to St. George, please let me know if you have particular needs or desires, and if you can't find information on any of the Web sites, please contact me and I'll be happy to see what I can track down! We know you'll love St. George and we aim to make the 2007 RMGSA meeting one of the best!

Jerry D. Harris
Director of Paleontology, Dixie State College
+1-435-652-7758, jharris@dixie.edu

CALL FOR PAPERS

Abstracts Deadline: 13 February 2007

Papers are invited from students and professionals for oral and poster presentations. Abstracts should be submitted online at www.geosociety.org. An abstract submission fee of US$15 will be charged. If you cannot submit the abstract electronically, please contact Nancy Carlson, +1-303-357-1061, ncarlson@geosociety.org. An individual may present only one volunteered paper but may be co-author on other papers. Individuals invited to participate in symposia may present an additional volunteered paper. Depending on time constraints in oral sessions, some submitters may be requested to switch to a poster presentation and vice-versa.

REGISTRATION

Early Registration Deadline: 2 April 2007

Registration fees will be published in the February 2007 issue of *GSA Today*. On-site registration will be available at the Dixie Center during the meeting.

TECHNICAL SESSIONS

A large number of diverse symposia is planned for the 2007 St. George meeting. If you are interested in participating in any of these symposia, please contact the person(s) listed. In addition to these symposia, theme sessions will be created upon receipt of abstracts for various geological disciplines. For information about the technical sessions, please contact technical program chair Mark Colberg, +1-435-865-8331, colberg@suu.edu.

An asterisk (*) indicates a session has an associated field trip.

Symposia

1. **Collaboration and Outreach: Industry, Education, and Public Land Partnerships (NAGT).** Robert Eves, Southern Utah University, +1-435-586-1934, eves@suu.edu; Gayle L. Pollock, Bryce Canyon Natural History Association, +1-435-834-4601; C. Fredrick Lohrengel, Southern Utah University, +1-435-586-7941, lohrengel@suu.edu.
2. **Nature of the Mojave Province, from Precambrian Assembly to Neotectonics.** Karl E. Karlstrom, University of New Mexico, +1-505-277-4346, kek1@unm.edu; Mark Colberg, Southern Utah University, +1-435-865-8331, colberg@suu.edu.
3. **Council on Undergraduate Research—Undergraduate Research (Posters).** Bill Dinklage, Utah Valley State College, +1-801-863-7607, dinklawi@uvsc.edu.
4. ***Engineering Geology in the Rocky Mountain West: Effective Geologic Practice.** Cosponsored by *Association of Engineering Geologists*. William R. Lund, Utah Geological Survey, +1-435-865-9034, billlund@utah.gov; David B. Simon, Simon Bymaster Inc., +1-801-943-3100, david@sbigeo.com.
5. ***Utah's Lower Cretaceous Cedar Mountain Formation: Advances in Geology.** James I. Kirkland, Utah Geological Survey, +1-801-537-3307, jameskirkland@utah.gov; Scott Madsen, Dinosaur National Monument, +1-970-374-3000.
6. ***Utah's Lower Cretaceous Cedar Mountain Formation: Advances in Geology and Paleontology (Posters).** James I. Kirkland, Utah Geological Survey, +1-801-537-3307, jameskirkland@utah.gov; Scott Madsen, Dinosaur National Monument, +1-970-374-3000.
7. **Trace and Indirect Evidence of Terrestrial Bolide Impacts.** Joe W. Fandrich, Westwater Group Geological Research Facility, +1-970-256-9029, joefandrich@hotmail.com.
8. **Laccoliths.** David B. Hacker, Kent State University–Trumbull, +1-330-675-8831, dhacker@kent.edu; Michael Petronis, New Mexico Highlands University, +1-505-453-3513, mspetro@nmhu.edu.
9. **Integrated Surface Water and Groundwater Systems Characterization and Modeling.** Kenneth E. Kolm, BBL Incorporated, +1-303-231-9115, kkolm@bbl-inc.com. Oral and Poster.
10. **Western Energy Resources: Oil, Gas, Coal, and Geothermal.** Bob Blackett, Utah Geological Survey, +1-435-865-9035, robertblackett@utah.gov.
11. **Advances in Utah Paleontology.** Alan L. Titus, Grand Staircase–Escalante National Monument, +1-435-644-4332, alan_titus@blm.gov; Jerry D. Harris, Dixie State College, +1-435-652-7758; jharris@dixie.edu.

FIELD TRIPS

In tandem with the technical sessions, field trips are planned to a broad spectrum of geologically fascinating locales. The following are confirmed field trips (titles and trip leaders may be tentative). An asterisk (*) indicates that the field trip has an associated symposium.

1. ***Utah's Lower Cretaceous Cedar Mountain Formation: Advances in Geology and Paleontology.** James I. Kirkland, Utah Geological Survey, +1-801-537-3307, jameskirkland@utah.gov; Scott Madsen, Dinosaur National Monument, +1-970-374-3000.
2. **Mesozoic and Cenozoic Paleoichnology of Southwestern Utah.** Andrew R.C. Milner, St. George Dinosaur Discovery Site at Johnson Farm, +1-435-705-0173, amilner@sgcity.org.
3. **Geology of Zion National Park.** Bob Biek, Utah Geological Survey, +1-801-537-3356, bobbiek@utah.gov; Grant Willis, Utah Geological Survey, +1-801-537-3355, grantwillis@utah.gov.
4. ***Engineering Geology in the Rocky Mountain West: Effective Geologic Practice.** Cosponsored by *Association of Engineering Geologists*. William R. Lund, Utah Geological Survey, +1-435-865-9034, billlund@utah.gov; David B. Simon, Simon Bymaster Inc., +1-801-943-3100, david@sbigeo.com.

Other potential field trips include (but are not limited to) the structure, tectonics, and geology of the Beaver Dam Mountains, hydrogeology of the Escalante Valley, geology of the Pine Valley Mountains, Late Cenozoic volcanism in southwestern Utah, and geology and paleontology of Grand Staircase–Escalante National Monument. Information on field trips will be posted online as soon as it becomes available.

If you have questions about field trips, please contact field trip chair David Simon, +1-801-943-3100, david@sbigeo.com, and/or guidebook chair Bill Lund, +1-435-865-9041, billlund@utah.gov.

ACCOMMODATIONS

Blocks of rooms have been reserved at the Crystal Inn, which is within walking distance of the Dixie Center: Crystal Inn, 1450 S. Hilton Dr., St. George, UT 84770, +1-435-688-7477; +1-877-462-7978; res.stg@crystalinns.com.

Please request your reservations with the code RMGSA 2007. Please make your reservations as soon as possible to ensure that you secure a room. For information on alternative accommodations, please contact Jerry D. Harris, +1-435-652-7758, jharris@dixie.edu.

ADDITIONAL MEETINGS

Two other meetings have been scheduled in conjunction with the Rocky Mountain GSA meeting. A meeting of the State Geologists–U.S. Geological Survey will tentatively take place on Tuesday, 8 May. Contact: Rick Allis, +1-801-537-3305, rickallis@utah.gov. A joint meeting of the Utah and Nevada Seismic Commissions is tentatively scheduled for Thursday, 10 May. No site for the meeting has yet been selected. Updates on both these meetings will be posted online.

CALL FOR SPONSORS

GSA's Rocky Mountain Section welcomes sponsors to help defray the costs of the meeting. We are seeking partial or full support for the welcoming party (Dixie Center, 6 May 2007), morning and afternoon refreshments (7–9 May), and general meeting expenses. When your company or organization sponsors an event, it will be prominently recognized at the event, bringing attention to your services. Please contact Jerry D. Harris, +1-435-652-7758, jharris@dixie.edu, to learn more about sponsoring events at the Rocky Mountain Section Meeting.

EXHIBITOR INFORMATION

GSA's Rocky Mountain Section Meeting will attract a wide array of both applied and academic geoscientists, including students, from the American West and elsewhere, providing exhibitors with an excellent opportunity to interact with potential customers, colleagues, and skilled employees. The exhibit area will be located in the beautiful Dixie Center in the midst of all technical sessions, ensuring maximum exposure to meeting attendees. Fees for companies and academic/non-profit organizations will be determined soon and posted online. Please direct all inquiries to Jerry D. Harris, +1-435-652-7758, jharris@dixie.edu.

STUDENT TRAVEL GRANTS

Undergraduate and graduate students seeking funding for travel to the Rocky Mountain Section Meeting in St. George should contact Ken Kolm, kkolm@bbl-inc.com, for an application form and eligibility information.

MENTORING PROGRAMS

Roy J. Shlemon Mentor Program in Applied Geoscience. Sponsored by *GSA Foundation.* Mon.–Tues., 7–8 May 2007, 11:30 a.m.–1 p.m.

The John Mann Mentors in Applied Hydrogeology Program. Sponsored by *GSA Foundation.* Tues., 8 May 2007, 5–6:30 p.m.

For more information, see www.geosociety.org/students.htm or contact Jennifer Nocerino, jnocerino@geosociety.org.

ACCESSIBILITY

GSA is committed to making its meetings accessible to all people interested in attending. Please indicate special requirements (wheelchair accessibility, etc.) when you register.

CONTACT INFORMATION

If you have questions or special requirements, please contact local committee chair Jerry D. Harris, +1-435-652-7758, jharris@dixie.edu, or technical program chair Mark Colberg, +1-435-865-8331, colberg@suu.edu. Additional meeting information is available at www.geosociety.org/sectdiv/rockymtn/07rmmtg.htm.

Call for Geological Papers

GSA Section Meetings

Northeastern Section
12–14 March 2007
University of New Hampshire
Durham, New Hampshire
Abstract Deadline: 5 December 2006
Information: Wally Bothner, University of New Hampshire, Dept. of Earth Sciences, James Hall, 56 College Rd., Durham, NH 03824-3578, USA, +1-603-862-3143, wally.bothner@unh.edu.

Southeastern Section
29–30 March 2007
Hyatt Regency Savannah on the Historic Riverfront
Savannah, Georgia
Abstract Deadline: 12 December 2006
Information: Pranoti Asher, Georgia Southern University, Dept. of Geology and Geography, Statesboro, GA 30460-8149, USA, +1-912-681-0338, pasher@georgiasouthern.edu.

Joint Meeting
North-Central and South-Central Sections
11–13 April 2007
Kansas Memorial Union, University of Kansas
Lawrence, Kansas
Abstract Deadline: 23 January 2007
Information: Greg Ludvigson, +1-785-864-2734, gludvigson@kgs.ku.edu—or—Greg Ohlmacher, +1-785-749-4502, ohlmac@kgs.ku.edu; both at Kansas Geological Survey, University of Kansas, 1930 Constant Ave., Lawrence, Kansas 66047-5317, USA.

Cordilleran Section
4–6 May 2007
Western Washington University
Bellingham, Washington
Abstract Deadline: 6 February 2007
Information: Bernie Housen, Western Washington University, Dept. of Geology, MS 9080, 516 High St., Bellingham, WA 98225-5946, USA, +1-360-650-6573, bernieh@cc.wwu.edu.

Rocky Mountain Section
7–9 May 2007
Dixie Center
Saint George, Utah
Abstract Deadline: 13 February 2007
Information: Jerry Harris, Dixie State College, Science Building, 225 South 700 East, Saint George, UT 84770-3875, USA, +1-435-652-7758, dinogami@gmail.com.

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STUDENTS—Meet Your Career Mentors!

2007 SECTION MEETING MENTOR PROGRAMS

See www.geosociety.org/students.htm or contact Jennifer Nocerino, jnocerino@geosociety.org, for more information.

NORTHEASTERN SECTION MEETING

University of New Hampshire, Durham, N.H., USA

Shlemon Mentor Program Luncheons:
Mon.–Tues., 12–13 March, 11:30 a.m.–1 p.m.

Mann Mentors in Applied Hydrogeology Program:
Mon., 12 March, 5–6:30 p.m.

SOUTHEASTERN SECTION MEETING

Hyatt Regency Savannah
on the Historic Riverfront, Savannah, Ga., USA

Shlemon Mentor Program Luncheons:
Thurs.–Fri., 29–30 March, 11:30 a.m.–1 p.m.

Mann Mentors in Applied Hydrogeology Program:
Thurs., 29 March, 5–6:30 p.m.

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Joint Meeting

NORTH-CENTRAL SECTION

SOUTH-CENTRAL SECTION

Kansas Memorial Union,
University of Kansas,
Lawrence, Kans., USA

Shlemon Mentor Program Luncheons:
Thurs.–Fri., 12–13 April, 11:30 a.m.–1 p.m.

Mann Mentors in Applied Hydrogeology Program:
Thurs., 12 April, 5–6:30 p.m.

CORDILLERAN SECTION MEETING

Western Washington University, Bellingham, Wash., USA

Shlemon Mentor Program Luncheons:
Fri.–Sat., 4–5 May, 11:30 a.m.–1 p.m.

Mann Mentors in Applied Hydrogeology Program:
Fri., 4 May, 5–6:30 p.m.

ROCKY MOUNTAIN SECTION MEETING

Dixie Center, Saint George, Utah, USA

Shlemon Mentor Program Luncheons:
Mon.–Tues., 7–8 May, 11:30 a.m.–1 p.m.

Mann Mentors in Applied Hydrogeology Program:
Mon., 7 May, 5–6:30 p.m.

UPCOMING APPLICATION & NOMINATION DEADLINES

Medals and Awards
Nominations Due: 1 February 2007

Candidate nominations are requested for the following medals and awards: Penrose Medal, Day Medal, Honorary Fellows, Young Scientist Award (Donath Medal), GSA Public Service Award, and GSA Distinguished Service Award. For details on the awards and nomination procedures, see the October 2006 issue of *GSA Today*. For the online nomination form, go to www.geosociety.org/aboutus/awards/ or call +1-303-357-1028. Materials and supporting information for any of the nominations may be sent to Grants, Awards, and Recognition, GSA, 3300 Penrose Place, P.O. Box 9140, Boulder, CO 80301-9140, USA.

GSA Fellows
Nominations Due: 1 February 2007

The Committee on Membership requests nominations of members to be elevated to GSA Fellow status. Any GSA Fellow may nominate a Member for this honor. Two supporting letters in addition to the online nomination form are needed. For details on nomination procedures, see the October 2006 issue of *GSA Today*, go to www.geosociety.org/members/fellow.htm, call +1-303-357-1028, or e-mail awards@geosociety.org.

2007 Subaru Outstanding Woman in Science Award
(Sponsored by Subaru of America Inc.)
Nominations Due: 1 February 2007

This award is given to a woman who has made a major impact on the field of the geosciences, based on her Ph.D. research. For details on the award and nomination procedures, see the October 2006 issue of *GSA Today*. For the new online nomination form, go to www.geosociety.org/aboutus/awards/ or call +1-303-357-1028. Send nominations and supporting material to Grants, Awards, and Recognition, GSA, 3300 Penrose Place, P.O. Box 9140, Boulder, CO 80301-9140, USA.

John C. Frye Environmental Geology Award
Nominations Due: 31 March 2007

In cooperation with the Association of American State Geologists, GSA makes an annual award for the best paper on environmental geology published either by GSA or by one of the state geological surveys. For details, see the October 2006 issue of *GSA Today*, go to www.geosociety.org/aboutus/awards/, or call +1-303-357-1028. Nominations must be sent to Grants, Awards, and Recognition, GSA, 3300 Penrose Place, P.O. Box 9140, Boulder, CO 80301-9140, USA.

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Student Research Grants 2007

Apply online at www.geosociety.org/grants/gradgrants.htm starting late November. Application for a GSA student research grant is an **online-only** process. No paper applications or letters will be accepted. Online submission must be completed by **Thurs., 1 February 2007, at 11:59 p.m. (MST).**

Students must be GSA members and may only receive a grant once at the master's level and once at the Ph.D. level. Those who have applied for grant funding but who did not receive a grant are welcome to apply again. The maximum award per grant is US$3500.

For more information on GSA's 2007 research grant program, go to www.geosociety.org/grants/gradgrants.htm, call +1-303-357-1028, or e-mail awards@geosociety.org.

National Awards
Nominations Due: 30 April 2007

Candidate nominations are needed for the following national awards: William T. Pecora Award, National Medal of Science, Vannevar Bush Award, and Alan T. Waterman Award. For details, see the October 2006 issue of *GSA Today*. Nominations should be sent to Grants, Awards, and Recognition, GSA, 3300 Penrose Place, P.O. Box 9140, Boulder, CO 80301-9140, USA.

Research Awards in Geomorphology and Micropaleontology

Two of GSA's most prestigious research-support awards are made possible by the generosity of the late W. Storrs Cole. Qualified GSA Members and Fellows are urged to apply.

Geomorphology

The **Gladys W. Cole Memorial Research Award** provides support for the investigation of the geomorphology of semiarid and arid terrains in the United States and Mexico. GSA Members and Fellows between the ages of 30 and 65 who have published one or more significant papers on geomorphology are eligible for the award. While the funds may not be used for work that is already finished, recipients of previous awards may reapply if they need additional support to complete their work. The 2007 award is US$8700.

Micropaleontology

The **W. Storrs Cole Memorial Research Award** supports research in invertebrate micropaleontology. This award carries a stipend of US$7700 in 2007 and will go to a GSA Member or Fellow between the ages of 30 and 65 who has published one or more significant papers on micropaleontology.

Deadline for applications: 1 February 2007.

Online application forms are now accepted at www.geosociety.org/grants/postdoc.htm. Supplemental information may be e-mailed to awards@geosociety.org or sent to Grants, Awards and Recognition, 3300 Penrose Place, P.O. Box 9140, Boulder, Colorado 80301-9140.

The Gladys W. Cole and W. Storrs Cole award funds are managed by the GSA Foundation.

2007 Birdsall-Dreiss Distinguished Lecturer

Bridget Scanlon of the University of Texas at Austin has been selected as the 2007 Birdsall-Dreiss Distinguished Lecturer. This lecture series is sponsored by the GSA Hydrogeology Division. At the request of interested institutions, she will present one of two lectures for audiences regarding broad aspects of water resources.

Bridget Scanlon received a B.S. in geology at Trinity College, Dublin (Ireland), an M.S. at the University of Alabama, and a Ph.D. from the University of Kentucky (Lexington). She is currently a senior research scientist at the Bureau of Economic Geology. The primary objective of her research group is to assess sustainability issues with respect to water resources, within the context of climate variability and land-use change. Studies integrate physical, chemical, and isotopic analyses and numerical modeling. Much of the research focuses on groundwater recharge in semiarid regions in natural and cultivated ecosystems. Scanlon has taught vadose zone hydrology at the University of Texas at Austin and has participated in focus groups on global recharge issues within the International Atomic Energy Agency. She served on National Academy of Sciences (NAS) committees on radioactive waste disposal and is currently serving on the NAS Integrated Observations on Hydrologic Sciences committee.

Bridget Scanlon

To request a visit to your institution, contact Bridget Scanlon, Bureau of Economic Geology, Jackson School of Geosciences, University of Texas at Austin, J.J. Pickle Research Campus, Bldg. 130, 10100 Burnet Rd., Austin, TX 78758-4445, +1-512-471-8241, bridget.scanlon@beg.utexas.edu. **The deadline for requests is 15 December 2006.** The GSA Hydrogeology Division will pay transportation expenses, and the host institution will provide local accommodations.

LECTURE TOPICS

Implications of Climate Variability for Groundwater Resources and Waste Disposal in Semiarid Regions—A Look at Ecological Controls from Annual to Millennial Timescales

Understanding impacts of climate variability on groundwater recharge is essential for management of water resources and waste disposal. Water scarcity is a critical issue in semiarid regions, and potential contaminant transport by recharge to groundwater is also important because of waste disposal. A key question is: how do climate variability and related vegetation dynamics impact groundwater recharge?

This talk will explore the role of vegetation dynamics in regulating the impact of climate variability on groundwater recharge. Results from a unique field data set from weighing lysimeters (large, soil-filled concrete containers) beneath nonvegetated and vegetated systems in the Mojave Desert, Nevada, unequivocally show that vegetation dynamics control the impact of elevated winter precipitation related to El Niño Southern Oscillation (ENSO) on groundwater recharge. The lysimeter data indicate that rapid increases in vegetation productivity in response to 2.5 times normal winter precipitation reduced soil water storage to half of that in the nonvegetated lysimeter, thereby precluding deep drainage below the root zone that would otherwise result in groundwater recharge. Satellite vegetation data provided regionalization of "point scale" lysimeter results. Unsaturated zone chloride and pressure data at sites across the southwestern U.S. indicate that similar feedbacks have minimized interstream basin-floor recharge since the last glacial period, 10,000–15,000 years ago. Strong correlations between satellite vegetation productivity and interannual precipitation variability related to ENSO in deserts in Australia, South America, and Africa indicate that the processes described in the southwestern U.S. may apply to deserts globally. The two-way coupling between the water cycle and vegetation dynamics is critical in controlling how climate variability influences water resources, with important implications for waste disposal in semiarid regions.

Impacts of Changing Land Use on Subsurface Water Resources

The most widespread changes in land use have occurred because of agricultural expansion. Over the past 300 years, cultivated cropland and pastureland have increased globally by 560% and 660%, respectively. Irrigated agriculture has expanded by 580% since 1900 and is projected to increase 20% by 2030 in developing countries. Agricultural food production accounts for ~85% of global fresh water consumption, led by irrigated agriculture. What impacts have these land-use changes had on water resources?

Measurements of pressure head, soil pore water chemistry, groundwater levels, and groundwater quality provide an archive of system response to past land-use changes. This presentation will focus on the Texas Southern High Plains, which is one of the largest agricultural areas in the United States. Cultivation of natural grasslands has changed the system from discharging through evapotranspiration since Pleistocene times (~10,000 to 15,000 yr) to recharging during the past 50 to 100 yr. Recharge under rain-fed agriculture is shown by large groundwater-level rises (average 7 m over 3400 km^2 area of rain-fed agriculture) during the past few decades, resulting in a median recharge rate of 21 mm/yr (5% of precipitation). Changes from discharge to recharge conditions reflect long fallow periods (~7 mo/yr) associated with cultivation. Recharge under irrigated agriculture is shown by downward hydraulic head gradients. Large groundwater-level declines (as much as 75 m) under irrigated areas indicate that irrigated agriculture is not sustainable. Results from land-use changes in this region will be compared with those from other global regions. Although past land-use changes had unintended impacts on the water cycle, a comprehensive understanding of these impacts could be used to alter land-use practices for better management of water resources.

2007 JAHNS DISTINGUISHED LECTURER

John E. Moylan

John E. Moylan has been named the 2007 Jahns Distinguished Lecturer. The Association of Environmental and Engineering Geologists and the GSA Engineering Geology Division jointly established the Richard H. Jahns Distinguished Lectureship in 1988 to commemorate Jahns and to promote student awareness of engineering geology through a series of lectures offered at various locations around the country throughout the year. Richard H. Jahns (1915–1983) was an engineering geologist who had a diverse and distinguished career in academia, consulting, and government.

Moylan received a B.S. in geology from the University of Kansas in 1958 and attended a special Corps of Engineers geological engineering program at the University of Minnesota in 1974. He worked as a geologist for the Corps of Engineers Kansas City District for 33 years, where he rose to chief of the geology section and retired as chief of the geotechnical branch in 1991. He was an adjunct instructor in geology at the University of Missouri at Kansas City from 1979 through 1985. Following his retirement from the Corps of Engineers, he worked for Woodward-Clyde Consultants/URS for 10 years as a senior consulting geologist and is currently an independent consulting geologist.

Moylan is experienced in most aspects of engineering geology. He has conducted geologic investigations for site selection, design, construction, performance monitoring, and remedial design of dam projects. In addition, he worked on the geologic investigations of many military projects, a natural salt contamination area, and a proposed nuclear waste disposal site. Since 1978, his work also included the investigation, remedial design, and performance evaluation of hazardous waste sites, and he has worked on over 50 National Priority List Superfund Sites. While with Woodward-Clyde/URS, he was technical advisor and peer reviewer on geotechnical and environmental projects throughout the company. He has actively encouraged expanding the focus of environmental geologic investigations and studies from the nature and extent of contamination to include site characterization, needed for effective remedial design and remedial action.

Moylan has been an active member of the Association of Environmental and Engineering Geologists since 1966 and was a founding member of the Kansas City–Omaha Section. He served as section chairman in 1969–1970 and 2003–2005. He has actively encouraged the participation of geology students at the University of Missouri at Kansas City and the University of Kansas in the activities of the Kansas City–Omaha Section and has made several technical presentations at these two universities and the University of Missouri at Rolla. Moylan is also a member of the Geological Society of America.

Titles for the 2007 Jahns lectures are "Strength Reduction in Shales—Causes, Effect on Stability, Case Histories, Recognition," "Site Characterization for the Design of Effective Groundwater Remediation Projects," "Geologic Influences on Selected Mid-Continent Dams," and "Effects of Geologic Factors on the Design and Performance of Permeable Reactive Barriers." Requests for lecture scheduling should be directed to John Moylan at john_moylan@sbcglobal.net.

2006 Biggs Awardee Named

THE GEOLOGICAL SOCIETY OF AMERICA

Gary S. Solar

Congratulations to **Gary S. Solar,** chair and associate professor of earth sciences and science education at SUNY College at Buffalo, who has been named the 2006 Biggs Award recipient.

The Biggs Award encourages and rewards excellence in teaching among college-level professors of earth science who are in the early stages of their careers. The award is made possible through support from the Donald and Carolyn Biggs Fund, the GSA Geoscience Education Division, and GSA's Education and Outreach Program. These funds are managed by GSA Foundation.

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Congressional Science Fellow Report

The Office of Technology Assessment: Bureaucratic Waste or Undervalued Resource?

Nicole Gasparini, *2005–2006 GSA–U.S. Geological Survey Congressional Science Fellow*

For the past year, GSA and the U.S. Geological Survey have sponsored me as a science fellow to Congress. The Congressional Science Fellowship program is run by the American Association for the Advancement of Science (AAAS) and places scientists from all backgrounds in congressional offices. Working as a congressional staffer has many perks, but as an AAAS congressional fellow, even more doors were open to me. Among my many "extras" were a private tour of the Pentagon, movie openings (the science type!), and a private tour of the U.S. Naval Observatory, including a view of Saturn through the 26-inch refracting telescope. I also had the privilege of attending a talk given by Newt Gingrich at the National Press Club on 20 July 2006.

Gingrich is probably best known for his term as Speaker of the House of Representatives from 1995 to 1999. Before he was elected to Congress in 1978, he taught history at West Georgia College. At the Press Club, Gingrich talked about the rapid advancement of science and stressed the importance of education, referring to the failure of U.S. math and science education as "a greater threat than any conceivable conventional war." On this point, Gingrich and I see eye-to-eye. Gingrich is an amazing politician, and it was clear to me how he swept our country up in his 1994 "Contract for America," which gained the Republican party 54 seats (there are 435 total) in the U.S. House of Representatives and thereby the majority.

In his first year as Speaker of the House, Gingrich abolished the Office of Technology Assessment (OTA). The OTA was created in 1972 to provide Congress objective analyses of major public policy issues related to scientific and technological change. When asked why he shut down the OTA, Gingrich said the office was expensive to run and produced sub-par studies. Some articles, however, suggest that a 1985 OTA study questioning the feasibility of the United States' ballistic missile defense program, or "Star Wars," led to the demise of the OTA.

Regardless of the reason, Congress is now without a resource devoted specifically to understanding how scientific and technical matters affect policy. While Gingrich was in office, he said he did not need the OTA because he would speak directly with the top scientists working on an issue. This approach worries me. First of all, identifying "top scientists" is not always easy. Areas of science remain contentious in the policy arena, regardless of whether there is relative scientific consensus on the topic. Would Gingrich speak with scientists on both sides of a debated issue? And even if he did speak with different scientists on a topic, would this provide a fair representation? Are scientists even prepared to talk about the nuances of their field with a policy maker? I'm sure I would take the call if any member of Congress wanted to talk with me about geomorphology, but I'm not sure I could have communicated the policy aspects of my field effectively before this year.

Although Gingrich found a way to survive without the OTA, other members of Congress have felt the loss. A few days after Gingrich's Press Club talk, the House Science Committee held a hearing titled "Scientific and Technical Advice for Congress," which addressed the loss of the OTA. Although some opponents of the OTA argued that it was a partisan office, the chair of the Science Committee, Rep. Sherwood Boehlert (R-N.Y.), stated that he was a strong defender of the OTA and that he had voted against defunding the office.

The first witness was Representative Rush Holt (D-N.J.). Holt is a Ph.D. physicist and a former AAAS Congressional Fellow. He has taken many steps to try to restore a scientific advisory office for Congress; in 2001 and 2003, he introduced similar bills to reestablish the OTA.

In general, in order for a freestanding piece of legislation to get a vote on the House floor, it must first pass through the committee of jurisdiction, which usually holds hearings on the legislation and then votes on the bill. Following a positive vote in committee, the bill is discharged and can be considered by the House. Ultimately, this leadership committee decides which bills will see the light of the House floor. Holt's bills have never even received a vote in committee, although both had bipartisan cosponsorship. (The lack of action on Holt's bills is not unusual; the vast majority of proposed legislation never makes it out of committee.)

During his testimony, Holt pointed out that there are already a number of resources for Congress, including the Congressional Research Service, the National Academy of Sciences, think tanks, and experts from a member's personal district. As Holt put it, "we do not suffer from a lack of information here on Capitol Hill, but from a lack of ability to glean the knowledge and to gauge the validity, credibility, and usefulness of the large amounts of information and advice received on a daily basis." Holt pointed out how many of the OTA reports, from over a decade ago, are still timely and pertinent, including reports like "Retiring old cars: Programs to save gasoline and reduce emissions," "Renewing our energy future," "Potential environmental impacts of bioenergy crop production," "Innovation and commercialization of emerging technologies," and "Testing in America's schools: Asking the right questions." Holt, the other witnesses, and many committee members echoed a common theme: Congress is getting a lot of information but not the information it needs.

Not all the committee members shared this sentiment, however. In the opinion of Rep. Dana Rohrabacher (R-Calif.), the OTA was always late and too expensive. Rohrabacher felt that outside consultants could produce a better product than the OTA, and by using consultants, Congress could "have more control." Rohrabacher

also suggested that Congress call on university scientists to carry out studies similar to those conducted by the OTA.

In some sense, the National Research Council (NRC) already provides a link between university scientists and Congress. The NRC assembles groups of academy members and independent scientists to study issues at the request of Congress and the administration. However, another witness at the hearing, Peter Blair, executive director of the Division on Engineering and Physical Sciences at the NRC, pointed out that the focus of NRC committees is to deliver consensus-based advice on science and technology topics. The OTA served a different role. As Blair stated, "OTA project teams sought to analyze and articulate the consequences of alternative courses of action and elaborate on the context of a problem without coming to consensus recommendations on a specific course of action." Blair has a unique perspective on the issue; he previously served as OTA assistant director.

There is still no legislation in the House to restore the OTA. Rep. Holt offered a failed amendment to the 2005 appropriations bill that would have allocated $30 million to restore some of the capabilities of the OTA. To put this in perspective, the President's 2007 budget request totaled $2.7 trillion, which does not include the $120 billion of supplemental funds for the Iraq and Afghanistan wars. Currently, the Senate's version of the budget would provide a total of about $138 billion for federal research and development programs. In my mind, the question is whether $30 million is too much to spend for some assurance that our lawmakers will have a resource that can clearly communicate how the findings of scientific studies, many of which are federally funded, can be used to make sound policy decisions. Ultimately, our lawmakers, and indirectly, U.S. voters, will answer this question.

This manuscript is submitted for publication by Nicole Gasparini, 2005–2006 GSA–U.S. Geological Survey Congressional Science Fellow, with the understanding that the U.S. government is authorized to reproduce and distribute reprints for governmental use. The one-year fellowship is supported by GSA and by the U.S. Geological Survey, Department of the Interior, under Assistance Award No. 05HQGR0141. The views and conclusions contained in this document are those of the author and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. government. *Gasparini can be reached at nicole.gasparini@yale.edu.*

PENROSE CONFERENCE REPORT

Chronostratigraphy: Beyond the GSSP

3–9 June 2006

Schloss Seggau, Leibnitz, Austria

Conveners:

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INTRODUCTION

Chronostratigraphy, the temporal organization and classification of (predominantly) sedimentary strata, provides the framework for deciphering earth history. Conceptually developed in the latter half of the nineteenth century, it has undergone successive metamorphoses, but at unprecedentedly accelerated rates in the last two decades. Given the size and scope of new databases, their ever-growing complexity and importance, and the multidisciplinary nature of modern studies, we urgently need to reexamine the bases upon which our classifications of rock, events, and time are assembled.

Topics

Thirty-one scientists from Africa, Australia, Europe, and North America and six part-time European observers attended this Penrose Conference at Schloss Seggau in Leibniz, Austria, from 3–9 June 2006. The conference was divided into several topics, prefaced by a keynote address by Gian Battista Vai (University of Bologna), who traced the history of the early bipartite, and latterly, tripartite chronostratigraphic subdivision as seen from the perspective of a century of international geological congresses.

The first topic of the conference reviewed the status quo of Cenozoic chronostratigraphy. William A. Berggren (Rutgers University) discussed some of the difficulties involved in constructing a satisfactory chronostratigraphy around some Cenozoic chronostratigraphic boundaries because of historic usage. He examined the heterogeneity in the procedures followed by various working groups in establishing Global Standard Stratotypes and Points (GSSPs), and questioned the use of the stage as the basic unit of the chronostratigraphic hierarchy. John Flynn (American Museum of Natural History) demonstrated how magnetostratigraphy and isotope stratigraphy have been instrumental in correlating terrestrial and marine stratigraphies, using examples from the South American Cenozoic record, the Neogene of Mexico, and the Paleocene-Eocene boundary interval in Asia and North America. Mike Woodburne (Museum of Northern Arizona, Flagstaff) discussed the concept of North American Land Mammal Ages and the need for renewed biostratigraphic studies in order to improve both boundary definitions and the potential development of continental stages. As reviewed by Dennis Kent (Rutgers University), magnetochronology now forms the backbone of the Late Jurassic through Cenozoic time scale, providing a resolution of <50 k.y. Whereas the Early and Middle Jurassic sequences of geomagnetic polarity reversals are as yet poorly known, Triassic sections have yielded a reliable magnetostratigraphy. Paleozoic magnetostratigraphy is promising. Carl Swisher (Rutgers University; as presented by D. Kent) pointed to the vast discrepancy between the analytical precision (<1%) of $^{40}Ar/^{39}Ar$ ages with the uncertainty (>1%) due to calibration and interlaboratory variations. His new age calibration on Paleogene tie-points brings the Paleogene time scale in synchrony with the new Neogene time scale (ATS04).

The second topic addressed problems in chronostratigraphy. Nick Christie-Blick (Columbia University) explained the rationale and procedures for placing in Australia the GSSP of the newly defined Ediacaran System of the Neoproterozoic erathem. Stan Finney (Long Beach State College) reviewed the status of the Paleozoic systems with emphasis on the Ordovician. He pointed to the major role of graptolite stratigraphy in guiding GSSP definitions. Jim Ogg (Purdue University) remarked on the slow progress in the definition of Mesozoic GSSPs. There is no GSSP for the base of the Cretaceous as yet, and the Berriasian Stage may have to be abandoned. Rick Fluegeman (Ball State University) reviewed the state of Cenozoic GSSPs. He pointed out the importance of erecting a Sparnacian Stage between the Thanetian and Ypresian s.s. stages. Brad Pillans (Australian National University, Canberra) reviewed the problem with equating the Pleistocene with the Quaternary and supported the recent suggestion to decouple the two and retain the Tertiary and Quaternary as suberathem/subera of the Cenozoic. Stan Finney (on behalf of Maria Cita, University of Milano) presented an overview of the history of Mediterranean Neogene stages. Werner Piller (Graz University) discussed the history of regional stages for the Paratethys and their correlation to Mediterranean stages. He indicated that the only appropriate resolution to these correlation problems is the application of an integrated stratigraphic approach within which sequence stratigraphy provides the basic framework for correlation supported by bio- and magnetostratigraphic tie points. He questioned the usefulness of regional stages in the light of a GSSP-based chronostratigraphy.

The third topic dealt with recent methodologies in chronostratigraphy. As discussed by Nick Christie-Blick, there is strong potential for miscorrelation of genetically (un)related surfaces, with significant implications for time-stratigraphy. Sequence stratigraphy is most useful at the basin scale and cannot serve for any global stratigraphic framework. It is not a convention or scheme

for stratigraphic classification. Linda Hinnov (Johns Hopkins University) reviewed the principles of cyclostratigraphy and its relationship to the astronomical time scale (ATS). She distinguished the canonical (Cenozoic-Mesozoic, insolation-based) ATS and floating (pre-Mesozoic, orbital-like pattern-based) ATS, and reviewed the Latemar controversy. Joszef Palfy (Hungarian Natural History Museum, Budapest) showed how the methods of Unitary Association (UA) and Constrained Optimization (CONOP) assist in the definition of GSSPs and the evaluation of the reliability of correlations. Thierry Moorkens (Antwerp, Belgium) discussed the role of sequence- and cyclostratigraphy in studies of the Rupelian and Ypresian unit stratotypes and recommended (re)introduction of the Sparnacian Stage at the base of the Eocene. Based on Toarcian sections, Stephen Hesselbo (Oxford University) demonstrated that very high resolution carbon isotope stratigraphy has great potential for global (marine and terrestrial) correlations, with stability and resolution that far exceed ammonite-based stratigraphy. Andy Gale (British Museum, London) reiterated this point based on Upper Cretaceous successions in England and showed that carbon isotopic records yield a Milankovich cyclicity.

The fourth topic was concerned with the future of chronostratigraphy. Stan Finney observed that there are competing definitions of chronostratigraphy and reviewed the use of biostratigraphy in assisting the definition of GSSPs. He described the current status of the global stratigraphic correlation program and demonstrated the home page of the International Commission on Stratigraphy and its subcommissions. Bob Carter (James Cook University, Townsville) questioned whether the stratigraphic tools exist to satisfy future societal needs. He proposed broadening lithostratigraphy to include synthems as the highest hierarchical unit, abandoning the dual concept of chronostratigraphy, merging global *chronostratigraphic* units into global *chronologic* units down to the level of ages, abandoning the (local) stage, and retaining local biostratigraphies, including the oppelzones.

The fifth topic was devoted to examining potential improvements in current concepts and practices. Marie-Pierre Aubry (Rutgers University) traced the concept of GSSP to Harland's approach to chronostratigraphy. She pointed to significant conceptual ambiguities in the GSSP approach, illustrated by the complex architecture

(continued on page 24)

(continued from page 23)

of the Cenozoic stratigraphic record with its extended gaps and the resulting potential for miscorrelation based on event stratigraphy. Among other items, she proposed that boundary definition be based on horizons rather than points and that reference sections in terrestrial and marginal marine stratigraphies complement the marine-based GSSP definition. Lucy Edwards (U.S. Geological Survey, Reston) attempted to reconcile the desirability of a stable means of communication among stratigraphers with the need to revise stratigraphic codes and guides to reflect advances in the field of stratigraphy. Yuri Gladenkov (Geological Institute, Moscow) represented the view of the Russian school of stratigraphy. He noted that, whether regional or global, "natural" boundaries (i.e., based on major changes in earth history) should prevail in stratigraphic classification. He questioned the validity of the GSSP concept and suggested that unit-stratotypes be reconsidered. Finally, he recommended that the revision of the *International Stratigraphic Guide* involve the international stratigraphic community. Brian McGowran (University of Adelaide) noted that cultural diversity in stratigraphy was not removed by the *Guide*, that our perceptions of earth and life history have changed greatly (e.g., a resurgence of punctuationism driven by "revolutions" in plate tectonics, cyclo- and sequence stratigraphy, and impact theory), and that we have become much more unifying and integrating in recent decades. He cited assertions that stratigraphy has marginalized itself by way of the triad of litho/bio/chronostratigraphy, and he used examples from each of the three facets to show how stratigraphy must reassert its rightful place at the integrating and synthesizing center of earth and life history.

In the form of a debate between Jan Zalesiewicz (Leicester University) and Marie-Pierre Aubry, the conference provided the opportunity to discuss the proposal of the British Stratigraphic Commission to transform the dualistic hierarchy of current chronostratigraphy into a unitary system.

A proposal to develop cyclostratigraphy tools for the Mesozoic by a task force within the CHRONOS project was elucidated by Linda Hinnov and Jim Ogg. The idea of a Web-based community time scale was also discussed by Ogg and John Van Couvering (Micropaleontology Project). This proposal was strongly questioned because of inherent instability, risking the paper trail on which clarity of citation and communication must be based.

The conference ended with an open discussion that revolved around two main topics: the current status of stratigraphy and the content of the *International Stratigraphic Guide*. The audience expressed its concern at current levels of recognition and growth of stratigraphy in the earth sciences. Stratigraphy is central to geology in academia and industry and must remain there as the earth sciences contribute to society welfare. The training of experts in basic stratigraphic disciplines is an important step in meeting this challenge. Another matter of concern is the revision of the *Guide*, in which members of the stratigraphic community wish to participate. The consensus was that the *Guide* should not be simplified at this time, and it should be more explicit in some categories, in particular with regard to the description of the GSSP. The majority was for preserving the dual hierarchy of chronostratigraphic and geochronologic subdivision.

As to the science of stratigraphy itself, Nick Christie-Blick captured the spirit of the meeting thus: our great advances in precision and accuracy in correlation and age determination embolden us to ask those questions of the stratigraphic record that we have hitherto been too insecure to ask.

Primary Recommendations

1. In the interests of integration, synergy and synthesis, the stratigraphic community must be brought further together. Multidisciplinary advances notwithstanding, the community is still too divided by methodologies and expertise and according to different precepts in subdividing the Proterozoic and Phanerozoic eonothems.
2. We need to unify concepts and protocols across different geocultural traditions.
3. Stratigraphy plays a strong central role in discovering and elucidating earth and life history. We have to promote that role vigorously, beginning with a revival of historicist thinking in education by way of historical biology and historical geology.

Secondary Recommendations

1. Regulating all stratigraphic tools and procedures is unnecessary (e.g., in sequence stratigraphy).
2. There was, on balance, a preference for retaining the dual nomenclature of stratigraphy (from eon/eonothem to age/stage).
3. Neither mammal ages nor biochronology are recognized explicitly in current stratigraphic codes or guides. This deserves further consideration.

PARTICIPANTS

Marie-Pierre J. Aubry, Bill Alfred Berggren, Robert M. Carter, Nick H. Christie-Blick, Michael Dermitzakis, Lucy E. Edwards, Hans Eggers, Stan C. Finney, Rick Fluegeman, John J. Flynn, Stefano Furin, Andy Gale, Yury Gladenkov, Stephen Hesselbo, Linda A. Hinnov, Dennis Kent, Brian McGowran, Thierry Moorkans, Stefan Muellegger, Jim G. Ogg, Khaled Ouda, Jozsef Palfy, Brad R. Pillans, Werner E. Piller, Markus Rueter, June Schwarzacher, Walther Schwarzacher, Fritz Steininger, Gian Vai, John A. Van Couvering, and Michael O. Woodburne

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Bob Fuchs

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If you are interested in learning more about life insurance as a gift to GSA, please contact the Foundation office, drussell@geosociety.org, +1-303-357-1054. Your estate planner can also assist you.

Fuchs is a former president of the GSA Foundation now living in Fort Myers, Florida, where he assists several charities in their planned giving programs.

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Most memorable early geologic experience:

Walking across a gravel pit near the north shore of Long Island, N.Y., in the late fifties or early sixties, looking for a Cretaceous-Pleistocene contact, Tom suddenly stopped and said, "Feels like clay under here." I thought, "A real field geologist! Even thinks with his feet!"

—Joseph Upson II

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International Conference on Continental Dynamics and Environmental Change of the Tibetan Plateau

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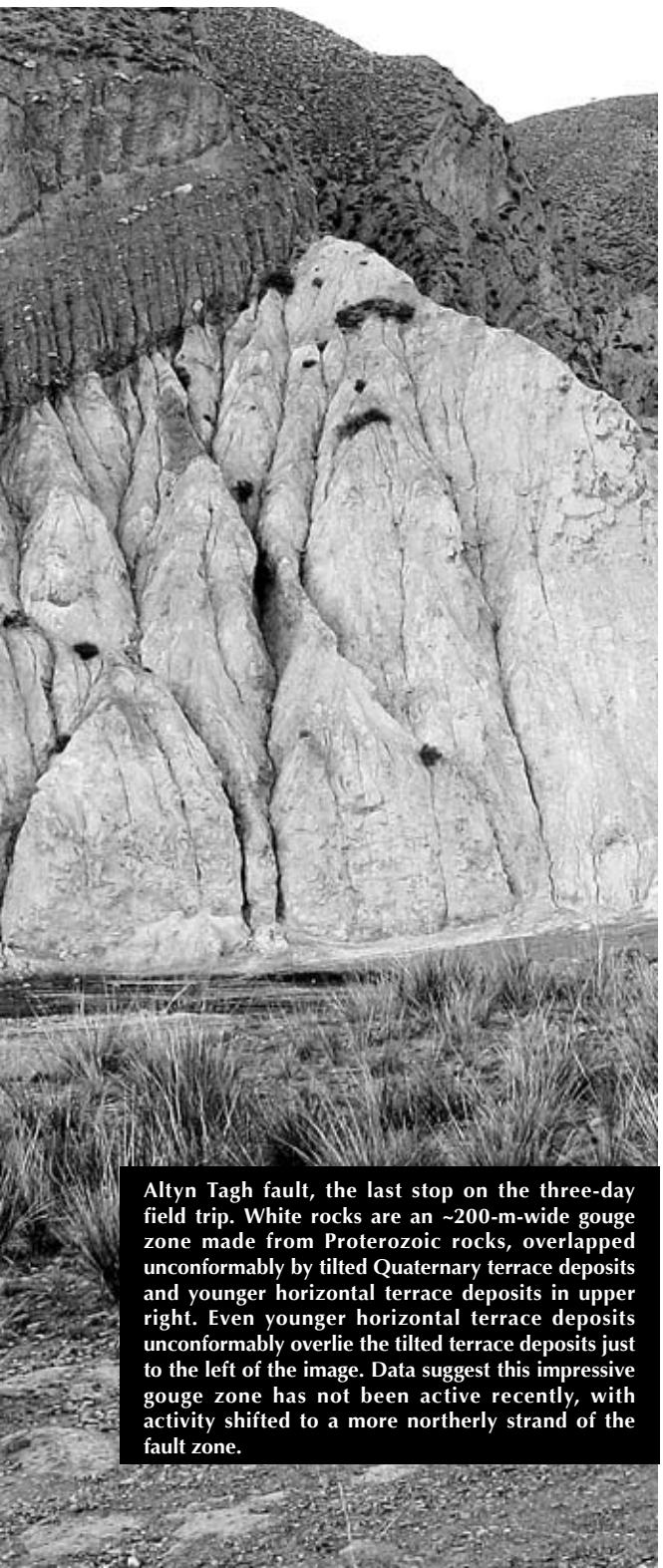


Altyn Tagh fault, the last stop on the three-day field trip. White rocks are an ~200-m-wide gouge zone made from Proterozoic rocks, overlapped unconformably by tilted Quaternary terrace deposits and younger horizontal terrace deposits in upper right. Even younger horizontal terrace deposits unconformably overlie the tilted terrace deposits just to the left of the image. Data suggest this impressive gouge zone has not been active recently, with activity shifted to a more northerly strand of the fault zone.

Xining, Qinghai Province, People's Republic of China, was the site of the International Conference on Continental Dynamics and Environmental Change of the Tibetan Plateau, 18–21 June 2006. A field trip from Xining to Dunhuang on 22–24 June followed. The meeting, sponsored by the Chinese Academy of Sciences, the Province of Qinghai, and the Geological Society of America, marks a milestone as the first conference cosponsored by GSA in China. Short introductions of welcome by Hu Xian Lai, secretary general of Qinghai Province; Jack Hess, GSA executive director; B.C. Burchfiel, co-chair of the scientific committee; and Erchie Wang, conference secretary general, opened the meeting, which attracted 96 participants, 31 from outside China. The diversity of papers and backgrounds of the participants led to an extraordinary experience for sharing data and ideas and discussing a broad range of interpretations, incorporating the many subdisciplines of the earth sciences focused on understanding the processes of Tibetan plateau evolution.

Xining lies within one of the many nonmarine Cenozoic basins bounded by mountain ranges of pre-Cenozoic rocks that form part of a Cenozoic deformational province currently being incorporated into the Tibetan plateau. Thus, Xining was a perfect venue for the conference. Xining also lies close to a transition between the large Qsidam basin and linear Qilian Shan ranges to the west and the smaller arcuate mountain ranges enclosing rhomb-shaped basins to the east.

Meeting presentations encompassed a wide range of topics, including tectonics, sedimentation, petrology, geodesy, geophysics, dynamic modeling, magmatism, and climatic change. Only a sampling is presented here.

Tectonic presentations covered many different subjects. Recent work by Eric Kirby and colleagues was presented to show that the slip rate on the Kunlun fault, one of the major active left-lateral faults in the northern part of the Tibetan plateau, decreases systematically along its eastward trace from >10 mm/yr to <2 mm/yr, and the fault terminates within the thickened crust of the plateau. Spatial variations in displacement and displacement rate may exist along other major strike-slip fault systems, and Kirby cautioned extrapolating a single rate to intracontinental faults. On a larger scale, Mark Harrison suggested that the interpretation of widespread shallow anatexis beneath southern Tibet is inconsistent with numerous observations. Harrison further suggested that models involving metamorphism of clastics on the leading edge of India via thrust imbrication to form the Greater Himalayan Crystallines followed by exhumation by thrust-induced erosion explain just as well the observed pattern of thermochronological and thermobarometric results as do more recently popular models of focused surface denudation coupled with ductile channel flow. The presentation elicited considerable discussion.

Zhang Peizhen presented a summary of evidence that compared short-term global positioning satellite data and longer-term data from neotectonic studies that indicated that these data differ significantly from plate-like models that require large slip rates of 20–30 mm/yr along major block

bounding strike-slip faults. He further suggested that present-day tectonics in the Tibetan Plateau are best described as the result of deformation on a network of faults that in turn result from deformation within a continuous medium at depth. An Yin and colleagues showed unexpected south-vergent thrusting within the Kunlun Mountains south of the western Qsidam basin, interpreted as tectonic wedging beneath the Kunlun lying above a possible regional décollement that extends beneath the Qsidam basin and the Qilian Shan to the north. This interpretation supports a hypothesis of significant out-of-sequence thrusting and growth of the plateau, as opposed to the progressive northward propagation of plateau development.

Geophysical presentations also covered a wide range of subjects. Rob van der Hilst presented preliminary tomographic data from a broadband network in the SE part of the Tibetan plateau and its foreland that showed unexpected results. As was expected, the SE part of the plateau shows slow wave speeds at 100 km depth with a low velocity zone in the lower and middle crust. However, slow wave speeds that extend east to Hainan Island are separated from slow wave speeds in the SE Tibetan plateau by a zone of high wave speeds extending from the Sichuan basin southwest to the area east of the eastern Himalayan syntaxis and Indo Burman subduction zone. These results, if corroborated by ongoing studies, suggest a possible separation in lithospheric tectonics between Tibetan and Pacific realms.

Gao Rui and colleagues summarized the lithospheric structure beneath the Song Pan Ganze area from recent seismic and aeromagnetic studies. Among the several interesting features they presented were a poorly reflective upper crust but a highly reflective lower crust and a well-defined Moho at a depth of from 49.5 km in the south to 54 km in the north. The line of section crossed the Zoige basin, the basin in which the Yellow River makes a hairpin bend on the plateau and whose origin remains difficult to explain. Results of the aeromagnetic study showed the entire Song Pan Ganze tectonic unit to be characterized by a low, almost smooth, magnetic signature that extends well into the Yidun arc to the south and is distinct from all surrounding tectonic units, with complex short wavelength highs and lows.

Mo Xuanxue and colleagues presented an analysis of latest Cretaceous to late Neogene magmatism in the Tibetan plateau that suggests that the magmatic contribution is important to the crustal thickening process. The process was not uniform, and they recognized three major periods of thickening. They estimated that the mantle contribution to the total thickness of the Tibetan crust was about 30%, with the remainder due to tectonic thickening.

Xu Jifeng and colleagues interpreted that Cenozoic magmatic products were derived from lower crustal sources, rather than from the lithospheric mantle. They recognize two suites of volcanic rocks from the Qiantang Province derived by melting from the lower crust at 45–40 Ma and 3–6 Ma. The early episode is interpreted to be related to melting of thick, eclogitic lower crust that was delaminated to produce melting, whereas the younger episode of melting was related to regional extension—thus, a change in heat sources during plateau evolution.

Detailed magnetostratigraphy from Eocene-Oligocene rocks in the Xining basin by Guillaume Dupont-Nivet showed that a distinct change from playa-lake to a dry playa depositional environment indicates that aridification correlated precisely with the isotopic shift in the marine record (Oi-1 event) between 33.6 and 34 Ma. Their study illustrates the principle that global climate drivers should first be eliminated using high-resolution chronostratigraphy before mountain uplift can be considered as a cause for sedimentary signatures—notoriously ambivalent when deciphering between uplift and climate. Yao Tangdong and colleagues' study of glacial retreat under the impact of climatic warming indicated that retreat has been continuous with a negative glacial mass balance in the recent several decades and very intensive in the past 10 years. The retreat in the 1990s caused an increase of 5.5% in river runoff in NW China and higher than 5.5% in the Tarim River basin.

Xiaomin Fang and colleagues presented a detailed magnetostratigraphic, paleontological, and sedimentological investigation of three of the rhombic-shaped basins in the NE part of the evolving Tibetan plateau. Their data are interpreted to record a flexural subsidence history for the Linxia and probable joint Gonhe-Guide-Xining-Minghe basins starting ca. 33–30 Ma and accelerating ca. 22–21 Ma, followed by rapid deformation and uplift of the plateau after 8 Ma, with the most intensive and significant uplift ca. 3.6 and 1.8 Ma. Meng Qingren presented an overview of the sedimentary and tectonic evolution for the Qsidam basin that revealed that the northern Tibetan plateau expanded by means of stepwise propagation of separate fold-thrust belts, with simultaneous development of intervening basins. The Qsidam basin originated by fragmentation from the Tarim basin, while other smaller basins behaved as piggyback basins. Subsequent deformation of sediments should cause the basins to evolve into folded domains that become integrated into the Tibetan plateau.

A break in presentations permitted a one-day field trip from Xining south into Guide basin, one of the rare basins incised by the Yellow River into its basement. Structure within the basin indicates transpression took place from the late Miocene, developing smaller subbasins that are well exposed because of the extensive incision and erosion by the Yellow River and its tributaries. Unexpectedly, an apparently large normal fault was discovered in the southern part of the basin that remains difficult to explain.

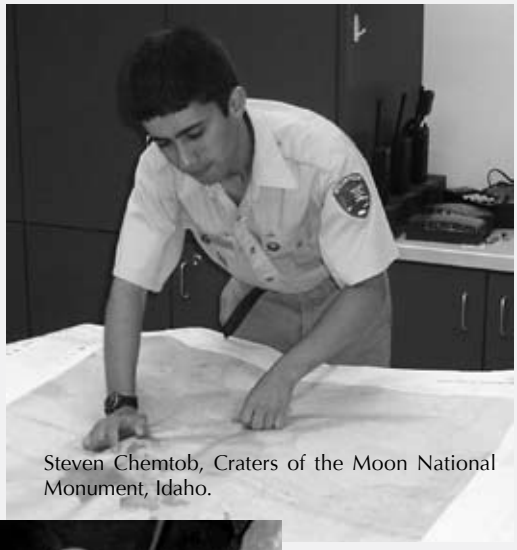
A three-day field trip from Xining to Dunhaung followed the formal meeting. The trip passed through rocks of Precambrian to Quaternary age and several different Cenozoic basins exposing the Cenozoic sections, structure, and morphology of these young and still active basins. The first day passed through the Laji Shan, the range separating the Xining and Guide basins. The Laji Shan comprises a complex suite of rocks related to an accretionary complex of early Paleozoic age, including ophiolitic rocks that were seen on day three to contain ultrahigh-pressure (UHP) rocks. The second day focused on the NW-striking Wenquan (or E'la Shan) fault and its transfer character, which at its north end merges into the Wulan thrust fault. Day three focused on the active mountain ranges of the Qilian Shan and their thrust margins, vergent both to the south and north. Two exposures of UHP and eclogitic rocks occur in these ranges. The final stop was at the Altyn Tagh fault (see photo), where an ~200-m-wide gouge zone is unconformably overlain by young river terraces, indicating no recent displacement on the fault at this locality. ■

Thank You

2006 GeoCorps America™ Participants!

The GeoCorps America™ program places GSA Members in summer positions across the United States to assist National Parks, National Forests, and the Bureau of Land Management (BLM) with geoscience projects. This year, GSA offered 41 positions in some of the most beautiful places in the country. Check the GeoCorps Web site, **www.geosociety.org/geocorps,** for a full list of the parks, forests, and BLM lands where we work. *Positions for 2007 will be posted on 4 December 2006.*

GSA recognizes the outstanding contributions to the GeoCorps America program this year by the Members listed here. With the help of these individuals, the National Park Service, the U.S. Forest Service, and the BLM were able to complete necessary geoscience projects to reach their land management goals.



Steven Chemtob, Craters of the Moon National Monument, Idaho.

Melissa Hendrickson, Tongass National Forest, Alaska.

Alan Watchman, Bureau of Land Management Gunnison Gorge National Conservation Area, Colorado.

Benjamin Brulet, Craters of the Moon National Monument, Idaho

Tanya Blacic, Lava Beds National Monument, Calif.

Heidi Faris, Rocky Mountain National Park, Colo.

Lynda Nicholson, Grand Canyon National Park N. Rim, Ariz.

Paul Mayer, Grand Canyon National Park S. Rim, Ariz.

Peter Mueller, White Sands National Monument, N.Mex.

Steven Chemtob, Craters of the Moon National Monument, Idaho

Mary Schubert, Oregon Caves National Monument, Ore.

David Shean, Yellowstone National Park, Wyo.

Elizabeth Copeland, Glacier National Park, Mont.

Christine Ruhl, Capulin Volcano National Monument, N.Mex.

Alicia Rosales, Oregon Caves National Monument, Ore.

Jane Darbyshire, Petrified Forest National Park, Ariz.

Nicole Reynaud, Fossil Butte National Monument, Wyo.

Nichole Knepprath, Mount Rainier National Park, Wash.

Jennifer Fisher, Bryce Canyon National Park, Utah

Susanne Tomsich, Denali National Park, Alaska

Alyson Cartwright, Petrified Forest National Park, Ariz.

Rachel Grandpre, Dinosaur National Monument, Colo.

Cherith Janes, Sleeping Bear Dunes National Lakeshore, Mich.

Rachel Brown, Grand Canyon National Park S. Rim, Ariz.

James Kirby, Gateway National Recreation Area, N.Y.

Kevin Hobbs, Denali National Park, Alaska

Ryan Jakubowski, Sierra National Forest, Calif.

Lauren Perreault, Idaho Panhandle National Forest, Idaho

Sunny Simpkins, Gallatin National Forest, Mont.

Chelsea Wood, Arapaho Roosevelt National Forest, Colo.

John Moore, San Bernardino National Forest, Calif.

Robert Anderson, Idaho Panhandle National Forest, Idaho

Deb Stringham, Intermountain Regional Office, Utah

Chelsa Leven, Nez Perce National Forest, Idaho

Melissa Hendrickson, Tongass National Forest, Alaska

Katherine Spencer, Gallatin National Forest, Mont.

Scott Bennett, Ozark St. Francis National Forest, Ark.

Corinne Wong, Tongass National Forest, Alaska

Andrew Argeski, Nez Perce National Forest, Idaho

Kathleen Mackie, BLM San Juan Public Lands Center, Colo.

Alan Watchman, BLM Gunnison Gorge National Conservation Area, Colo.

Ryan McKenna, BLM Royal Gorge Resource Area, Colo.

Katharine Magary, BLM Black Rock Desert High Rock Canyon National Conservation Area, Nev.

Scott Richardson, BLM Grand Staircase–Escalante National Monument, Utah

Memories from GSA GeoVentures™ Summer Travels

Iceland for teachers, 23–30 July 2006

Hawaii for teachers, 8–14 July 2006

Colorado, 17–22 June 2006

GeoVenture tours are wonderful ways to travel and learn about the science you are interested in. Brush up on your world geography and geology by joining us each year on fabulous trips around the world!

GeoVentures 2006 included trips to Colorado, Hawaii, and Iceland.

SAVE THE DATE!

Grand Canyon River Trip in 2007

GSA's GeoVentures™ offers a trip down the Colorado River on 2–9 June 2007. Expert Grand Canyon geologist, Wayne Ranney, will host us down the river for six nights and seven days of geologic wonders!

Participants on this trip will learn about the rich and varied ideas concerning the Grand Canyon's origin, both depositional and erosional. Traveling by boat down the river allows up-close-and-personal sequential observation of all the named rock formations.

Mark the date and plan to join us! More information will be coming soon. Check the GeoVentures Web site, **www.geoventures.org,** for details and sign up for E-news to get automatic updates.

Classified Rates

Ads (or cancellations) must reach the GSA Advertising office one month prior to issue. Contact Advertising Department: advertising@geosociety.org; +1.800.472.1988 x1053; +1.303.357.1053. Complete contact information, including mailing and email address, must be included with all correspondence.

Classification	Per Line for 1st month	Per line each addt'l month (same ad)
Situations Wanted	$2.75	$2.40
Positions Open	$7.50	$6.50
Opportunities for Students		
First 25 lines	$0.00	$3.35
additional lines	$2.35	$3.35

To estimate cost, count 54 characters per line, including all punctuation and blank spaces. Actual cost may differ if you use capitals, centered copy, or special characters.

Positions Available

TENURE TRACK POSITION IN MARINE GEOLOGY
SAN FRANCISCO STATE UNIVERSITY

The Department of Geosciences at San Francisco State University invites applications for a tenure-track faculty position at the assistant professor level in marine geology, beginning August 2007. The position requires a Ph.D. in geology or a closely related field, and a strong commitment to excellence in teaching and research at the graduate and undergraduate levels. The ideal candidate will have an interdisciplinary background and be able to teach courses relevant to all our degree programs (B.S. in Geology, B.A. in Earth Sciences, B.S. in Atmospheric and Oceanic Sciences and M.S. in Applied Geosciences).

We prefer a marine geoscientist with expertise in the general area of coastal processes. Possible areas of focus include coastal response to changes in sediment transport patterns caused by human activities or natural events such as sea-level change or storms, coastal and marine slope stability and landslides, wetland and estuarine processes, and hazards caused by tsunami or earthquakes. A background in geophysics, physical oceanography, and/or paleoclimatology would be desirable. The successful applicant will need to maintain an externally funded research program that involves graduate and undergraduate students. Salary for this position is to be negotiated and is commensurate with experience.

The Department of Geosciences includes programs in geology, meteorology, and oceanography and currently has approximately 50 undergraduate majors, 20 M.S. students and 11 tenured/tenure track faculty members. Department of Geosciences faculty and students have full access to the facilities of Romberg Tiburon Center (RTC), the University's marine field station located 30 minutes north of San Francisco. RTC is the only academic research facility situated on San Francisco Bay, the largest estuary on the west coast of the United States.

San Francisco State University, a large urban university, is part of the 23-campus California State University system and serves a diverse student body in liberal arts, sciences, and professional programs. The mission of the University is to maintain an environment for learning that promotes an appreciation of scholarship, freedom, and human diversity; fosters excellence in instruction and intellectual accomplishment; and to provide broadly accessible higher education. SFSU faculty are expected to be effective in teaching; to demonstrate professional achievement and growth through continued research, publications, and/or creative activities; and to contribute their academic expertise and leadership to the campus and community.

To apply, send a curriculum vitae, a statement of teaching and research interests, and three letters of reference to Dr. Oswaldo Garcia, Chair, Dept. of Geosciences, San Francisco State University, San Francisco, CA 94132. Dr. Garcia can be contacted by phone at +1-415-338-1778 and by e-mail at ogarcia@sfsu.edu. Applications should be received before 22 December 2006. San Francisco State University is an Equal Opportunity/Affirmative Action employer.

TENURE TRACK FACULTY POSITION
GEOBIOLOGY, MIAMI UNIVERSITY

The Department of Geology at Miami University invites applications for a tenure-track faculty position at the Assistant Professor level, beginning August 2007. Applicants must have a Ph.D. degree at the time of appointment. The successful applicant will be expected to teach effectively at the undergraduate and graduate levels, supervise student research at the undergraduate, M.S. and Ph.D. levels, initiate and maintain a vigorous, externally-funded research program, and provide service to the university.

We seek an outstanding candidate who is undertaking significant field and/or laboratory-based research in Geobiology. The particular research emphasis, for example high-resolution biostratigraphy, paleobiology/paleontology, paleoecology, paleobiogeochemistry, or paleoclimatology, should complement current program strengths indicated below. It is anticipated that this new position will expand our interdisciplinary research and teaching capabilities and will enable us to address important questions pertaining to the interactions between life and Earth systems through geologic time.

The successful applicant will join an active department that consists of ten faculty members, four research/technical staff members, forty undergraduate and twenty-five graduate students. The department maintains active research programs in geomicrobiology, geomorphology, geophysics, hydrogeology, igneous petrology, isotope geochemistry, low-temperature geochemistry, mineralogy, paleoclimatology, sedimentology and stratigraphy, structural geology, tectonics, volcanology, and Quaternary geology. The department also maintains modern teaching, research, and instrumentation laboratories, and portable instrumentation in support of the above specialties. Please visit www.muohio.edu/geology for additional information.

Miami University, with 16,000 students, is located in a small-town setting adjacent to a rapidly growing suburban corridor between Cincinnati and Dayton. Interested candidates should submit a packet containing a letter of application, curriculum vitae, statement of teaching and research objectives and accomplishments, transcripts, and arrange three letters of reference to be sent to: Geobiology Search Committee, Department of Geology, Miami University, 114 Shideler Hall, Oxford, OH 45056 (fax: +1-513-529-1542). Review of applications will begin on 27 November 2006 and will continue until the position is filled.

Miami University is an affirmative action/equal opportunity employer. Women and minorities are encouraged to apply. For information regarding campus crime and safety, visit www.muohio.edu/righttoknow.

UNIVERSITY OF ARKANSAS
TENURE-TRACK ASSISTANT PROFESSOR
GEOSCIENCES

The Department of Geosciences, University of Arkansas–Fayetteville invites applications for a 9-month appointment tenure-track assistant professor position with an anticipated start date of August 2007. We are seeking an outstanding individual with expertise in geochemistry to take advantage of newly funded low and high resolution ICP-MS at UA, with emphasis on analysis of terrestrial and extra-terrestrial materials. The applicant must demonstrate ability for independent research and potential for collaboration with existing research programs in the Department of Geosciences (www.uark.edu/depts/geology) and the Arkansas Center for Space and Planetary Sciences (http://spacecenter.uark.edu). The successful applicant is expected to develop an externally funded research program, and teach courses within the Department of Geosciences and the Space and Planetary Sciences Program.

Review of applications will begin 15 November 2006 and will continue until the position is filled. Applicants should submit their curriculum vitae, statement of research and teaching plans and objectives, and names, addresses and contact information for at least three professional references to: Dr. Ralph K. Davis, Search Committee Chair, Department of Geosciences, 113 Ozark Hall, Fayetteville, AR 72701.

The University of Arkansas is a nationally competitive student-centered research university located in Fayetteville, Arkansas. The Department of Geosciences offers baccalaureate and masters degrees in geology and geography, and is a primary participant in two interdisciplinary graduate programs, Space and Planetary Sciences and Environmental Dynamics, providing opportunity for supervision of Ph.D. and MS students. Fayetteville, nestled in the Ozarks of Northwest Arkansas, is part of a metropolitan area of about 360,000 people that retains its small college town atmosphere. It is the sixth fastest growing metropolitan area in the U.S. spurred by opportunities with national companies including Wal-Mart, Tyson Inc., and J.B. Hunt trucking. The quality of life is high and it's a great place to work, play and raise a family.

The University of Arkansas is an Affirmative Action/Equal Opportunity Employer and applications will be accepted without regard to age, race, color, sex, or national origin. Applicants must have proof of legal authority to work in the United States at the time of the appointment. Women and minorities are encouraged to apply. All applicants are subject to public disclosure under the Arkansas Freedom of Information Act.

ASSISTANT PROFESSOR OF EARTH SCIENCES
9-MONTH BEGINNING FALL 2007
UNIVERSITY OF NORTH CAROLINA–CHARLOTTE

The Department of Geography and Earth Sciences at the University of North Carolina Charlotte seeks to fill a tenure-track Assistant Professor of Earth Sciences. Required qualifications are: (1) Ph.D. in geology, earth sciences, physical geography or a related discipline by 10 August 2007; (2) research and teaching specialization in hydrogeology; (3) an individual who has an established record in or shows the potential of creating an aggressive externally funded program in field-based hydrogeologic research. The specific area of research is open but one or more of the following interests would be desirable: aqueous flow in porous media or fractured reservoirs; groundwater/surface water interactions; contaminant transport and reactions on a range of scales; geochemistry of vadose and near-surface fluid systems; hydrologic consequences and impacts of climate variability and climate change.

This faculty member will teach graduate and undergraduate courses in his or her specialty, and will be responsible for maintaining a rigorous applied introduction to hydrogeology in an undergraduate curriculum that includes degree tracks in geology, earth sciences, and meteorology. All faculty also cooperate in occasionally teaching introductory earth sciences courses in the general curriculum. The Department of Geography and Earth Sciences offers an M.S. program in earth sciences and an interdisciplinary Ph.D. in Infrastructure and Environmental Systems and the successful candidate will be expected to be an active participant in both programs.

The Department, the College of Arts and Sciences and the University of North Carolina Charlotte are strongly committed to creating and maintaining a community in which all students, staff and faculty can work, learn and live in an environment of respect and support. We welcome applications that help us achieve these goals.

Review of applications will begin 15 November and continue until the position is filled. Send (1) a letter of application describing teaching and research interests, (2) a full curriculum vita, and (3) three letters of reference to Dr. Gerald L. Ingalls, Chair, Department of Geography and Earth Sciences, University of North Carolina at Charlotte, 9201 University City Boulevard, Charlotte, NC 28223-0001. AA/EOE

GEOCHRONOLOGY—UNIVERSITY OF KANSAS

The Department of Geology at the University of Kansas seeks applications for an academic year, tenure-track faculty member in the field of geochronology. We are seeking an individual with expertise in tectonic or petrological applications of high to moderate temperature geochronology and analytical methods (e.g., TIMS, MC-ICP-MS, etc.) who will complement existing programs in tectonics, petrology, and geo- and thermochronology. The successful candidate will be expected to establish an externally funded research program, direct graduate students, and participate in teaching at graduate and undergraduate levels, including courses in the fields of geochronology, petrology, and isotope geochemistry. Refer to www.geo.ku.edu and links for additional information about our department and the University of Kansas. Appointment will begin 18 August 2007, with a later starting date possible.

Applicants must have a completed Ph.D. degree by the starting date. A letter of application outlining research and teaching interests, a complete resume, and names and contact information of at least three persons, who can be contacted for letters of reference, should be sent to Dr. Daniel Stockli, Department of Geology, University of Kansas, 120 Lindley Hall, 1475 Jayhawk Blvd., Lawrence, KS 66045 (tel. +1-785-864-7714, fax +1-785-864-5276, e-mail: stockli@ku.edu). Review of complete application will begin on 20 December 2006, and will continue until the position has been filled. EO/AA employer. The University is committed to increasing the ethnic and gender diversity of its faculty, and we strongly encourage women and minority candidates to apply.

COLBY COLLEGE
VISITING ASSISTANT PROFESSOR OR
INSTRUCTOR OF GEOLOGY
MINERALOGY/GEOCHEMISTRY

The Department of Geology invites applications for a one-year, non-tenure track, Visiting Assistant Professor or Instructor in mineralogy with complementary exper-

tise in either geochemistry, diagenesis, or petrography/petrology beginning 1 September 2007. The successful applicant will be expected to teach five undergraduate courses including: a 200-level Mineralogy with laboratory during Spring 2008 and an upper division laboratory course of his/her choice for geology majors in Fall 2007. The upper division course is an elective and should complement those presently offered in the department. The remainder of the teaching assignment will focus on course offerings for potential majors and non-majors. Additionally, the candidate may have the opportunity to direct one or more independent research projects. Colby is a highly selective liberal arts college recognized for excellence in undergraduate education and for close student-faculty interaction. Ph.D. with teaching experience at time of employment preferred; ABDs encouraged to apply. Applicants should submit a letter of application, curriculum vitae, transcripts, statement of teaching and research Interests, and three letters of reference to Dr. Robert A. Gastaldo, Chair, Department of Geology, 5807 Mayflower Hill Drive, Waterville, ME 04901. Review of applications will begin on 15 December 2006 and will continue until the position is filled. Colby is an Equal Opportunity/Affirmative Action employer, committed to excellence through diversity, and strongly encourages applications and nominations of persons of color, women, and members of other underrepresented groups. For more information about the College, please visit the Colby Web site: www.colby.edu.

UNIVERSITY OF WYOMING
DISTINGUISHED PROFESSORSHIP, GEOPHYSICS

The Department of Geology and Geophysics at the University of Wyoming invites applications for a Distinguished Professor of Geophysics. This is an Endowed Chair position in the Department and in the newly created School of Energy Resources (SER) at the University of Wyoming, an institute dedicated to energy-related teaching and research in support of state, national, and international energy-related activities. This appointment may be made at any rank, including Associate and Full Professor. The position can begin as soon as 1 July 2007.

We seek an individual who directs an internationally recognized, externally funded research program in reservoir imaging using 3-D seismic technology and/or reservoir characterization using petrophysical techniques. The successful candidate will be involved in the undergraduate and graduate teaching mission of the Department of Geology and Geophysics, and will complement and expand on departmental strengths not only in geophysics, but also in areas including structural geology/tectonics, sedimentary geology, and environmental geology. We seek a person with the ability to cooperate productively with other SER professors in geology and geophysics, mathematics, chemical and petroleum engineering, economics, and other energy-related fields. The SER is an ambitious, new state-funded institute that requires innovative, forefront researchers with the ability to produce benefits tangible to SER stakeholders and supporters. Information about the School of Energy Resources is available at_uwyo.edu/SER. Additional information on the Department Geology and Geophysics can be obtained at http://home.gg.uwyo.edu/.

Applications should include a statement of research and teaching interests and accomplishments, curriculum vitae, and the names and contact information for three individuals who can provide letters of evaluation. Review of completed applications will begin immediately upon receipt; however, applications will be accepted until the position is filled. Send an electronic copy of your application to: Ms. Carol Pribyl at cpribyl@uwyo.edu; if you have additional application materials to send, please direct them to the Geophysics Search Committee, Department of Geology and Geophysics, University of Wyoming, 1000 East University Avenue, Dept. 3006, Laramie, WY 82071-2000.

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

COLBY COLLEGE
VISITING ASSISTANT PROFESSOR OR INSTRUCTOR OF GEOLOGY
STRUCTURE/GEOPHYSICS

The Department of Geology invites applications for a one-year, non-tenure track, Visiting Assistant Professor or Instructor in structure/tectonics and geophysics/remote sensing, beginning 1 September 2007. The successful applicant will be expected to teach five undergraduate courses including a 200-level Structural Geology with laboratory during Fall 2007 and an upper division laboratory course of his/her choice for geology majors in Spring 2008. The upper division course should complement those already offered in the department. The remainder of the teaching assignment will focus on course offerings for potential majors and non-majors. Additionally, the candidate may have the opportunity to direct one or more independent research projects. Colby is a highly selective liberal arts college recognized for excellence in undergraduate education and for close student-faculty interaction. Ph.D. with teaching experience at time of employment preferred; ABDs encouraged to apply. Applicants should submit a letter of application, curriculum vitae, statement of teaching and research Interests, and three letters of reference to Dr. Robert A. Gastaldo, Chair, Department of Geology, 5807 Mayflower Hill Drive, Waterville, ME 04901. Review of applications will begin on 19 January 2007 and will continue until the position is filled. Review of applicants will begin immediately thereafter. Colby is an Equal Opportunity/Affirmative Action employer, committed to excellence through diversity, and strongly encourages applications and nominations of persons of color, women, and members of other underrepresented groups. For more information about the College, please visit the Colby Web site: www.colby.edu.

CONCRETE MICROSCOPIST/PETROGRAPHER
CTLGROUP

CTLGroup, a major consulting engineering and scientific firm with full-service testing laboratories for all construction related materials, has a new position for a geologist with 2+ years work experience with optical microscopy. Will be involved with the examination of cement, concrete, and aggregates and some field work and field sampling of construction materials. Also includes preparation of samples for petrography and microscopy analysis, interpretation of observations and data, and preparation of reports and proposals. The ideal candidate will have basic knowledge of concrete and related materials, an M.S. degree in geology or related field, (or B.S. and 3 years work related experience), has excellent written and oral communication skills and computer skills. Works well in team environment and with clients, in person and on the phone, and has the ability to handle multiple projects simultaneously.

CTLGroup offers excellent benefits and competitive salary. Start the process of mutual consideration by sending your resume with cover letter indicating your interest and qualifications to: Ethel Doyle, Human Resources, EDoyle@CTLGroup.com; fax: +1-847-965-0859; address: 5420 Old Orchard Rd., Skokie, IL 60077. EOE/m/f/d/v.

GEOLOGICAL SCIENCES, SUNY–GENESEO

The Department of Geological Sciences, SUNY–Geneseo, solicits applications for a tenure-track position at the Assistant Professor level. Teaching responsibilities include large and small-enrollment introductory-level courses, as well as upper-level courses in surface processes (including Geomorphology) and electives that will complement those offered by current faculty. General areas of expertise at present are mineralogy/petrology, paleontology/stratigraphy, structural geology/geophysics, geomorphology/glacial geology/remote sensing, and hydrology/geochemistry. The Department consists of six faculty members and approximately 50 geology majors, 70% of who continue to graduate schools. The Geological Sciences Department shares a brand new 106,000 square-foot building with Biology.

We seek a dynamic individual who is committed to sustaining an outstanding undergraduate program in the geological sciences. The successful candidate will be expected to foster the departmental culture of excellence in teaching in both introductory and majors' courses, active research, engagement of undergraduates in research projects, as well as guiding and mentoring students. A Ph.D. is required. We seek a colleague who is devoted to undergraduate education, has demonstrated a potential to achieve excellence in teaching, an interest in establishing a research program involving undergraduates that results in peer-reviewed publications, a willingness to take an active role in departmental field experiences, and enthusiasm for departmental, college, and public service. Special consideration will be given to candidates with any or all of the following: field-based skills, lake studies, glacial geology, sedimentation, oceanography, GIS competence, and interest in participating in a college-wide writing seminar for freshmen.

SUNY–Geneseo is highly selective and is consistently rated among the top public universities in the north by U.S. News & World Report. Located in the national historic landmark village of Geneseo, the residential campus overlooks the picturesque Genesee Valley, just 30 miles south of the major metropolitan area of Rochester and 70 miles east of Buffalo. SUNY–Geneseo is a member of the Council of Public Liberal Arts Colleges, a national alliance of leading liberal arts colleges in the public sector.

To apply candidates should submit an online faculty application by 1 December 2006 at http://jobs.geneseo.edu and attach a letter of interest addressing their qualifications for the position, curriculum vitae, a statement of teaching interests and philosophy, a statement of research interests in the context of undergraduate education, evidence of effective teaching, copies of college transcripts (unofficial acceptable), and arrange to have three recent letters of reference sent to: Dr. Richard B. Hatheway, Chair. Department of Geological Sciences, One College Circle. State University College at Geneseo, Geneseo, NY 14454.

Review of applications will begin 1 December 2006 and continue until the position is filled. SUNY–Geneseo is an affirmative action/equal opportunity employer committed to recruiting, supporting, and fostering a diverse community of outstanding faculty, staff, and students.

FACULTY POSITION: PHYSICAL SCIENCE–GEOSCIENCE–ENVIRONMENTAL SCIENCE
HAROLD WASHINGTON COLLEGE

Position Information: The physical sciences department at Harold Washington College, one of the City Colleges of Chicago, invites applications for a tenure-track faculty position in Physical Science–Geoscience–Environmental Science. Candidates must have at least a Master's Degree in Geochemistry, Earth Sciences, Environmental Sciences, Physical Sciences or a related discipline. Candidates should demonstrate successful experiences in curricular and teaching innovation, program development, instructional technology, and other educational initiatives that promote active learning. Candidates should also demonstrate a commitment to on-going professional development in their subject area and in the teaching/learning process.

The City Colleges of Chicago is an equal opportunity employer. Chicago residency is required within six months of hire for all full-time positions.

Application Information: Please send resume or curriculum vitae to: Search Committee, Physical Science Department, Harold Washington College, 30 E. Lake Street, Chicago IL 60601; fax: +1-312-553-5786.

TENURE-TRACK FACULTY POSITION
IN STRUCTURAL GEOLOGY
UNIVERSITY OF WISCONSIN–EAU CLAIRE
BEGINNING 20 AUGUST 2007

A Ph.D. in structural geology or a closely related discipline is required at the time of appointment. Preference may be given to individuals with substantial field experience and demonstrated success in teaching undergraduates. Development of a vigorous research program involving undergraduate students is expected.

Applications include a letter describing interest and qualifications for the position along with a curriculum vitae, three letters from professional references and unofficial copies of university transcripts. Send applications electronically (PDF files or MS-word attachments strongly preferred) to GeologyHire@uwec.edu. Arrangements should be made to have three letters of recommendation sent either electronically (PDF files) or by mail directly from your references. Review of completed applications will commence 15 December 2006 and continue until the position is filled.

For a complete position description, call +1-715-836-3732 or visit www.UWEC.edu/Geology. UW–Eau Claire is an AA/EEO employer and encourages applications from women and minorities.

TENURE TRACK POSITION—GEOPHYSICS
BOSTON UNIVERSITY

The Department of Earth Sciences at Boston University invites applications for a tenure track position in Solid Earth Geophysics, starting 1 September 2007. We seek an applicant in research areas across a range of subdisciplines, including global-scale earth structure, numerical or experimental solid-earth geodynamics, or crustal geophysics.

The successful applicant will be expected to supervise graduate research in M.A. and Ph.D. programs, maintain an externally funded research program, and teach at all levels in the Earth Sciences curriculum. The research should complement departmental expertise in seismology, rock physics, geochemistry, and surface processes. Interaction is encouraged with allied departments including Geography & Environment, Chemistry, and Physics, as well as the Center for Remote Sensing and the B.U. Marine Program. For more information about the Department, see www.bu.edu/es. A Ph.D. at the time of appointment is required.

Applicants should send a curriculum vitae, a statement of research and teaching interests, and the names and addresses of at least three referees to: Search Committee Chair, Department of Earth Sciences, Boston University, 675 Commonwealth Ave., Boston MA 02215, USA; email: earth@bu.edu. Review of applications will begin on 17 November 2006. Women

and underrepresented minorities are particularly encouraged to apply. Boston University is an Equal Opportunity/Affirmative Action employer.

ASSISTANT PROFESSOR
ORGANIC CARBON DYNAMICS
BOSTON UNIVERSITY

The Department of Earth Sciences at Boston University invites applications for a tenure track assistant professor position in Organic Carbon Dynamics, starting 1 September 2007. We seek an applicant whose research emphasizes the dynamics of organic carbon in marine and/or aquatic environments. Potential fields of study might include organic carbon cycling at river-dominated ocean margins; interactions within and among estuarine, coastal, shelf and slope environments; development and application of biomarkers, radioisotopic and/or stable isotopic signatures of organic compounds; and linkages between the terrestrial environment and the coastal ocean. The successful applicant will be an active participant in the Boston University Marine Program and will help strengthen existing departmental programs in climate and surface processes.

The successful applicant will be expected to supervise graduate research in M.A. and Ph.D. programs, maintain an externally funded research program, and teach at all levels in Earth Sciences and Marine Sciences curricula. The faculty member will have responsibilities in both the Department of Earth Sciences and with the Marine Program. Interaction is encouraged with various departments including Biology, Geography & Environment, and Chemistry. For more information about the Department, see www.bu.edu/ES, and for the Marine Program, see www.bu.edu/bump/. A Ph.D. at the time of appointment is required.

Applicants should send a curriculum vitae, a statement of research and teaching interests, and the names and addresses of at least three referees to: Search Committee Chair, Department of Earth Sciences, Boston University, 675 Commonwealth Ave., Boston, MA 02215, USA; e-mail: earth@bu.edu. Review of applications will begin on 1 December 2006. Women and underrepresented minorities are particularly encouraged to apply. Boston University is an Equal Opportunity/Affirmative Action employer.

BATEMAN POSTDOCTORAL FELLOWSHIPS
FOR STUDY IN GEOSCIENCES
AT YALE UNIVERSITY

The Department of Geology and Geophysics announces an annual competition for one or more Bateman Postdoctoral Fellowships. We welcome applicants with research interests across the full range of disciplines within the Earth Sciences, including studies of the solid earth, oceans, atmosphere, climate dynamics, geochemistry, paleoclimatology, and the evolution of life. (See www.geology.yale.edu for more information about our department.)

This fellowship is awarded for two years, and provides a stipend ($43,000/yr) and research funds ($5,000/yr), plus health care benefits and expenses for relocation. Applicants should submit a short (2-3 page) statement of research interests and proposed research, a curriculum vita, a list of publications, and reference letters from three referees. Applicants should also contact a sponsor in the Department to identify potential research projects. The deadline for all application materials is 2 January 2007 and decisions will be announced by 28 February 2007. Successful candidates are expected to begin their program at Yale between 1 July 2007 and 30 June 2008.

Application materials and reference letters should be sent by e-mail to bateman.fellowship@geology.yale.edu or by mail to: Bateman Postdoctoral Fellowship, Department of Geology and Geophysics, P.O. Box 208109, 210 Whitney Avenue, Yale University, New Haven, CT 06520-8109. Yale University is an equal opportunity/affirmative action employer.

TENURE-TRACK POSITION IN PEDOLOGY
UNIVERSITY OF NEVADA–LAS VEGAS

The Department of Geoscience is seeking candidates for a full-time, 9-month, tenure-track appointment at the Assistant Professor level in Pedology, commencing Fall 2007. Preference will be given to candidates who conduct research in Arid Soil Processes. Duties include teaching undergraduate/graduate level courses in soil chemistry/biogeochemistry, graduate courses in their research specialty, an undergraduate introductory geoscience course, and assist in directing a large Soil Analytical Laboratory. For more information see http://geoscience.unlv.edu/. Applicant must have a Ph.D. from an accredited college or university in Soil Science or related field.

Application materials including a cover letter, curriculum vitae, proposed research plans (five page limit), statement of teaching philosophy and interests, and contact information for five referees should be addressed to: Terry Spell, Search Committee Chair and are to be submitted via online application at https://hrsearch.unlv.edu. To receive full consideration, application materials should be received by 30 November 2006. For assistance with UNLV's online applicant portal, contact Jen Feldmann at +1-702-895-3886 or hrsearch@unlv.edu.

Salary competitive; contingent upon labor market and contingent upon funding.

UNLV is an Affirmative Action/Equal Opportunity educator and employer committed to excellence through diversity.

FACULTY POSITION, SEDIMENTARY GEOLOGY
UNIVERSITY OF WISCONSIN–MADISON

The Department of Geology and Geophysics invites applications for a position as tenure-track assistant professor or associate professor, beginning August 2007. The evaluation of candidates will focus primarily on their potential for innovative scientific research and teaching. We invite applications from outstanding candidates from a variety of fields within sedimentary geology. We encourage candidates who would engage in interdisciplinary research involving our existing programs, and who would complement our current research strengths (see www.geology.wisc.edu). Petroleum industry interest is also desirable. Teaching responsibilities are at both the graduate and undergraduate level, and include field-based courses. Ph.D. required by start of appointment. Applicants should submit a resume, statement of research and teaching interests, and names of three or more references to: Sedimentary Geology Search Committee Chair, Department of Geology and Geophysics, University of Wisconsin–Madison, 1215 W. Dayton St., Madison, WI 53706-1692.

To ensure full consideration, applications must be received by 15 December 2006.

The University of Wisconsin-Madison is an equal-opportunity/affirmative action employer and encourages applications from women and minorities.

INDIANA UNIVERSITY OF PENNSYLVANIA
SEDIMENTARY GEOLOGY

The Geoscience Department at Indiana University of Pennsylvania invites applications for a tenure-track appointment at the Assistant Professor level to begin August 2007. We seek an individual who is broadly trained in the field of sedimentary geology. Preference will be given to those with experience in marine sedimentary processes or climate reconstruction. Candidates should demonstrate outstanding skill and enthusiasm for undergraduate education with emphasis on developing an active research program involving students. All applicants must be work-eligible. Applicants should send a cover letter, CV, statements of teaching and research interests, three reference letters, and copies of academic transcripts to Michael A. Poage, IUP Geoscience Dept., 114 Walsh Hall, Indiana, PA 15705-1087. Full consideration will be given to applications received by 31 January 2007. IUP is an EOE M/F/H/V and is a member of the PA State System of Higher Education. Please visit www.iup.edu/humanresources/jobline/faculty for details.

UNIVERSITY OF SOUTHERN CALIFORNIA
FACULTY POSITION IN GEOBIOLOGY

The University of Southern California seeks applicants for a tenure-track position in Geobiology at the level of assistant, associate or full professor. The University of Southern California is committed to the emerging field of Geobiology and has active research programs in earth sciences, molecular biology and marine environmental biology, all of which have strong interactions and share resources. The successful candidate is expected to establish an active research program in Geobiology with an emphasis on his/her particular area of interest. Candidates will be expected to teach courses in their home department and to take part in interdisciplinary teaching. A Ph.D. in earth sciences, biology, chemistry, or physics is required. Postdoctoral experience is encouraged.

Applicants with expertise in the following areas are particularly encouraged to apply: novel isotopic or trace element systems, microbe-mineral interaction, modeling geobiologic systems, and/or organic geochemistry.

Review of applications will begin 1 December 2006 and continue until the position is filled. The appointment will begin 16 August 2007. Applications should include curriculum vitae, statement of research interests, statement of teaching experience and interests, and the names, addresses, and e-mail addresses of at least three references.

Applicants should apply to Dr. Kenneth H. Nealson, Geobiology Search Committee Chair, c/o Dana Coyle, Department of Earth Sciences, University of Southern California, Los Angeles, CA, 90089-0740.

USC is an affirmative action/equal opportunity employer.

PETROLOGY
OBERLIN COLLEGE

Oberlin College invites applications for a full-time, tenure-track faculty in petrology. Teaching requirements include course with laboratory in igneous/metamorphic petrology. Faculty must also participate in academic advising, serve on committees, and sustain their scholarly research. Requirements: Ph.D. (in hand or by August 2007); potential excellence in undergraduate teaching; college-level teaching experience desirable. Send letter of application, curriculum vita, graduate academic transcripts, and three letters of recommendation to Steven F. Wojtal, Chair, Department of Geology, Oberlin College, Oberlin, Ohio 44074 (steven.wojtal@oberlin.edu) by 11/10/06. Late applications may be accepted until position filled. AA/EOE

GEOMORPHOLOGY, NEOTECTONICS,
OR EARTH SURFACE PROCESSES
CALIFORNIA STATE UNIVERSITY, LONG BEACH

The Department of Geological Sciences invites applications for a tenure-track position at the assistant professor level to begin Fall 2007; associate rank will be considered for exceptional candidates. A Ph.D. in Geological Sciences or Earth Sciences with a strong background in geomorphology, neotectonics, or surficial processes is required. Full Position description may be viewed at: www.csulb.edu/divisions/aa/personnel/jobs/posting/186/index.html. Review of applications will commence 24 January2007. Contact Dr. Stanley Finney, Chair, Department of Geological Sciences, California State University, Long Beach, 1250 Bellflower Blvd., Long Beach, CA 90840-3902; phone: +1-562-985-4809; fax: +1-562-985-8638; e-mail: scfinney@csulb.edu. CSULB IS AN EQUAL OPPORTUNITY EMPLOYER.

PETROLEUM GEOLOGISTS AND GEOPHYSICISTS
THE PETROLEUM INSTITUTE
ABU DHABI, UNITED ARAB EMIRATES

Positions: The Petroleum Geosciences Program of The Petroleum Institute, Abu Dhabi, United Arab Emirates (UAE), is seeking outstanding candidates to begin January 2007 or August 2007 for several possible positions. Appointment at Assistant Professor, Associate Professor, Professor, and Distinguished Professor will be considered, depending on qualifications. Ph.D. from a first-rank university is required for all positions. Teaching experience and petroleum industry experience are desirable. Experience with carbonate rock systems is also advantageous.

Geoscience Educator: Successful candidate will be primarily responsible for coordinating multiple sections of introductory geoscience, teaching introductory and other undergraduate geoscience courses as needed, and supervising undergraduate laboratories. Research opportunities exist, but research will not be a main responsibility. Ph.D. in a relevant area of geoscience and several years of university-level teaching are required. Candidates must have strong interpersonal, communication, and organizational skills. Candidates must also have a commitment to excellent teaching and have demonstrated use of modern, innovative educational methods.

Reflection Seismology: Candidates must have expertise in seismic acquisition and processing, with skills in advanced processing, seismic inversion, seismic imaging, and multi-component analysis, or in seismic interpretation, including interpretation of seismic attributes. Successful applicants for the possible position will teach undergraduate and graduate courses, develop an active research program that impacts the UAE petroleum industry, and engage in institutional service work. Opportunities exist to work with PI industry stakeholders in research.

Petrophysics–Rock Physics: Petrophysicist with experience in carbonate well log interpretation and rock physics techniques is requested. Rock physics techniques must include fluid substitution, seismic/rock physics reservoir characterization, AVO, and monitoring of recovery processes. Candidates should have good IT, data management, rock laboratory, and teaching skills. Successful applicant will be working in a multidisciplinary department with oil industry projects and teach undergraduate and graduate courses.

The petroleum geosciences will consider additional applicants, particularly in the areas of organic geochemistry, stratigraphy and sedimentology, structural geology with experience in fractured reservoirs, quantitative geologic modeling, and petroleum geology, which would support the Program's educational goals.

Salary/Benefits: Salary is competitive and com-

mensurate with qualifications and experience, with an excellent benefits package, including housing and furniture allowance, educational allowance for dependent children, annual air passages, and medical care. The UAE levies no income taxes.

Institution: The Petroleum Institute was created in 2001 with aspirations to establish itself as a world-class institution in engineering in areas of significance to the oil and gas and the broader energy industries. The Petroleum Institute's sponsors and affiliates include major oil companies, including four of the five major oil companies in the world. The campus has modern instructional laboratories and classroom facilities and is now in the planning phase of three major research centers on its campus. The Petroleum Institute is an affiliate institute with Colorado School of Mines and in the process of signing working relationships and collaborations with other major universities and research institutions around the world to capitalize on joint collaborations and research areas of interest. For additional information, please refer to the PI Web site: www.pi.ac.ae.

To Apply: Application materials must include (1) a letter of interest, which addresses the applicant's qualifications for the position; (2) a current resume; and (3) the names, email and business address, and home and business telephone numbers of at least three references. Electronic Submission is greatly preferred, and should be sent to The Recruiting Coordinator at The Petroleum Institute (recruiting-coordinator@pi.ac.ae) and submission of materials as an MS Word/PDF attachment is strongly encouraged.

Candidates are encouraged to submit an application as soon as possible and no later than 15 November 2006, although applications will be considered until vacant positions are filled.

ASSISTANT PROFESSOR–RESEARCH SEDIMENTARY BASIN ANALYSIS–PETROLEUM GEOLOGY—LOUISIANA STATE UNIVERSITY'S LOUISIANA GEOLOGICAL SURVEY

The Louisiana State University's Louisiana Geological Survey invites applications for a research faculty position in sedimentary basin analysis-petroleum geology at the Assistant Professor-Research level. Research will be focused mainly on basin analysis and the many aspects of sedimentary geology related to petroleum formation, maturation, migration, and accumulation within Louisiana's petroleum systems. A variety of other projects dealing with the State's petroleum reserves are also potential areas for both original and applied research. **Required Qualifications:** strong academic record; Ph.D. in sedimentary geology/petroleum geology or in a related field of geosciences from an accredited institution; experience within the oil and gas industry in exploration and production; understanding of petroleum system analysis, especially in terms of modeling and simulation; proven experience in successful grant writing **(Required Research Projects)**; strong background in subsurface geology, especially in creating and interpreting geologic maps and cross-sections; working knowledge of applying GIS to aspects of geologic research. **Special Requirements:** ability and willingness to travel to various locations, over a few days at a time as well as other travel as necessary. **Responsibilities:** presents research results at appropriate conferences; submits papers in appropriate journals or Geological Survey publications; makes contribution to other petroleum technology forums. Salary and rank will be determined by the successful candidate's qualifications and experience. An offer of employment is contingent on a satisfactory pre-employment background check. Application review will begin immediately and will continue through 15 November 2006 or until a candidate is selected. Applications should send a full resume (including e-mail address and a salary history), a one-page statement outlining short-term and long-term visions of research while at the Geological Survey, and contact information (e-mail, telephone number, and mailing address) for three references to: Search Committee, Louisiana Geological Survey, Room 3079 Energy, Coast & Environment Building, Louisiana State University, Ref: #016129, Baton Rouge, LA 70803.

LSU IS AN EQUAL OPPORTUNITY/EQUAL ACCESS EMPLOYER.

TENURE TRACK FACULTY POSITION: APPLIED GEOPHYSICS—CALIFORNIA STATE POLYTECHNIC UNIVERSITY AT POMONA

The Geological Sciences Dept. invites applications for an Assistant Professor–level tenure-track appointment beginning September 2007. Applicants must have a doctorate in geophysics/geology by August 2007. Applicants must be versatile, dynamic, enthusiastic instructors. The new faculty member will teach undergraduate applied shallow subsurface geophysics and one or more extant upper division core courses: e.g., engineering geology, computer applications, and/or groundwater geology. The successful candidate will develop a new undergraduate core course in applied geoscience mathematics, and courses in such areas as seismic hazard analysis, well logging, groundwater modeling or water resource issues. In addition, applicants are expected to teach a variety of undergraduate gen. ed. classes; notable examples include: natural disasters, astronomy, and physical geology. Applicants must have a strong commitment to a polytechnic, hands-on approach to educating undergraduates for careers in the geosciences. Candidates must have the ability to work with a diverse student body and are expected to develop a research program involving undergraduates. Collaborative, interdisciplinary research, scholarly activity and/or science/math curriculum development or teaching with university faculty is expected. The position requires excellence in teaching and advising, professional and scholarly achievements, and service to the university. Additional responsibilities include overseeing seismic and geophysical instrumentation. Applicants must submit a letter of interest, CV, statement of teaching and research interests, contact information for five individuals who can speak to the candidate's potential for success in this position, unofficial transcripts of doctoral work and a completed signed application form (supplied by the Department). After initial screening three written references (electronic OK) are required. A campus interview, three formal signed letters of reference and official confirmation of degree (transcripts) are required of all finalists. Initial screening begins 1 December 2006; position open until filled or terminated. Mail requests and materials to Dr. John A. Klasik, Chair, Geological Sciences Dept., Cal Poly Pomona, Pomona, Calif. 91768. E-mail requests to: jaklasik@csupomona.edu. EO/AA employer.

Full position description: www.csupomona.edu/~academic/faculty/.

ST. LAWRENCE UNIVERSITY

GEOLOGY: ASSISTANT PROFESSOR SEDIMENTOLOGY OCEANOGRAPHY TENURE TRACK

The Geology Department at St. Lawrence University has an opening for a full-time, tenure track position at the rank of Assistant Professor. We desire an individual with expertise in Marine Sedimentology who will complement our existing strengths in Geomorphology, Structural Geology, Paleontology, Petrology and Geochemistry. The successful candidate will be expected to teach Sedimentology, an introductory course in Oceanography, and to assist in the teaching of our entry courses to the Geology program, in addition to advanced courses within their interest area.

We are a small, high quality, undergraduate program that emphasizes both field and laboratory aspects of the science. Our students are commonly involved with faculty in research and the nearby Adirondack Mountains, Canadian Shield, and St. Lawrence Valley offer rich opportunities for study. A high percentage of our majors advance to graduate programs. Each of the five faculty members in the department are involved in teaching introductory Geology courses and we encourage participation in interdisciplinary university programs.

Applicants must have a Ph.D., demonstrated ability in teaching, and a proven research record in their specialty. Interested candidates should submit a curriculum vitae, a letter of application expressing what the candidate feels she/he would contribute to the Geology program at St. Lawrence, and three letters of recommendation to: Dr. Catherine Shrady, Search Committee, Geology Department, St. Lawrence University, Canton, N.Y. 13617.

Processing of applications will begin February 5, 2007 and all materials must be received at that time.

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

SOIL BIOGEOCHEMISTRY
LEHIGH UNIVERSITY

The Department of Earth and Environmental Sciences has an opening at the assistant-professor level for a scientist whose research focuses on the "critical zone," the near-surface environment in which biological processes, rock, water, air, and soil interact. We seek an individual doing innovative research that will complement existing expertise in the areas of surface processes and environmental change. We expect the successful candidate to develop a vigorous externally funded research program, teach a modern course in soil development, otherwise contribute to our undergraduate and graduate curricula in their area(s) of expertise, and mentor Ph.D., M.S., and undergraduate students in internships and research. This position is one of several new hires in Earth and Environmental Sciences, engineering, and the social sciences expected to participate in a university wide, multidisciplinary initiative focusing on the environment. To receive full consideration, applicants should submit by 15 November a letter of application, curriculum vitae, statement of research and teaching interests, up to 3 reprints, and the names of three referees to Frank J. Pazzaglia, Search Committee Chair, Department of Earth and Environmental Sciences, 31 Williams Drive, Lehigh University, Bethlehem, PA 18015. For further information about the EES Department, see www.ees.lehigh.edu/. Lehigh University is an Equal Opportunity Affirmative Action Employer. The College of Arts and Sciences at Lehigh is especially interested in qualified candidates who can contribute, through their research, teaching, and/or service, to the diversity and excellence of the academic community.

DEPT. OF GEOLOGICAL SCIENCES, COLLEGE OF NATURAL SCIENCE AND MATHEMATICS
CALIFORNIA STATE UNIVERSITY–FULLERTON
ENVIRONMENTAL GEOCHEMISTRY/ HYDROGEOCHEMISTRY, TENURE TRACK

The Department of Geological Sciences at California State University Fullerton invites applications for a tenure-track, Assistant Professorship that will begin August 2007. The successful candidate is expected to develop an active, field-based, externally-funded research program in coastal Environmental Geochemistry and/or Hydrogeochemistry involving undergraduate and Master's students, and must be committed to excellence in teaching the diverse student population at CSU-Fullerton. A Ph.D. in Geological Sciences or a related field is required at the time of appointment.

Teaching responsibilities include aqueous geochemistry, general education classes such as oceanography, and upper-division/graduate courses in the candidate's field of expertise. The department places a strong emphasis on field-based instruction in all class offerings. For a complete description of the requirements, go to http://diversity.fullerton.edu/

The Department currently has approximately 50 undergraduate majors, 25 MS students and 12 full-time faculty. Fullerton's location offers convenient access to coastal, mountain, and desert environments, providing many opportunities for field-based research and instruction. Abundant collaborative research and teaching opportunities exist within the Departments of Geological Sciences, Biology, Chemistry and Biochemistry and the Environmental Studies Program. Applicants are encouraged to visit http://geology.fullerton.edu/ for additional information.

To apply, please send (1) a detailed curriculum vita; (2) a letter of application; (3) a teaching statement that includes: a discussion of relevant course work and/or experience in preparation for teaching, a list of courses you would feel comfortable teaching, and a statement of your teaching philosophy; (4) a statement of your future research plans and goals; and (5) letters of recommendation from at least three references familiar with your teaching and research potential. Applicants and referees should send materials directly to: Search Committee Chair, Department of Geological Sciences, California State University, 800 N. State College Blvd., Fullerton, California 92834-6850.

Applications will be accepted until the position is filled. To insure full consideration, submit all application materials by 20 November 2006.

CSU Fullerton is an Equal Opportunity/Title IX/503/504/VEVRA/ADA Employer.

SURFACE HYDROLOGY
MONTCLAIR STATE UNIVERSITY

The Department of Earth and Environmental Studies at Montclair State University invites applications for a full-time, tenure-track faculty position in surface hydrology, with an emphasis on water resource management. This appointment will be at the assistant rank starting 1 September 2007. Expertise in metropolitan water quality issues and integrated research and teaching in applied GISciences would be highly desirable. A Ph.D. is required at the time of appointment. Additional information about the position and the department is available at www.csam.montclair.edu/earth. Applicants should send cover letter, CV, three letters of recommendation, and a statement of professional goals, research interests, and teaching philosophy to Dr. Duke Ophori, ophorid@mail.montclair.edu, Hydrology Search Committee Chair (VF-30), Dept. of Earth & Environmental Studies, Montclair State University, Montclair, NJ 07043. Review of applications will begin immediately. Montclair State University is an Equal Opportunity/Affirmative Action Employer. Qualified women, minorities, and individuals with disabilities are encouraged to apply.

MICHIGAN STATE UNIVERSITY
DEPARTMENT OF GEOLOGICAL SCIENCES
SOLID-EARTH GEOCHEMISTRY/GEODYNAMICS

The Department of Geological Sciences at Michigan State University announces an academic year tenure-track position in solid-earth geochemistry/geodynamics beginning Fall 2007. The position is at the Assistant Professor level. The successful candidate will be expected to develop a strong, externally funded research program, be committed to excellence in teaching at both the graduate and undergraduate level, and be able to contribute enthusiastically to both the intellectual and collegial life of the department. This position is open to candidates with a Ph.D. in Geological Sciences that focuses on chemical evolution of the crust and mantle, and applied processes; field experience is desirable. Post-doctoral experience and the ability to complement one or more existing departmental strengths are desirable.

Additional information on the Department can be obtained on our Web page at www.geology.msu.edu. Michigan State University is an Equal Opportunity/Affirmative Action Institution and strongly encourages applications from women, minorities, and persons with disabilities. Persons with disabilities have the right to request and receive reasonable accommodation. Review of applications will begin 20 December 2006 and continue until the position is filled. Interested applicants should forward a curriculum vita, official transcripts, a statement of teaching and research interests, and the names and contact information for three references to: Ralph E. Taggart, Chair, Department of Geological Sciences, Michigan State University, 206 Natural Science Building, East Lansing, MI 48824-1115

POMONA COLLEGE FACULTY POSITION
IN PETROLOGY/MINERALOGY

The Geology Department at Pomona College invites applications for a tenure-track position at the level of Assistant Professor beginning 1 July 2007. For further details see www.pomona.edu/ADWR/AcademicDean/FacultyJobs.shtml. Applicants should send a letter of interest, curriculum vitae, undergraduate and graduate transcripts, a statement of teaching philosophy, a summary of research plans and three letters of reference to **Pet-Min Search, Geology Department, Pomona College, Claremont, CA 91711.** Web address: www.geology.pomona.edu; e-mail: GeoFacSearch@pomona.edu. Review of completed applications begins 15 November 2006 and will continue until the position is filled. Pomona College is an equal opportunity employer, and it especially invites applications from women and members of underrepresented groups.

TENURE-TRACK FACULTY POSITION
GEOCHEMISTRY
EASTERN WASHINGTON UNIVERSITY

The department of geology at Eastern Washington University invites applications for a full-time, tenure-track position in geochemistry. Appointment will be at the rank of Assistant Professor, and a Ph.D. in geology is required. The successful candidate will be expected to teach courses in introductory geology, environmental science, and geochemistry. Preference will be given to candidates who can make use of existing analytical geochemical lab equipment including ICP-MS and AA. The successful applicant will contribute to current departmental strengths in teaching and research and will apply research-based instructional approaches suitable for a diverse student body. Candidates should: (1) send letter of application detailing teaching and research interests with an up-to-date CV, and (2) arrange to have at least three letters of reference sent to: Geochemistry Search Committee, Department of Geology, Eastern Washington University, 130 Science Building, Cheney, WA 99004-2439. Questions may be directed to charbolt@mail.ewu.edu or +1-509-359-2286. Review of applications will begin 10 November 2006 and continue until the position is filled. The position will begin in September 2007. For more information about Eastern Washington University and the Department of Geology,

please see www.ewu.edu. The successful candidate will be required to show proof of eligibility to work in the U.S. pursuant to U.S. immigration laws. Eastern Washington University is an Equal Opportunity/Affirmative Action employer. Applications from members of historically underrepresented groups are especially encouraged to apply.

PALEONTOLOGIST/PALEOECOLOGIST
UNIVERSITY OF MIAMI–CORAL GABLES, FLORIDA

The Department of Geological Sciences, College of Arts and Sciences invites applications for a tenure-track position at the assistant-professor level from persons who use paleontology as a research tool in such fields as paleoecology, environmental geology, and global climate change. The department is particularly interested in expertise in comparative (modern/ancient) shallow marine paleoecology and paleontology as a complement to our coastal stratigraphy and paleoenvironmental research program.

The position is located at the main campus in Coral Gables.

Applicants will be expected to teach undergraduate courses in invertebrate paleontology, historical geology, and evolution of the biosphere. Also, the successful applicant will be expected to collaborate with other faculty, guide graduate students, advise undergraduate students, seek extramural research funds, develop and maintain an active research program, and participate in the general activities of the university.

Research interests of the current faculty members range from coastal and shallow marine sedimentation to isotopic studies of the mantle, climatic and hydrologic modeling, volcanism, tectonics, environmental mineralogy, carbonate and organic sediment processes and diagenesis.

The Department works closely with the 15 faculty members of the Division of Marine Geology and Geophysics at the Rosenstiel School on the Key Biscayne campus approximately seven miles from main campus.

Applicants should submit a letter summarizing their research interests, a curriculum vitae and the names of three references before 1 December 2006, to Dr. Harold R. Wanless, Chairman, Faculty Search Committee, Department of Geological Sciences, University of Miami, Box 249176, Coral Gables, 33124-9176 or hwanless@miami.edu.

We expect to fill the position by 1 April 2007 with a start date of 15 August 2007. The University of Miami is an equal opportunity/affirmative action employer.

TENURE-TRACK FACULTY POSITIONS
STONY BROOK UNIVERSITY

Stony Brook University's Department of Geosciences is seeking to fill tenure-track faculty positions at the Assistant Professor level. Preference will be given to candidates who compliment existing research strengths including planetary sciences and computational geosciences. Required: Ph.D. in geoscience or closely related field and significant past research accomplishments based on quality and originality in published work or manuscripts in preparation. The successful candidate will be expected to teach at graduate and undergraduate levels and to develop a vigorous research program. Evaluation of applicants will begin 15 December 2006. Applicants should send curriculum vitae, statement of research interests, and names and complete contact information of three references to Professor John B. Parise, Chair, Faculty Search Committee, Department of Geosciences, Stony Brook University, Stony Brook, NY 11794-2100. Equal Opportunity/Affirmative Action Employer. Information about the Department of Geosciences may be obtained at **www.geosciences.stonybrook.edu.**

For more information, visit **www.stonybrook.edu/cjo.**

Opportunities for Students

Doctoral Opportunities in Paleontology, Volcanology and Paleoceanography in New Zealand. The University of Auckland, Geology Department, offers 4 Ph.D. scholarships in hydrocarbon-seep paleontology of eastern North Island, deep marine explosive volcanism in the Kermadecs, and global extinctions of deep sea foraminifera. Covers fees, stipend and research costs; start in first quarter of 2007. Applications will be reviewed from 1 November 2006. Details at www.geology.auckland.ac.nz/uoa/science/about/departments/geology/phd_opportunities.cfm. Inquiries: ka.campbell@auckland.ac.nz.

Jonathan O. Davis Scholarship, Division of Earth and Ecosystem Sciences, Desert Research Institute. The family and friends of Jonathan O. Davis, a prominent U.S. geologist and geoarchaeologist and a DRI faculty member, have established an endowment that provides a yearly national Jonathan O. Davis Scholarship, as well as a stipend for a University of Nevada–Reno student.

Jonathan was tragically killed in an automobile accident in December 1990. It is the wish of his family and friends to support graduate students working on the Quaternary geology of the Great Basin, research close to Jonathan's heart. The national scholarship is $4,000 and the University of Nevada–Reno stipend is $1,500.

The national scholarship, administered by the Division of Earth and Ecosystem Sciences of the Desert Research Institute, is open to graduate students enrolled in an M.S. or Ph.D. program at any university in the United States. The stipend, also administered by the Division of Earth and Ecosystem Sciences, is open to graduate students enrolled in an M.S. or Ph.D. program at the University of Nevada–Reno. Quaternary geology, as used here, encompasses a wide range of topics normally considered as part of the Quaternary sciences. The research, however, must have a substantial geologic component or demonstrate a strong reliance on geological techniques and must be focused on the Great Basin.

Applications should include: (1) A cover letter explaining how the individual qualifies for the award. Please include your social security number and state whether you are applying for the national scholarship or for the UNR stipend; (2) A current résumé or vitae; (3) A two-page, single spaced description of the thesis/dissertation research, which also clearly documents the geological orientation and research significance. Figures, tables, and references do not count against the two-page limit; (4) A letter of recommendation from the thesis/dissertation supervisor, which emphasizes the student's ability and potential as a Quaternary scientist.

Applications must be postmarked by 2 February 2007. Proposal reviews will not be returned to applicants. Applications should be addressed to: Executive Director, Division of Earth and Ecosystem Sciences, Desert Research Institute, 2215 Raggio Parkway Reno, NV 89512.

If you have further questions regarding the awards or the application process, please contact Barbara Jackson at +1-775-673-7454 or bj@dri.edu.

The Department of Geological Sciences at Southern Methodist University currently has four NSF-funded graduate research assistantships, to be awarded for PhD- or Master's-level study, for terrestrial paleoenvironmental and paleoclimatological reconstruction. These GRA's will support projects focused upon (1) Late Oligocene paleobotanical, sedimentological or geochemical research in northwestern Ethiopia (or a combination of these), (2) stable isotope geochemical reconstructions of paleoclimate from paleosol profiles and fossil floras preserved in (i) Carnian-age strata from northwest Argentina, (ii) Permo-Carboniferous strata of western Europe, central Asia and South America and (iii) Middle and Upper Permian strata of central sub-Saharan Africa, central- and southeast Asia. Research projects will include both field and laboratory studies, and will be integrated into ongoing multidisciplinary projects involving faculty and students from 11 different institutions located on 5 different continents. Because of the multi-disciplinary nature of these research projects, we are particularly interested in students with strong backgrounds in sedimentology, plant taxonomy and taphonomy, light-stable isotope geochemistry, and pedology. Please contact Drs. Bonnie Jacobs (bjacobs@smu.edu) and/or Neil Tabor (ntabor@smu.edu), Department of Geological Sciences, Southern Methodist University, Dallas, TX 75275-0395. For more information about graduate studies at SMU, visit our Web site at www.smu.edu/geology.

Graduate Student Opportunities, Ohio University. The Department of Geological Sciences at Ohio University is seeking qualified students for its graduate program. Positions are available beginning January or September 2007. The department offers a competitive program 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 tuition scholarship and a stipend of $12,150/year. For program and application information, visit the department Web site at www.ohiou.edu/geology/ or contact the graduate chair, David Schneider, schneidd@ohio.edu, for additional information.

ST. LAWRENCE UNIVERSITY

VISITING ASSISTANT PROFESSOR GEOMORPHOLOGY

The Geology Department at St. Lawrence University has an opening for a one-year Visiting Assistant Professor. We desire an individual with expertise in Geomorphology and, ideally, Hydrology/Hydrogeology, who will complement our existing strengths in Structural Geology, Sedimentology, Paleontology, Petrology and Geochemistry. The successful candidate will be expected to teach Geomorphology, Hydrology/Hydrogeology, and to assist in the teaching of our entry courses to the Geology program, in addition to advanced courses within their interest area.

We are a small, high quality, undergraduate program that emphasizes both field and laboratory aspects of the science. Our students are commonly involved with faculty in research and the nearby Adirondack Mountains, Canadian Shield, and St. Lawrence Valley offer rich opportunities for study. A high percentage of our majors advance to graduate programs. Each of the five faculty members in the department are involved in teaching introductory Geology courses and we encourage participation in interdisciplinary university programs.

Applicants must have a Ph.D., demonstrated ability in teaching, and a proven research record in their specialty. Interested candidates should submit a curriculum vitae, a letter of application expressing what the candidate feels she/he would contribute to the Geology program at St. Lawrence, and three letters of recommendation to: Dr Stephen Robinson, Search Committee, Geology Department, St. Lawrence University, Canton, N.Y. 13617.

Processing of applications will begin March 5, 2007 and all materials must be received at that time.

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

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Tulane University—Graduate Opportunities in Earth & Environmental Sciences. We consider graduate applications throughout the year. In addition to teaching assistantships, research assistantships are available for top applicants to the Ph.D. program, both through competitive fellowships and funded projects. Annual stipends range from $18,000 to $20,000. The department has a strong focus on river-ocean studies, with access to a research vessel and a variety of analytical and computing facilities. We are particularly interested in applicants who are excited by the many challenges faced by the Gulf Coast in the recovery from Hurricane Katrina. Particular strengths are in sedimentology, stratigraphy, marine geology, paleoclimatology, neotectonics, structural geology, geological hazards and environmental geochemistry; there are also opportunities in paleontology, petrology and volcanology. Applications should be submitted online at **www.tulane.edu/%7Egradprog/** and should include a clear statement of research interests and career goals, a CV, transcripts, GRE scores, TOEFL scores (for international applicants), and 3 recommendation forms. More information about the department can be obtained via our Web site (**www.tulane.edu/~eens/**). Women and minorities are encouraged to apply.

M.Sc. Graduate Student Opportunity in Lacustrine Paleoclimatology, California State University–Fullerton. A combined RA/TA package is available beginning August of 2007 for a motivated student to study past climate variability using a combination of sedimentological and geochemical analyses from Lake Elsinore, Southern California. Please direct inquiries to Dr. Matthew Kirby, Department of Geological Sciences, California State University, Fullerton (mkirby@fullerton.edu).

Graduate Student Opportunities: The Department of Geological Sciences at Case Western Reserve University (www.case.edu) is seeking qualified students for its graduate program. Current research strengths in the department include: surface processes, soil erosion, sediment transport, geologic sequestration of carbon, geochemistry, planetary materials, planetary geology and geophysics, and high-pressure mineral physics and chemistry. Financial assistance may be available for qualified applicants interested in pursuing M.S. or Ph.D. degrees. For more information, please see http://geology.case.edu or contact the department at geo-gradinfo@case.edu.

Applications for graduate study at Case are accepted on a rolling basis, though students requesting financial assistance in Fall 2007 are encouraged to apply by 1 February 2007.

Case is committed to diversity and equality. Students from all backgrounds are encouraged to apply.

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Bicentennial Conference

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• 10-12 September 2007 • Queen Elizabeth II Conference Centre, Westminster, London

The conference

Earth Sciences in the Service of Society is an international conference marking the Bicentennial of The Geological Society of London, the world's oldest national geological society.

The conference will review the current state of the science and demonstrate the relevance of modern-day Earth science to the important issues of our times.

Days one and two will feature invited speakers, all international leaders in their fields, reporting on the state of the science in four parallel sessions:

- **Resources – energy, minerals**
- **Environment – engineering geology of London, groundwater, waste and contamination, geophysics**
- **Earth and Planetary Interiors – geochemistry, geophysics, active tectonics, volcanology**
- **The Earth System – evolution of Earth environments, Quaternary change**

These will be accompanied by open poster sessions and opportunities for specialist discussion.

Day three will be devoted to a plenary session on **Earth's Future**. Distinguished speakers will present new results and ideas relevant to our understanding of the planet and how these affect key environmental issues, present and future, including: natural hazards, climate change, energy and water resources. At the same time the QEII Centre will play host to A-level/Scottish Higher students and undergraduates, and introduce them to the exciting prospects offered by careers in Earth sciences. Although primarily forward-looking, this conference is also a 200th birthday celebration. There will therefore be talks by leading historians of science and

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opportunities to look back on past achievements. All Earth scientists and science historians are cordially invited to join the party!

Abstracts of all contributions (posters and oral presentations) will be included in a conference volume.

Speaker list and programme are updated on the Web site.

Field trips

Pre and post-conference excursions will visit many of the most important and interesting sites of British geology – though one is also planned to Tierra del Fuego!

For a full list, please visit www.geolsoc.org.uk/bicentenary where you can sign up to express your interest. Excursions will go ahead when sufficient interest has been shown, so please do not hesitate to sign up for any excursion that attracts you.

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Here is just a brief sample of what is on offer.

Classic British geology: *Ironbridge World Heritage Site: geology in the cradle of the Industrial Revolution; 200 years of geological controversy in the English Lake District; Transect of Wales; The classic geology of the north of Ireland; Three billion years of Earth history in the North West Highlands Geopark; Dorset and East Devon: The 'Jurassic Coast' World Heritage Site and Western Europe's largest onshore oilfield; William Smith and the Dinosaur Coast of Yorkshire; Hutton, Horne and Barrow: classic localities of the Edinburgh region and the Eastern Scottish Highlands.*

Special Interest: *In Darwin's footsteps: the geology of Tierra del Fuego; Coal Mining and Minewater Treatment: National Coal Mining Museum for England; Cretaceous-Paleogene sedimentary history and stratigraphy of the Isle of Wight; Pleistocene and Precambrian glacial records in Western Scotland; Mineral deposits of South West England; Folds, faults, fractures and the odd fossil: the world-class geological structures of the north Cornwall-north Somerset coast; The Malvern Hills.*

Expressions of interest

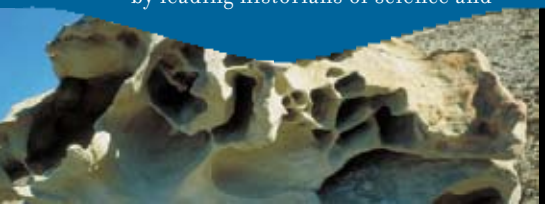
Register your interest directly at: www.geolsoc.org.uk/bicentenaryconference.

Important dates

Registration opens: **8 January 2007**
"Early bird" registration ends: **31 May 2007**

Call for posters

The Society welcomes submissions on any topics relevant to the programme. See the Conference Web site for details of poster sessions. Poster sessions may be restructured in the light of submissions received. Abstracts will be subject to review by poster session conveners.
Submission deadline: **30 June 2007**



• **Up-to-date information** • **Conference Web site:** www.geolsoc.org.uk/bicentenaryconference
• **More information about the venue:** www.qeiicc.co.uk
• **Email** bicentenary@geolsoc.org.uk • **Telephone** +44 (0)20 7434 9944
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CHARACTERISTICS OF A "GROUNDWORK" ARTICLE:

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The Origins of Geology in ITALY

edited by Gian Battista Vai and W. Glen E. Caldwell

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This volume includes an eclectic group of papers by authors of varied backgrounds and nationality who describe contributions to natural science and philosophy by Italian or foreign geologists working in Italy between the fourteenth and nineteenth centuries. Each of these scientists contributed to the emergence of modern geology as a distinct scientific discipline, starting with Aldrovandi, who coined the term *geology* in 1603, and continuing with Agricola, the early gemologists and mineralists, the Florentine artists, Descartes, Gassendi, Kircher, Steno, Marsili, Arduino, Gregory Watt, William Maclure, Brocchi, and Pilla. When Lyell disseminated the Huttonian doctrine in his *Principles*, he fully recognized the legacy of pioneering Italian studies in geology. The aim of the volume is to restore Lyell's insights, which were not investigated further by Italian geoscientists and historians of science during the nineteenth and twentieth centuries. Rediscovering the roots of modern geology is an invaluable and crucial goal for a sound assessment of long-term perspectives of this science and of science as a whole.

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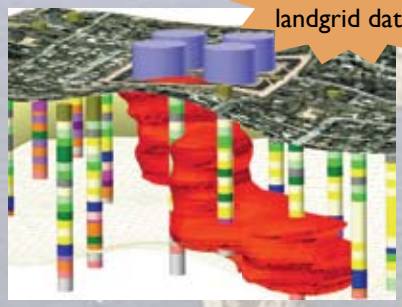

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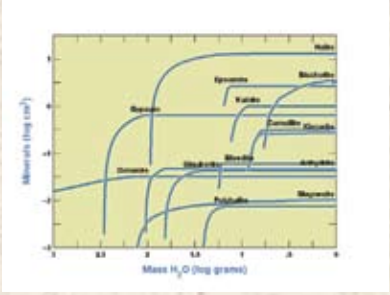

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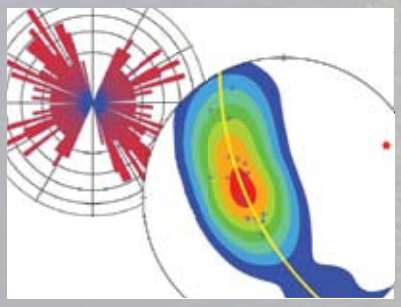

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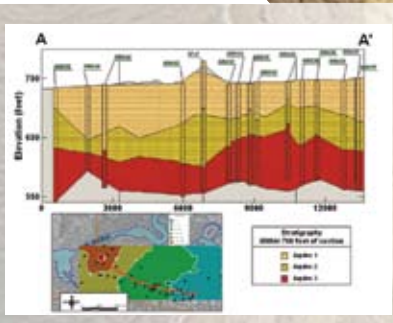

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