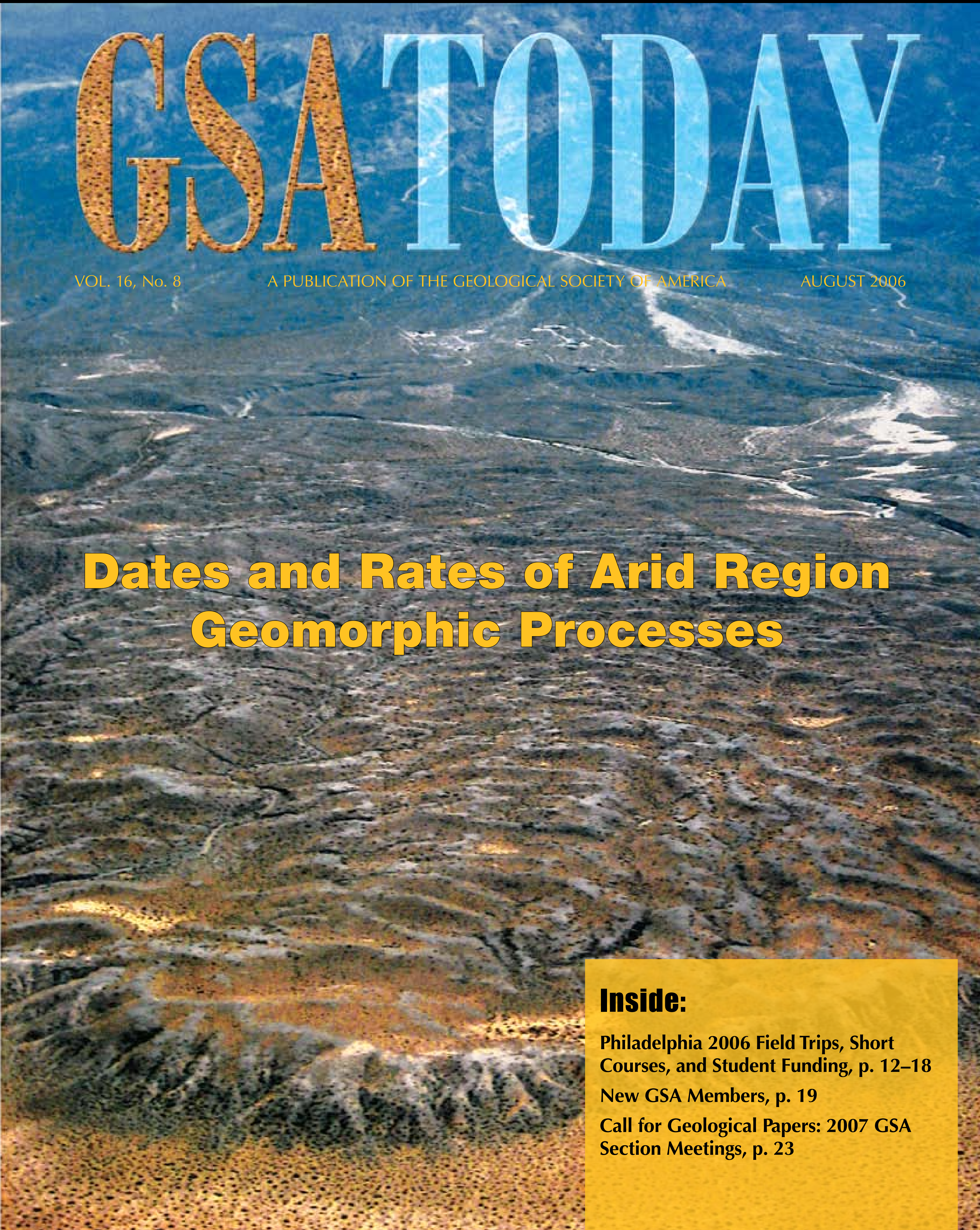

GSA TODAY

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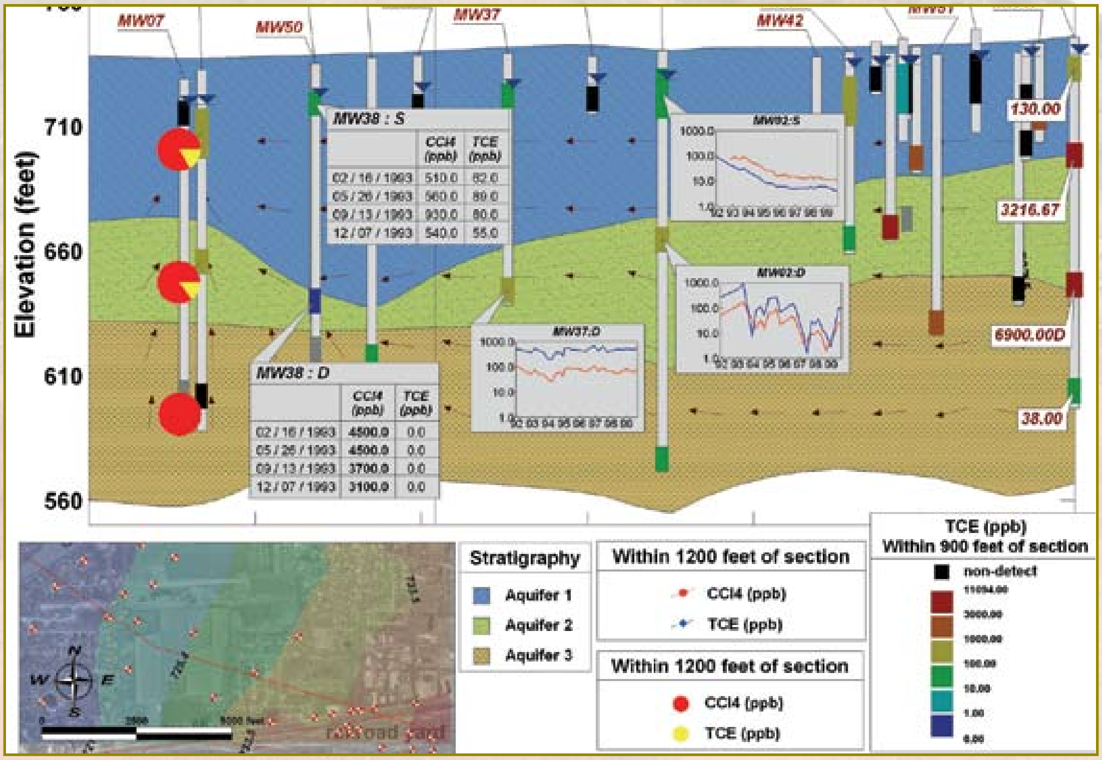

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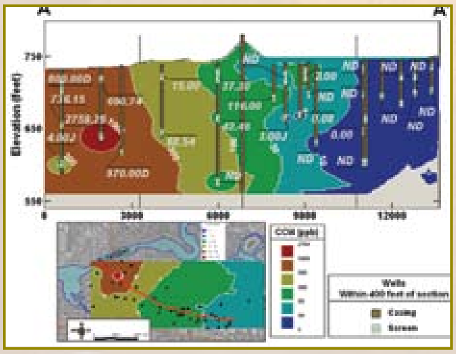

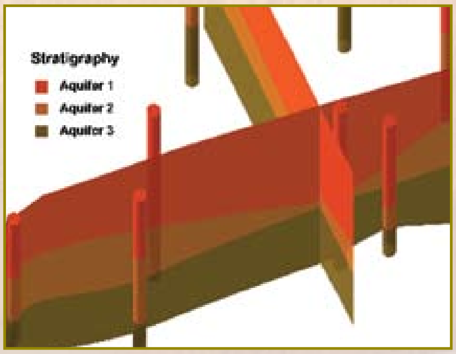

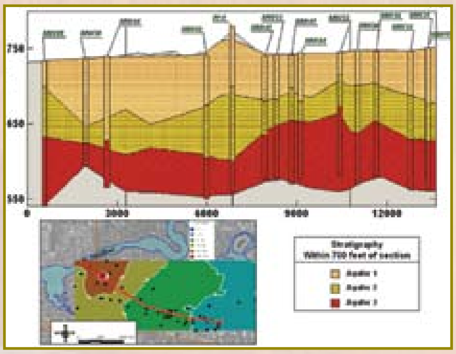

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Cover: The ~3 km³ Blackhawk Landslide is a well-known example of a large-volume landslide, which sourced in the San Bernardino Mountains (background) and ran out 9 km into Lucerne Valley in the Mojave Desert, California. The cause of the landslide is unknown, in part because the age is unknown. Photograph taken May 2006 by K.K. Nichols. See "Dates and rates of arid region geomorphic processes," by Nichols et al., p. 4–11.

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Erratum: In the July issue of *GSA Today* (v. 16, no. 7, p. 15), new GSA Fellow Lynda B. Williams' affiliation was listed as the University of Arizona. The correct affiliation is Arizona State University at Tempe.

Dates and rates of arid region geomorphic processes

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ABSTRACT

Analysis of in situ–produced cosmogenic nuclides, including ^{10}Be, ^{26}Al, and ^{36}Cl, has changed how geologists understand desert surface processes. Here, we provide a series of examples from arid mountain-piedmont systems that illustrate both the power and limitations of this geochronometer. Analyses of samples collected from bare bedrock surfaces at the Alabama Hills, California, demonstrate slow but variable (1.4–20 m m.y.$^{-1}$) rates of erosion, whereas cosmogenic dating of the Blackhawk landslide debris (~6.5–31 k.y.) and the Castle Dome piedmont allows linkages between landscape-scale processes and climate change. However, data show that nuclides inherited from prior periods of exposure, as well as the effect of post-depositional surface change, limit the accuracy and precision of exposure dating in some settings. On the broad Castle Dome piedmont, detailed isotopic stratigraphies, coupled with analysis of desert soils, indicate depositional histories over the past ~70 k.y. in the absence of radiocarbon-datable organic material. Transect-based amalgamated sampling techniques allow for estimation of sediment velocity down mountain-fringing piedmonts. In drainage basins, the concentration of ^{10}Be in fluvial sediment demonstrates the efficacy of fluvial mixing even in areas where surface flow is intermittent. Considered together, these applications of the cosmogenic technique allow the delineation of sediment budgets in areas where no other technique has been useful. Such data are important for the arid Southwest, where population is increasing rapidly, as is the interaction of society and surface processes.

INTRODUCTION

Desert landscapes contain a rich record of geomorphic and geologic change (Cooke et al., 1993). Over the past century, geomorphologists and pedologists have used a variety of approaches, such as interpreting and dating sediments from dry-lake playas (Enzel, 1992; Lowenstein, 2002; Anderson and Wells, 2003), alluvial fans (Harvey and Wells, 2003; McDonald et al., 2003), and landforms offset by fault systems (Weldon et al., 2004; Matmon et al., 2005), to determine the effects of climate change on sediment generation and transport systems and to quantify process rates. Such studies allow us to understand the broad timing of sediment deposition and erosion, their drivers, and the overall rates and processes of soil development. However, at finer temporal and spatial resolution, there is significant variability in the data, which often makes it difficult to interpret because numeric age-control is frequently lacking. Furthermore, the timing of older events is often inferred solely from the behavior of the system during more recent ^{14}C-datable climatic and tectonic episodes. Quantifying rates and dates beyond the 40–50 k.y. limit of radiocarbon dating not only allows geologists to test long-standing hypotheses regarding desert process behavior during climate change (e.g., Bull, 1991), but also allows for systematic evaluation of the effects of lithology, nonglacial climate change, tectonics, and other potential drivers of landscape change.

Determining rates of surface change in the desert is no simple task. Most desert surfaces change imperceptibly over human time scales (Webb, 1996) because much geomorphic work in arid climates is accomplished during large but infrequent storm events (Schick, 1977; Cooke et al., 1993). Quantifying the effects of such storms, both spatially and temporally, requires expensive and time-consuming monitoring programs (Schick, 1977; Persico et al., 2005). Over millennia, the timing of such events is difficult to establish because dry desert climates are not conducive to the generation or preservation of plant material for radiocarbon analysis, the standard means by which late Quaternary deposits are dated and rates of surface change are often calculated (Bull, 1991). It is clear that major advances in the understanding of desert landforms and the rate at which they shed sediment require widely applicable, quantitative, and reliable chronometers. In this paper, we present new data to illustrate both the promise and limitations of cosmogenic nuclides when combined with field data as a tool for understanding arid-region geomorphic systems. Many of the approaches we present are also applicable to other climatic and tectonic settings (Bierman and Nichols, 2004).

CASE STUDIES

Fundamental to the application of cosmogenic nuclides as a monitor of desert surface processes is understanding that (1) most production of cosmogenic nuclides occurs near Earth's surface and (2) production decreases to minimal rates at depths of several meters. The measured concentration of isotopes, such as ^{10}Be, reflects the near-surface residence time, or cosmic-ray dosing, of a mineral grain. This leads to an inverse relationship between nuclide concentration and erosion rate and a direct relationship between surface age and nuclide con-

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centration. Here, we present a series of three case studies from sites in southern Arizona and California (Fig. 1) that highlight both the utility and limitations of using cosmogenic nuclides to study arid-region geomorphology and the landscape-scale continuum of sediment production, transport, and deposition.

Case 1—Sediment Production from Eroding Rock: The Alabama Hills, California

You have probably seen the Alabama Hills even if you've never been there. This weathered granite landscape in the shadow of the Sierra Nevada is one of Hollywood's favorites, providing backdrops for John Wayne movies, Subaru Outback ads, and the subterranean monsters of the movie *Tremors*. Despite the visual popularity of this and other bare rock landscapes, little is known about the rates of bedrock weathering, which is a problem because weathering-limited bare-rock slopes play an important role as sources of desert sediment (Bull, 1991) and runoff (Yair and Kossovsky, 2002). Without knowledge of bare-rock erosion rates, one cannot craft accurate and useful sediment budgets (Dietrich and Dunne, 1978).

The Alabama Hills, dominated by varnished tors and inselbergs that crop out of small but distinct grus-mantled pediment surfaces (Fig. 2A), are a down-faulted block of deeply weathered and jointed granite (Richardson, 1975; Chen and Tilton, 1991) that sit ~3000 m below the crest of the Sierra Nevada but well above the deeply alluviated bedrock floor of adjacent Owens Valley (Pakiser et al., 1964). The linear eastern margin of the Hills appears to be controlled by the Owens Valley fault system (Beanland and Clark, 1993), whereas to the west their margin is convoluted and buried by debris fans shed from the Sierra Nevada (Bierman et al., 1994).

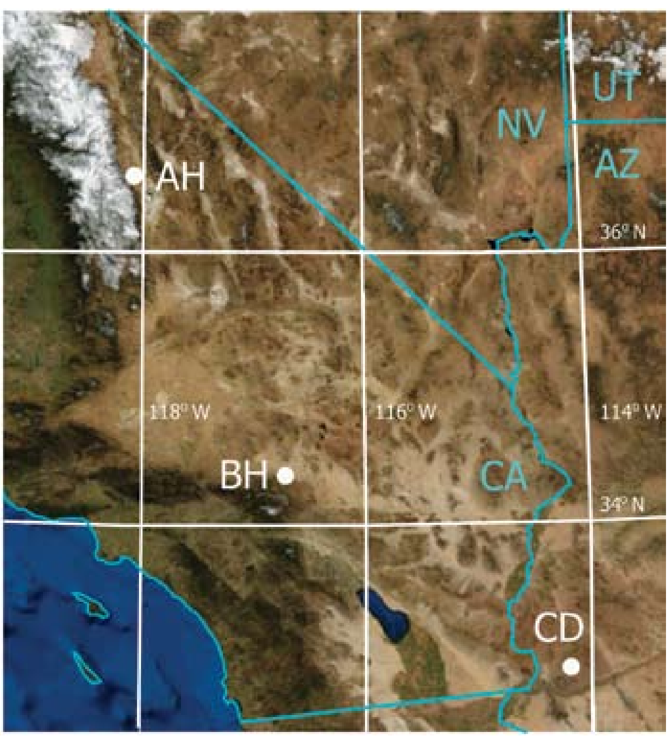

Figure 1. Location of case studies. The Alabama Hills (AH) are in Owens Valley near Lone Pine, California (CA); the Blackhawk slide (BH) is in the Mojave Desert near Apple Valley, California; and the Castle Dome piedmont (CD) is north of Yuma, Arizona (AZ). Background is a true color image of the American Southwest taken in January 2004 (courtesy of the National Aeronautics and Space Administration's Blue Marble: Next Generation database). NV—Nevada; UT—Utah.

To estimate the rate at which the Alabama Hills are eroding, we obtained 20 measurements of ^{10}Be from quartz that had been separated from samples of exposed rock. This provides a direct measure of bedrock landscape stability (Fig. 2; Data Repository Table DR1[1]). The samples were collected from three distinct geomorphic environments (Bierman, 1993) in order to test the hypothesis that heavily varnished, high-standing landforms were eroding more slowly than nonvarnished, lower geomorphic features. Five samples were collected from the top or sides of dark, high inselbergs, which stand tens of meters above low-lying, colluvium-covered valleys within the Alabama Hills. These high inselbergs are losing mass primarily via detachment of 1–3-cm-thick rock sheets (Fig. 2B). Seven samples were collected from more topographically isolated low inselbergs 5–20 m above the adjacent pediments or colluvial surfaces (Fig. 2C). Eight samples were collected from unvarnished, flat-lying bedrock pediment surfaces sloping away from the inselbergs (Fig. 2D). Unlike the inselbergs, the pediment surfaces appeared to be losing mass primarily by granular disintegration.

Field observations and isotopic data show that the inselbergs and pediments of the Alabama Hills are dynamic landforms losing mass over time and shedding sediment onto adjacent colluvial surfaces. All samples contain significant amounts of cosmogenically produced ^{10}Be, $0.45–5.4 \times 10^6$ atoms g^{-1}. If we interpret the data as reflecting nuclide concentration in steadily eroding surfaces, model erosion rates range from 1.4 to 20 m/m.y. and are related to the sampled geomorphic environment (Fig. 2E). The high inselbergs are the most stable, eroding at 5.4 ± 2.7 m/m.y. ($n = 5$); the low inselbergs are eroding at 7.2 ± 3.2 m/m.y. ($n = 7$); and the pediments are least stable, eroding on average at 11.1 ± 4.5 m/m.y. ($n = 8$). It is possible that the bare-rock pediment surfaces we sampled were exposed by the recent stripping of colluvial or alluvial cover; thus, the inferred erosion rates are maxima. In any case, the pediment surfaces we sampled experienced less cosmic-ray dosing than the inselbergs.

The isotopic data are consistent with bare-rock erosion rates for granite measured in other arid regions of North America (Nishiizumi et al., 1986; Bierman and Turner, 1995) and Namibia (Bierman and Caffee, 2001). In all of these cases, erosion rates are higher than those indicated by samples collected from Australian granite surfaces, particularly those on the semiarid Eyre Peninsula, where many samples indicate erosion rates on the order of ≤1 m/m.y. (Bierman and Caffee, 2002). It does not appear that precipitation or temperature play major roles in setting the rate of bare-rock erosion (Bierman and Caffee, 2001; Riebe et al., 2001), with the possible exception of Australian granites (Bierman and Caffee, 2002). Therefore, we

[1]Data repository item 2006166, cosmogenic isotope data for the Alabama Hills, the Castle Dome piedmont, and the Blackhawk landslide, is available on the Web at www.geosociety.org/pubs/ft2006.htm. You can also obtain a copy by writing to editing@geosociety.org.

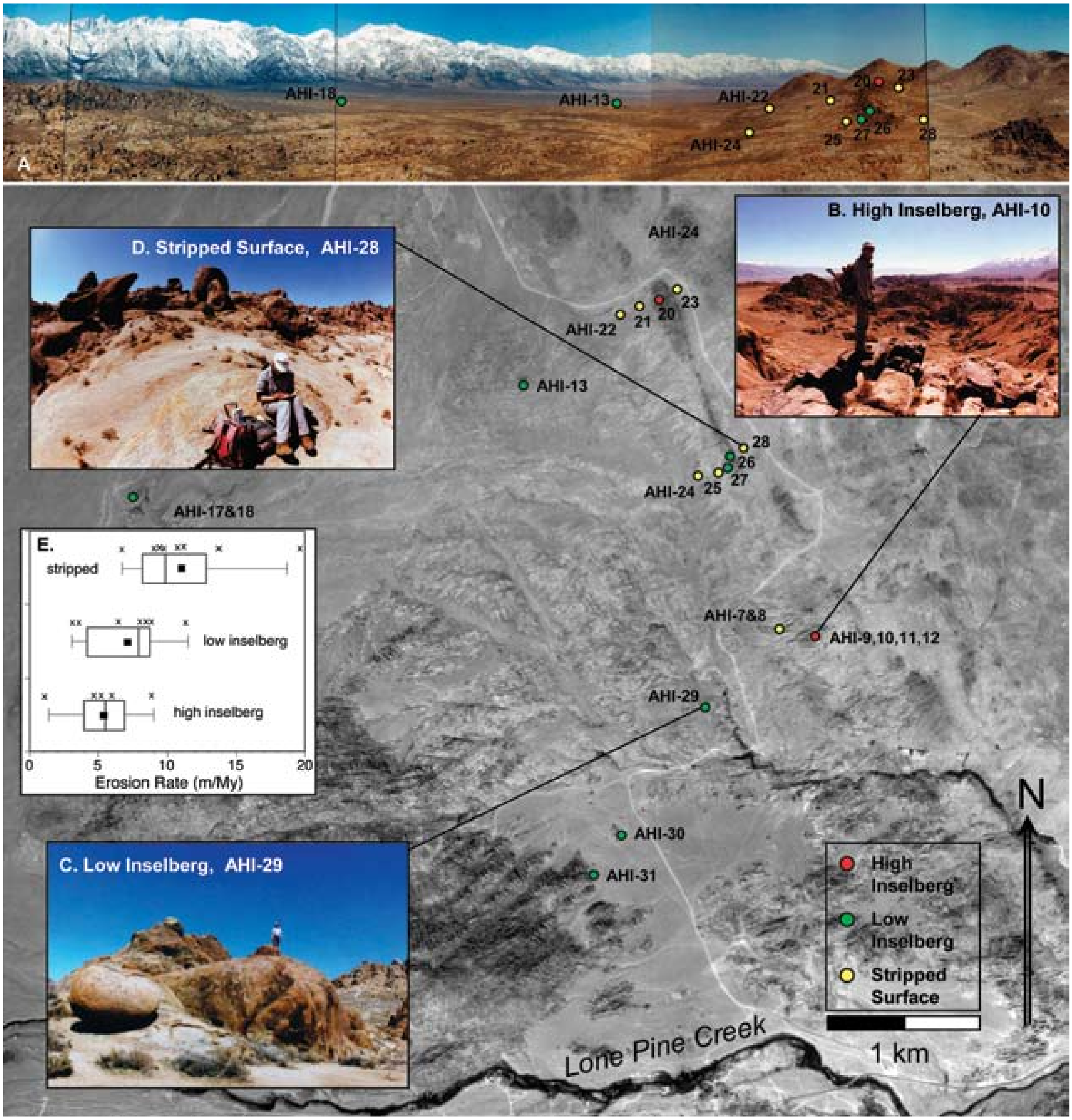

Figure 2. Alabama Hills, California, sample site map, based on scanned aerial photograph (GS-VEQR 133, 8-15-1978). Sample locations are marked by sample identification numbers and color-coded by geomorphic environment (red—high inselberg; green—low inselberg; yellow—stripped surface). Inset images show typical morphology of the three sampled geomorphic environments. (A) Panoramic view taken looking north from sample sites AHI-9–AHI-12 shows other sample sites and their topographic relationships. (B) High inselberg, sample site AHI-10. (C) Low inselberg, sample site AHI-29. (D) Stripped pediment surface, sample site AHI-28. (E) Box and whisker plot showing results of isotopic analyses; solid square—mean; vertical line—median; box ends—25th and 75th percentiles; whisker ends—10th and 90th percentiles; x—data points. Students *t*-test (two-tailed) indicates that at $\alpha < 0.1$, mean erosion rates of high and low inselbergs are indistinguishable and that both populations have lower erosion rates than stripped pediment surfaces.

suspect that the measured variation in the Alabama Hills bare-granite erosion rates may result primarily from differences in joint frequency and spacing, as suggested by Twidale (1982). The inselbergs may be blocks of less-jointed rocks that have greater topographic relief today because they are eroding more slowly, as indicated by the cosmogenic data, than their low-lying brethren. Alternatively, the valleys and peaks of the Alabama Hills may be inherited features, and the isolation of the inselbergs from erosion catalysts, such as soil moisture and wildfire (Bierman and Gillespie, 1991), may explain their stability and relatively low rates of erosion.

Case 2—Sediment Deposition on the Castle Dome Piedmont, Arizona

After sediment is shed from mountainous uplands, it is transported to and deposited on low-gradient alluvial slopes, or piedmonts. Such deposits have the potential to reveal important events in surface histories, such as the timing of fan incision

(Liu et al., 1996), the timing and rate of tectonic activity (Bierman et al., 1995; Zehfuss et al., 2001; Phillips, 2003; Matmon et al., 2005), and the rate of surface aggradation (Nichols et al., 2002, 2005b). Here, we present ^{10}Be data from a soil pit dug into a piedmont that has a well-developed and varnished pavement extending as an apron from the Castle Dome Mountains in Arizona (Fig. 3; Data Repository Table DR2 [see footnote 1]). These data demonstrate how cosmogenic nuclide data compliment traditional soil profile descriptions, providing more precise age control and quantifying piedmont process rates at time scales beyond the 40 k.y. limit of radiocarbon dating.

Soil development in piedmont sediment and the shape of nuclide depth profiles derived from soil-pit samples depend on both the deposition rate and the length of time since deposition (Phillips et al., 1998; Birkeland, 1999; Nichols et al., 2002, 2005b). For example, cummulic soils (overthickened, homogeneously weathered soil profiles) represent periods of steady, relatively slow deposition (Birkeland, 1999). Such slow deposition yields nuclide concentrations that increase with depth. Conversely, packages of sediment with no evidence of pedogenesis suggest well-mixed soils or relatively rapid sediment deposition characterized by uniform nuclide concentrations with depth. Sediment that was deposited rapidly but has been stable since deposition will exhibit both soil development that is representative of the age of the deposit as well as nuclide concentrations that decrease with depth. However, many desert surfaces have complex histories of deposition, erosion, and stability. Buried soils represent a paleo-ground surface, where the degree of soil development is representative of the length of surface stability before burial. Often, these buried soils are truncated, as evidenced by missing horizons or sharp irregular boundaries, providing evidence of some erosion prior to burial. A model of the ^{10}Be depth profile, set in the context of soil development, can constrain near-surface depositional histories.

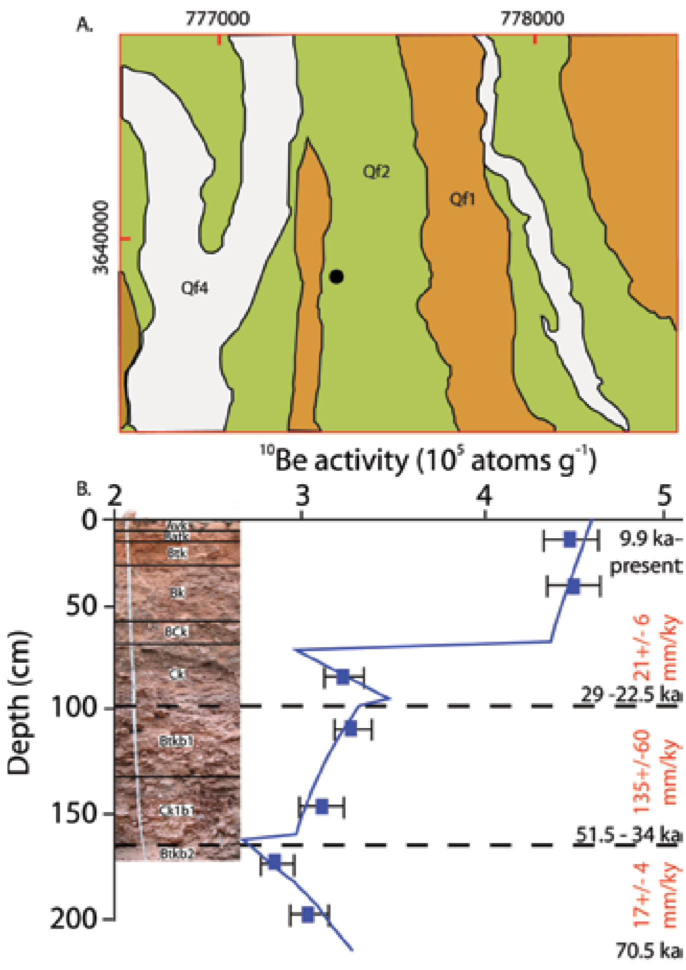

Figure 3. (A) Geomorphic map of the Castle Dome piedmont near soil pit location (black dot). Qf1 surfaces are topographically high abandoned piedmont surfaces, Qf4 surfaces represent active channels, and Qf2 surfaces are intermediate. Map modified after Lashlee et al. (1999). Map datum and red 1000-m tick marks are in zone 11N 1927 of the North American Datum. (B) Nuclide and soils data for Castle Dome piedmont soil pit. Photo mosaic of pit wall shows two buried soils (dashed lines) at 98 cm and 165 cm. Thin black lines—approximate boundaries of soil horizons; blue squares and 1σ analytical error bars—mid-point of depth samples; blue line—average model fit based on Monte Carlo simulation (root mean square error = 3.4×10^3 atoms g^{-1}); black numbers—time before present; aggradation rates are represented by red numbers (in k.y.). The total time represented in the soil pit is ~70.5 k.y.

The Castle Dome Mountain piedmont has multiple surfaces (Fig. 3A; Lashlee et al., 1999). The lowest surface (Qf4) corresponds to the active ephemeral channels; the highest surface (Qf1) has the best-developed and most darkly varnished pavements, an indicator of landscape stability. Soils data, from a pit dug into the Qf2 surface, suggest that the surface is between 12 and 70 ka based on a correlation to the soil development of the nearby Whipple Mountain piedmont (Lashlee et al., 1999). Two buried soils at depths of 98 cm and 165 cm in the pit each suggest a period of stability and shallow erosion before the next episode of deposition (Fig. 3B). The data, however, do not show significant changes in nuclide concentration in sediment above and below these depositional unconformities. Rather, the nuclide data are uniform from the surface to 50 cm and then step to lower but uniform nuclide concentrations from 50 to 165 cm. The bottom of the soil pit shows increasing nuclide concentrations from 165 to 200 cm.

An interpretative model constrains both the ages and the rates of piedmont processes (Nichols et al., 2005b). We use a numerical solution, optimized by Monte Carlo simulation of normally distributed nuclide concentrations for each sample, to estimate the mean and standard deviation of each period of stability, as recognized by buried soils (Nichols et al., 2005b). We also date each period of deposition and calculate average aggradation rates. Starting at the bottom of the soil pit, sediment was deposited at a rate of 17 ± 4 mm/k.y. for ~19 k.y. from 70.5 to 51.5 ka. At ca. 51.5 ka, the surface was stable for ~17.5 ± 3.5 k.y., producing the Btkb2 soil horizon from 165 to 200 cm depth. At ca. 34 ka, deposition at a rate of 135 ± 60 mm/k.y. began, likely caused by erosion and incorporation of sediment up-gradient of the soil pit location. Such reworking, common in piedmont soils of the Desert Southwest, would also cause the higher nuclide inheritance values required for the model fit. At ca. 29 ka, the surface was stable for at least 6.7 ± 2.8 k.y., depending on the assumed amount of soil erosion, forming the Btkb1 and Ck1b1 soils at 98 to 165 cm. Slow aggradation, at a rate of 21 ± 6 mm/k.y., occurred from ca. 22.5 ka to ca. 9.9 ka. At ca. 9.9 ka, rapid deposition of 70 cm of sediment with high ^{10}Be activity suggests derivation from a near-surface source. Over the past 9.9 ± 2.6 k.y., the surface has aggraded 8 cm from dust accumulation.

Our numerical model constrains the ages and rates of piedmont processes that are within the 12–70 ka soils-based age estimated by Lashlee et al. (1999). The model suggests three periods of stability (present to ca. 9.9 ka, 22.5–29 ka, and 34–51.5 ka) separated by periods of slow aggradation (135 and 17 mm/k.y.), and instantaneous deposition of the top 70 cm of sediment. Deposition from ca. 70 ka to ca. 50 ka agrees with many dated depositional events in the Southwest (Gosse et al., 2004; Anders et al., 2005; Nichols et al., 2005b). The pulse of sediment at the Pleistocene–Holocene transition is consistent with other depositional events identified elsewhere and with geomorphic models (Bull, 1991; McDonald et al., 2003). The periods of deposition and stability between ca. 10 ka and 50 ka vary from being in phase with some data to being out of phase with other data (Anders et al., 2005). Such asynchrony may result from lags induced by changing basin processes or from differing propagation rates of base-level change. In any case, cosmogenic nuclide depth profile data, teamed with soil development analysis, offer an improved understanding of piedmont surface processes, soil ages, and piedmont history. The use of nuclide depth profiles allows for quantification of past surface processes and histories, supplementing the information available from boulders cropping out at the surface.

Case 3—Dating Desert Landslides: The Blackhawk, California

Sometime in the past, a thundering avalanche of rock peeled off Blackhawk Mountain above the Mojave Desert and came crashing down to the valley bottom, leaving lobes of pulverized rock studded with boulders (Shreve, 1968, 1987; Stout, 1977). The Blackhawk slide is not alone; large slides have affected other parts of the Mojave Desert (Bishop, 1997). The exact timing and cause of these events is unknown. Some suggest an increase in precipitation is to blame (Stout, 1977); however, seismic shaking can trigger large landslides (Philip and Ritz, 1999). Accurate and precise dating is needed to better understand the timing, and thus perhaps the triggers, such as dated large earthquakes, of these megaslides.

Until recently, the only age control for the Blackhawk landslide was radiocarbon dating of freshwater gastropod and pelecypod shells found in the sediments of a small, ephemeral pond on the landslide's surface: 17,400 ± 550 ^{14}C yr B.P. (Stout, 1975, 1977). This age is problematic for two reasons. The pond is younger than the slide; thus, the age is a stratigraphic minimum. However, since the pond developed on carbonate rocks that may have added ^{14}C-free carbon to the pond water, the date may be too old. With such ambiguity in the ^{14}C dating, the Blackhawk would seem to be an excellent site for applying cosmogenic nuclides as a dating tool; therefore, Stone et al. (1995) collected and analyzed samples of limestone for ^{36}Cl, and we collected samples from gneissic and sandstone boulders and analyzed them for ^{10}Be and ^{26}Al. Stone et al. (1995) concluded that the ^{36}Cl data were ambiguous and difficult to interpret, with apparent ages between 12 and 44 ka. Our results are similarly equivocal and point out limitations in cosmogenic-nuclide dating.

We sampled five boulders to date the Blackhawk landslide (Fig. 4A): a 1.5-m-high quartz-rich gneissic boulder (BH-3) located on the left levee side slope facing the debris zone (Fig.

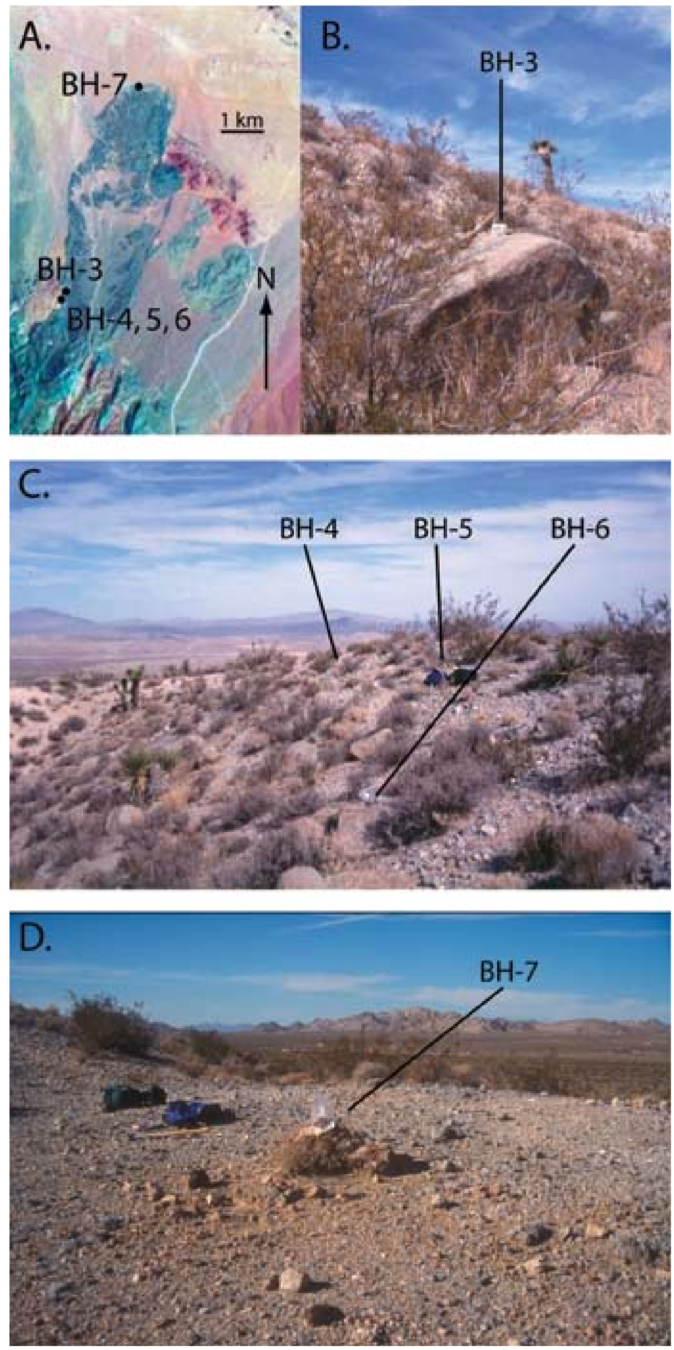

Figure 4. Location map and photographs of Blackhawk landslide boulders sampled for ^{10}Be and ^{26}Al analysis. (A) Landsat 7 image (bands 7, 4, 2) of the Blackhawk landslide debris (dark gray) with sample locations. (B) Granitic boulder BH-3, located on the side of the levee. There is little evidence of sediment erosion or deposition; thus, the slope is a surface of transport. (C) Three granitic boulders (BH-4, BH-5, and BH-6) are near the levee crest, suggesting little chance of burial after initial exposure. (D) Varnished sandstone boulder (BH-7) located at the toe of the landslide debris.

4B); three gneissic boulders (~1 m high, BH-4, BH-5, BH-6) near the left levee crest (Fig. 4C); and one varnished sandstone boulder (BH-7) near the top of the levee crest at the toe of the landslide (Fig. 4D). We set out to determine the age of the slide by assuming that the boulders were unearthed by the landslide and deposited on the surface of the debris, and that the boulders and the slide debris have not eroded since the landslide event. At least one of these assumptions, however, is invalid.

The amount of ^{10}Be and ^{26}Al varies from sample to sample. Because the concentrations of ^{10}Be and ^{26}Al are well correlated (Data Repository Table DR3 [see footnote 1]), we quote two-isotope, average ages. The three boulders near the levee crest have low amounts of ^{10}Be and ^{26}Al and suggest a young age (6.4–7.7 ka; n = 3), whereas the boulder at the toe of the landslide and the side slope boulder contain higher concentrations of nuclides, which suggest older ages (24.1 ± 3.7 ka and 30.9 ± 5.1 ka, respectively; Table DR3).

These data suggest that cosmogenic-nuclide dating is not straightforward for the Blackhawk landslide and that the sampled boulders have not had the same exposure history. The lightly dosed levee boulders could initially have been buried in the levee and later exhumed, a scenario that would result in an age underestimate. Conversely, the boulder at the toe of the landslide and the side-slope boulder could have had previous cosmic-ray exposure, resulting in nuclide inheritance and an age overestimate (Briner and Swanson, 1998). If we assume that the nuclide concentration in levee-crest boulders represents a two-stage history (initial burial followed by exhumation and exposure), we can model a range of landslide ages. By extrapolating the levee slopes to a peak, a maximum of 9.5 m of levee crest erosion could have occurred, based on measured nuclide concentrations. If we use erosion rates of moraines from the eastern side of the Sierra Nevada (Hallet and Putkonen, 1994)—even though such rates may not represent the erosion rates of the Blackhawk landslide debris very well—and model the depth of boulder burial between the surface and 9.5 m, we can model deposition ages between 6.4 and 31 ka. Regardless of the landslide debris erosion rates, the nuclide data do not constrain the age of the landslide any more precisely than to the late Pleistocene. The resulting age ambiguity precludes investigation into possible landslide timing and causes of failure.

The Blackhawk slide highlights two problems inherent to dating landforms: nuclide inheritance and landform erosion or modification after deposition. Boulders exposed near Earth's surface before being transported to a new location carry nuclides from prior periods of cosmic-ray exposure. Thus, a boulder's model age represents total exposure time, not the age of the sampled landform. Such inherited nuclides have proven to complicate the interpretation of cosmogenic data from moraine boulders (Putkonen, 2003), lake-shoreline clasts (Trull et al., 1991; Matmon et al., 2003), striated bedrock (Colgan et al., 2002), and alluvial fan clasts and boulders (e.g., Liu et al., 1996; Zehfuss et al., 2001; Matmon et al., 2005). If one is fortunate enough to avoid, or account for, nuclide inheritance, then exhumation of boulders through landform erosion and/or the loss of mass from boulder surfaces complicates the interpretation of boulder ages (Bierman and Gillespie, 1991; Hallet and Putkonen, 1994; Zimmerman et al., 1994; Putkonen, 2003). Therefore, predepositional exposure and post-depositional surface modification are fundamental limits on the accuracy of cosmogenically determined landform ages.

OTHER RECENT APPLICATIONS

The power of cosmogenic nuclides as a tool for understanding desert systems is just beginning to be realized. In addition to dating fan surfaces (Liu et al., 1996; Phillips et al., 1998), quantifying erosion rates (Bierman and Caffee, 2001, 2002), and determining burial ages (Granger and Smith, 2000), cosmogenic nuclides can be used as sediment tracers (Clapp et al., 2001, 2002; Matmon et al., 2006), allowing the construction of sediment budgets (Nichols et al., 2005a). Such budgets can be robust quantitative descriptors of desert systems, addressing rates of change, forming a framework for rational landscape management, and providing the means to test long-standing conceptual models of landscape behavior in arid regions (Bierman and Nichols, 2004).

Recently, the rich history contained in the sediments of long piedmonts has been deciphered using ^{10}Be (Bierman et al., 1995; Liu et al., 1996; Zehfuss et al., 2001; Phillips, 2003; Matmon et al., 2005). Sediment amalgamation techniques provide cost- and time-effective means to address the spatial variability in ^{10}Be concentration and thus describe the behavior of the piedmont sediment transport system as a whole (Nichols et al., 2002, 2005b). Cosmogenic data allow calculation of long-term average sediment velocities and fluxes on low-gradient piedmonts. The average sediment grain on a piedmont moves a few decimeters to meters per year, depending on the geomorphic setting (Nichols et al., 2005a). These data provide an important land-management tool, essentially a natural benchmark against which to measure human-induced rates of change as development sweeps across the Desert Southwest.

One way to address the role of tectonics, lithology, and climate change on the rate and distribution of geomorphic process is to measure erosion over space and through time. Bierman et al. (2005) quantified the spatial variability of subbasin erosion rates and constrained the average erosion rate of the 14,225 km^2 Rio Puerco basin to ~100 m/m.y. ^{10}Be concentration, and thus erosion rates, are more variable in smaller headwater basins (98% standard deviation [s.d.]; n = 16, μ = 392 km^2) than in larger downstream basins (53% s.d.; n = 21, μ = 5440 km^2), because stream flows homogenize sediment with different cosmic-ray exposure histories and erosion histories. As predicted by numerous geomorphologic studies (e.g., Bull, 1991), Bierman et al. (2005) found that erosion rates are best correlated to vegetation, precipitation, and rock erodibility.

Erosion rates over time can also be measured. Using a flight of well-preserved fluvial terraces, Schaller et al. (2004) measured paleo-erosion rates of the humid Meuse River catchment. By dating the terraces and back-calculating the nuclide inventory during deposition, they were able to determine paleo-erosion rates. Similarly, Bierman et al. (2005) measured ^{10}Be in a 6-m radiocarbon-dated section of Rio Puerco sediment deposited over >1000 yr; the similarity of ^{10}Be concentration among the 15 samples indicated that average cosmic-ray dosing, and thus the basin-scale erosion rate, did not change substantially over the millennial time scale on this arid-region river.

These are only a few examples of how cosmogenic nuclides have advanced our understanding of desert systems and of how using cosmogenic nuclide dating in conjunction with methods, such as thermochronology and luminescence dating, will enable geomorphologists to more thoroughly decipher the detailed history of desert landscape change (House et al., 2001; Lancaster and Tchakerian, 2003). These new data provide quantitative estimates of rates and dates, an important requirement for testing the validity of long-standing models of desert processes/response, such as those linking aggradation and incision with climate and tectonics (Bull, 1991).

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PREMEETING

1. Along-Strike Changes in the Architecture of a Fold-Thrust Belt: An Example from the Hudson Valley, New York [401]
Thurs.–Sun., 19–21 Oct. Kurtis C. Burmeister, Dept. of Geosciences, University of the Pacific, 3601 Pacific Ave., Stockton, CA 95211-0110, USA, +1-217-369-2733, fax +1-213-740-8801, kburmeister@pacific.edu; Steve Marshak. Max.: 30; min.: 12. Cost: US$245 (2ON, vans).

2. Behind the Scenes at the American Philosophical Society, the Library Company, and the Academy of Natural Sciences: Research Collections in the History of Geology and Paleontology [402]
Fri., 20 Oct. Cosponsored by *GSA History of Geology Division.* Gary Rosenberg, Dept. of Geology, Indiana University–Purdue University, 723 W. Michigan St., Indianapolis, IN 46202-5191, USA, +1-317-274-7468, fax +1-317-274-7966, grosenbe@iupui.edu; Sally Newcomb. Max.: 30; min.: 5. Cost: US$79 (L, R, vans).

3. Buried Holocene Streams and Legacy Sediment: Late Pleistocene to Historical Changes in Stream Form and Process and Implications for Stream Restoration, Mid-Atlantic Piedmont Region [403]
Sat., 21 Oct. Dorothy Merritts, Dept. of Earth & Environment, Franklin and Marshall College, P.O. Box 3003, Lancaster, PA 17604-3003, USA, +1-717-291-4398, fax +1-717-291-4186, Dorothy.merritts@fandm.edu; Robert Walter; Ward Oberholtzer. Max.: 35; min.: 10. Cost: US$89 (L, R, bus).

4. Coastal Hydrology and Processes of Atlantic Barrier Islands [404]
Sat., 21 Oct. Rip Kirby, Coastal Research Lab, University of South Florida, 4202 E. Fowler Ave., SCA520, Tampa, FL 33620, USA, +1-850-217-1616, jkirby@mail.usf.edu. Max.: 24; min.: 10. Cost: US$89 (B, R, vans).

5. Effects of Metasomatism and Fusion of Host Rock on the Chemistry of Early Jurassic Palisades Diabase in the Newark Basin [405]
Sat., 21 Oct. Alan Benimoff, Dept. of Engineering Science & Physics, City University of New York, College of Staten Island, 2800 Victory Blvd., Staten Island, NY 10314-6609, USA, +1-718-982-2835, fax +1-718-892-2830, benimoff@mailcsi.cuny.edu; John Puffer. Max.: 12; min.: 6. Cost: US$129 (L, R, vans).

6. Journey into Anthracite [406]
Sat., 21 Oct. Aaron R. Frantz, CDM, One Cambridge Place, 50 Hampshire Street, Cambridge, MA 02139, USA, +1-610-293-0450, frantzar@cdm.com; Ed Simpson; Dale Freudenberger. Max.: 33; min.: 12. Cost: US$69 (L, R, vans).

7. Lacustrine Cyclicity and the Triassic-Jurassic Transition [407]
Fri.–Sat., 20–21 Oct. Cosponsored by *GSA Sedimentary Geology Division; GSA Limnogeology Division.* Paul Olsen, Lamont-Doherty Earth Observatory, Columbia University, P.O. Box 1000, 61 Route 9W, Palisades, NY 10964-1000, USA, +1-845-365-8491, fax +1-845-365-8163, polsen@ldeo.columbia.edu; Jessica Whiteside. Max.: 40; min.: 5. Cost: US$245 (2L, R, ON, bus).

8. Late Pleistocene to Modern Lacustrine Processes and Paleoclimatic History in the Finger Lakes, New York [408]
Fri.–Sat., 20–21 Oct. Cosponsored by *GSA Sedimentary Geology Division; GSA Limnogeology Division.* John Halfman, Dept. of Geosciences & Environmental Studies, Hobart and William Smith College, 4002 Scandling Ctr, Geneva, NY 14456-3322, USA, +1-315-781-3918, fax +1-315-781-3860, halfman@hws.edu; Tara Curtin; Neil Laird; Pete Knuepfer. Max.: 40; min.: 21. Cost: US$299 (2L, D, 2R, ON, bus).

9. New Insights to an Old Fold-Thrust Belt [409]
Fri.–Sat., 20–21 Oct. Steven Wojtal, Dept. of Geology, Oberlin College, 52 W. Lorain St., Oberlin, OH 44074-1044, USA, +1-440-775-8352, fax +1-440-775-8038, steven.wojtal@oberlin.edu; Patricia Campbell; Tom Anderson. Max.: 30; min.: 15. Cost: US$185 (2L, 2R, ON, vans).

10. Plant Paleoecology and Geology of the Southern Anthracite Field, Pennsylvania [410]
Fri., 20 Oct., Hermann Pfefferkorn, Dept. of Earth & Environment Science, University of Pennsylvania, 240 S. 33rd St., Philadelphia, PA 19104-6316, USA, +1-215-898-5156, fax +1-215-898-0964, hpfeffer@sas.upenn.edu; Rudy Slingerland; William Kochanov. Max.: 44; min.: 17. Cost: US$69 (L, R, bus).

11. Prehistoric and Urban Landscapes of the Middle Atlantic Region: Geoarchaeological Perspectives [411]
Sat., 21 Oct. Cosponsored by *GSA Archaeological Division.* Joseph Schuldenrein, Geoarcheology Research Associates,

5912 Spencer Ave, Riverdale, NY 10471, USA, +1-718-601-3861, fax +1-718-601-3864, geoarch@aol.com. Max.: 50; min.: 30. Cost: US$85 (L, R, bus).

12. Refining the Metamorphic and Tectonic History of the Southeastern Pennsylvania Piedmont: Recent Results from Monazite and Zircon Geochronology and Accessory-Phase Thermometry [412]
Fri.–Sat., 20–21 Oct. Joe Pyle, Rensselaer Polytechnic Institute, 110 8th St., Troy, NY 12180-3522, USA, +1-518-276-4899, fax +1-518-276-2012, pylej@rpi.edu; Hal Bosbyshell; Gale Blackmer. Max.: 25; min.: 7. Cost: US$245 (B, 2L, D, 2R, ON, vans).

13. Rivers, Glaciers, Landscape Evolution, and Active Tectonics of the Central Appalachians, Pennsylvania and Maryland [413]
Wed.–Sat., 18–21 Oct. Cosponsored by *GSA Quaternary Geology and Geomorphology Division.* Frank Pazzaglia, Dept. of Earth & Environmental Sciences, Lehigh University, 31 Williams Dr., Bethlehem, PA 18015-3126, USA, +1-610-758-3667, fax +1-610-838-2344, fjp3@lehigh.edu; Duane Braun; Noel Potter; Dru Germanoski; Milan Pavich; Paul Bierman; Dorothy Merritts; Allen Gellis. Max.: 30; min.: 15. Cost: US$375 (3B, 3L, 2D, 3ON, vans). *Begins in Washington, D.C. Participants will be advised on arrival options.*

14. Rodinian Collisional and Escape Tectonics in the Hudson Highlands, New York [414]
Thurs.–Sat. 19–21 Oct. Cosponsored by *Highlands Environment Research Institute.* Alexander Gates, Dept. of Earth & Environmental Sciences, Rutgers State University, Newark, NJ 07102-1811, USA, +1-973-353-5034, fax +1-973-353-1965, agates@andromeda.rutgers.edu; David Valentino; Mathew Gorring. Max.: 30; min.: 8. Cost: US$245 (2L, 2D, R, 2ON, vans).

15. Stratigraphy and Paleontology of the Chesapeake Group [415]
Wed.–Sat., 18–21 Oct. Luack Ward, Virginia Natural History Museum, 1001 Douglas Ave, Martinsville, VA 24112-4717, USA, +1-276-666-8628, fax +1-276-666-8624, lwward@vmnh.net; Alton C. Dooley Jr., Max.: 20; min.: 5. Cost: US$275 (L, D, 2R, 2ON, vans).

16. Stratigraphy of the Cambrian and Lower Ordovician Carbonates of the Kittatinny Supergroup, Northwestern New Jersey: Special Attention to the Nature and Timing of Silica Diagenesis and the Origin of Nodular Cherts [416]
Fri.–Sat., 20–21 Oct. Philip C. LaPorta, City University of New York and LaPorta Associates, 116 Bellvale Lakes Rd., Warwick, NY 10990-3402, USA, +1-845-986-7733, fax +1-845-988-9988, plaporta@laportageol.com; Margaret Brewer; Scott Minchak. Max.: 12; min.: 6. Cost: US$199 (2L, 2R, ON, vans).

17. Taconic Orogeny in the Susquehanna Shelf and Foreland [417]
Fri.–Sat., 20–21 Oct. Don Wise, Dept. of Geosciences, University of Massachusetts, Amherst, MA 01003, USA, +1-413-545-0482, fax +1-717-291-4186, dwise@geo.umass.edu; Bob Ganis. Max.: 45; min.: 20. Cost: US$199 (B, 2L, D, R, ON, bus).

18. Tectonic History of the Blue Ridge, North-Central Virginia [418]
Thurs.–Sat., 19–21 Oct. Christopher (Chuck) Bailey, College of William and Mary, Williamsburg, VA 23187-8795, USA, +1-757-221-2445, cmbail@wm.edu; Scott Southworth; Richard Tollo. Max.: 32; min.: 12. Cost: US$285 (2B, 3L, D, 3R, 2ON, vans).

19. The Great Centralia Mine Fire: A Natural Laboratory for the Study of Coal Fires [419]
Sat., 21 Oct. Glenn Stracher, Div. of Science & Mathematics, East Georgia College, 131 College Cir., Swainsboro, GA 30401-3643, USA, +1-478-289-2073, fax +1-478-289-2050, stracher@ega.edu; Melissa Nolter; Daniel H. Vice; Janet L. Stracher. Max.: 45; min.: 12. Cost: US$95 (L, D, R, bus).

DURING THE MEETING

20. 135 Million Years of History in Southwestern Philadelphia [420]
Sun., 22 Oct. Raymond A. Scheinfeld., Weston Solutions Inc., 1 Weston Way, West Chester, PA 19380-1469, USA, +1-215-841-2019, ray.scheinfeld@westonsolutions.com. Max.: 30; min.: 10. Cost: US$59 (R, vans).

21. Bicycle Tour of the Geology and Hydrology of Philadelphia [421]
Tues., 24 Oct., Raymond A. Scheinfeld, Weston Solutions, 1 Weston Way, West Chester, PA 19380-1469, USA, +1-215-841-2019, ray.scheinfeld@westonsolutions.com. Max.: 25; min.: 5. Cost w/bike rental: US$55. Cost w/o bike rental: US$25 (R, bikes).

22. Erosion and the Hickory Run Boulder Field—1st Annual Kirk Bryan Field Seminar [422]
Tues., 24 Oct. Cosponsored by *GSA Quaternary Geology and Geomorphology Division.* Frank Pazzaglia, Dept. of Earth & Environmental Sciences, Lehigh University, 31 Williams Dr., Bethlehem, PA 18015-3126, +1-610-758-3667, fax +1-610-838-2344, fjp3@lehigh.edu; Paul Nierman; Milan Pavich; Dorothy Merritts. Max.: 60; min.: 20. Cost: US$59 (B, L, vans).

23. Geology of Delaware Water Gap, New Jersey–Pennsylvania [423]
Wed., 25 Oct. Jack Epstein, U.S. Geological Survey, 926-A National Ctr., Reston, VA 20192-0001, USA, +1-703-648-6944, fax +1-703-648-6953, jepstein@usgs.gov; Tim Connors; Denise Cooke-Bauer; Rab Cika. Max.: 40; min.: 15. Cost: US$89 (L, bus).

24. Philadelphia Urban Hydrology [424]
Tues.–Wed., 24–25 Oct. Laura Toran, Dept. of Geology, Temple University, Philadelphia, PA 19122, USA, +1-215-204-2352, fax +1-215-204-3496, ltoran@temple.edu; Chris Crockett. Max.: 45; min.: 5. Cost: US$45 (L, R, vans).

POSTMEETING

25. A Tour of the Peach Bottom Slate—Once the Best Building Slate in the World [425]
Thurs., 26 Oct. Jeri Jones, Jones Geological Services, 276 N. Main St., Spring Grove, PA 17362-1127, USA, +1-717-225-3744, fax +1-717-840-7403, JLJ276@aol.com; Mary Ann Schlegel; Charles Scharnberger; Donald Robinson. Max.: 24; min.: 12. Cost: US$69 (L, R, vans).

26. Arsenic in Groundwater in the Newark Basin [426]
Thurs., 26 Oct. Cosponsored by *GSA Sedimentary Geology Division; GSA Geology and Health Division.* Mike Serfes, New Jersey Geological Survey, P.O. Box 427, Trenton, NJ 08625-0427, USA, +1-609-984-6587, mike.serfes@dep.state.nj.us; Steve Spayd; Paul Olsen. Max.: 40; min.: 10. Cost: US$59 (L, R, bus).

27. Central Appalachian Transect along the Potomac River Corridor [427]
Thurs.–Fri., 26–27 Oct. Scott Southworth, U.S. Geological Survey, 1500 Hampton Hill Circle, Reston, VA 20192, USA, +1-703-648-6385, ssouthwo@usgs.gov; Robert Wintsch; Michael Kunk. Max.: 24; min.: 5. Cost: US$259 (2L, 2R, ON, vans).

28. Environmental Issues Associated with Sulfide Occurrences in Pennsylvania [428]
Wed.–Fri., 25–27 Oct. Ryan Mathur, Dept. of Geology, Juniata College, 1700 Moore St., Huntingdon, PA 16652-2119, USA, +1-814-641-3725; David P. Gold, dpgold33@adelphia.net; Ryan Mather; Arnold Doden; Larry Mutti. Max.: 45; min.: 25. Cost: US$225 (B, 2L, 2ON, bus).

29. From the K-T to the Coast: Paleontology, Stratigraphy, and Coastal Sedimentation from the Late Cretaceous through the Quaternary, Southern New Jersey [429]
Thurs., 26 Oct. William Gallagher, New Jersey State Museum, 205 West State St., CN530, Trenton, NJ 08625-0530, USA, +1-609-292-6330, william.gallagher@sos.state.nj.us; Ken Lacovara. Max.: 45; min.: 25. Cost: US$69 (L, bus).

30. Geologic, Hydrogeologic, and Biogeochemical Controls on Natural and Enhanced Degradation of Industrial Solvents in Fractured Rocks [430]
Thurs., 26 Oct., Dan Goode, U.S. Geological Survey, 770 Pennsylvania Dr. #116, Exton, PA 19341-1186, USA, +1-717-571-8783, djgoode@usgs.gov; Claire Tiedeman. Max.: 60; min.: 20. Cost: US$65 (L,R, bus).

31. History and Geology of Gettysburg National Battlefield [431]
Thurs., 26 Oct. Roger Cuffey, Dept. of Geosciences, Pennsylvania State University, 412 Deike Bldg., University Park, PA 16802-2713, USA, +1- 814-865-1293, fax +1-814-863-8724, cuffey@ems.psu.edu; Jon Inners. Max.: 42; min.: 15. Cost: US$95 (R, bus).

32. Karst and Environmental Hydrology in Central Pennsylvania [432]
Wed.–Fri., 25–27 Oct. Richard Parizek, Pennsylvania State University, 751 Mckee St., State College, PA 16803-3631, USA, +1-814-865-3012, fax +1-814-238-5261, parizek@ems.psu.edu. Max.: 45; min.: 10. Cost: US$295 (3B, 3L, 3D, 2ON, vans).

33. Paleontology and Paleoenvironments of the Upper Devonian Catskill Formation in North-Central Pennsylvania [433]
Thurs.–Fri., 26–27 Oct. Ted Daeschler, Academy of Natural Science, 1900 Parkway, Philadelphia, PA 19103-1101, USA, +1-215-299-1133, fax +1-215-299-1028, daeschler@acnatsci.org; Walt Cressler. Max.: 27; min.: 12. Cost: US$175 (B, 2L, D, ON, vans).

34. Prehistoric Quarries and Early Mines in the New York–New Jersey–Pennsylvania Tri-State Metropolitan Area [434]
Thurs.–Sat., 26–28 Oct. Cosponsored by *GSA Archaeological Geology Division.* Philip C. LaPorta, City University of New York and LaPorta Associates, 116 Bellvale Lakes Rd., Warwick, NY 10990-3402, USA, +1-845-986-7733, fax +1-845-988-9988, plaporta@laportageol.com; Margaret Brewer; Scott Minchak. Max.: 12; min.: 6. Cost: US$299 (3L, 3R, 2ON, vans)

Philadelphia 2006 Short Courses

GSA-SPONSORED SHORT COURSES

GSA-sponsored professional development short courses will be held immediately before and during the annual meeting and are open to members and nonmembers. If you register *only* for a short course, you must pay a US$40 nonregistrant fee in addition to the course fee. This fee may be applied toward meeting registration if you decide to attend the meeting. Excepted from this requirement are GSA K–12 Teacher Members, who need only pay the short course fee if not attending the entire meeting. Early registration is recommended; standard registration (after 18 Sept.) is an additional US$30. A special Subaru of America grant is available to Pennsylvania graduate students and two-year college faculty that will cover half of the meeting registration fee. Go to www.geosociety.org/meetings/2006/rSubaru.htm for more information on this grant.

Cancellation Deadline: 19 Sept. 2006

Continuing Education Unit (CEU) Service

All professional development courses and workshops sponsored by GSA offer CEUs. A CEU is made up of 10 contact hours of participation in an organized continuing education experience under responsible sponsorship, capable direction, and qualified instruction. A contact hour is defined as a typical 60-minute classroom instructional session or its equivalent; ten instructional hours are required for one CEU.

1. Beyond the Content: Teaching Scientific and Citizenship Literacies in the Geosciences [501]

Sat., 21 Oct., 9 a.m.–5 p.m. Cosponsored by *GSA Geoscience Education Division*

Have you, as an earth science instructor, been restricted in the complexity of the course material you can present by students' limited basic skills? This workshop focuses on successful and innovative techniques for incorporating the review of scientific and citizenship literacy into introductory and junior-level university earth science courses, without compromising content.

Faculty: Erin Campbell-Stone, Ph.D.; James D. Myers, Ph.D.; both with the Department of Geology and Geophysics, University of Wyoming. Limit: 60. Fee: US$200; includes course materials and lunch. CEU: 0.7.

2. Using GPS Data to Study Crustal Deformation, Earthquakes, and Volcanism: A Workshop for College Faculty [502]

Sun., 22 Oct., 7:30 a.m.–12:30 p.m.
Cosponsored by *GSA Geoscience Education Division*

This course is geared toward faculty at two- and four-year institutions who teach general education or introductory or lower level geoscience courses in which plate tectonics is a topic. Faculty will be introduced to place-based, data-rich educational materials about global positioning systems (GPS) and plate tectonics to use in their classrooms, receive an introduction to high-precision GPS, and have the opportunity to discuss pedagogical strategies for classroom implementation. Anticipated topics include slow earthquakes in Cascadia and monitoring volcano deformation. Although individuals with GPS experience are welcome, knowledge of GPS is not required. **Participants should bring a laptop computer with wireless Internet capability.**

Faculty: Susan Eriksson, Ph.D.; Becca Walker; David Phillips, Ph.D.; all with UNAVCO. Limit: 20. Fee: US$160; includes course materials and refreshments. CEU: 0.5.

3. Digital Terrain Mapping [503]

Sat., 21 Oct., 8 a.m.–5 p.m.
Cosponsored by *GSA Engineering Geology Division; GSA Quaternary Geology and Geomorphology Division*

Hands-on introduction to digital elevation models (DEMs), triangulated irregular networks (TINs), and xyz(i) point clouds to visualize and analyze topography. Conventional, radar, and LIDAR elevation data; geodetic datum and coordinate systems; interpolation; derivative maps; effects of errors; image processing tools; and geologic process models. No previous terrain modeling experience required. **Participants are asked to bring a laptop computer (Macintosh OS X, Windows, Linux) with wireless capabilities and pre-installed free software (instructions provided) to participate in the computer exercises.**

Faculty: William C. Haneberg, Ph.D., consulting geologist, www.haneberg.com. Limit: 50. Fee: US$240; includes course materials and refreshments. CEU: 0.8.

4. Enhanced Seismology Education for Undergraduates [504]

Sat., 21 Oct., 8 a.m.–5 p.m.
Cosponsored by *GSA Geoscience Education Division*

This workshop is intended for faculty at 2- and 4-year colleges and universities who wish to learn both new seismology content and instructional strategies to effectively convey content to students. Seismology topics will include "hot topics," causes of earthquakes, propagation of seismic waves, statistics and data, Earth's structure, and hazards. Educational topics will feature instructional sequences, student conceptions in geoscience, and constructivist learning theory. Effective science instruction will be modeled by emphasizing hands-on and inquiry-based activities to deliver content to learners.

Faculty: Jeff Barker, Ph.D., Binghamton University; Michael Hubenthal, IRIS Consortium; Tom Owens, Ph.D., University of South Carolina; John Taber, Ph.D., IRIS Consortium. Limit: 25. Fee: US$15; includes course materials and lunch. CEU: 0.8.

5. Scientific Inquiry in the K–16 Classroom: What Every Scientist Should Know about Effective Science Education [505]

Sat., 21 Oct., 8 a.m.–noon
Cosponsored by *GSA Geoscience Education Division*

This course provides research-based and hands-on experiences with scientific inquiry in school classrooms. Inquiry is both a content area—the understanding of how science works that every student needs to become a science-literate citizen—and a set of teaching and learning strategies that replicates the discovery process of science in teaching students the big ideas of science. This course is designed for scientists and science educators at all levels who wish to contribute to education as volunteers or in professional capacities as part of research-related outreach programs or to meet the "broader impacts" requirements of their research funders.

Faculty: Sandra Laursen, Ph.D., Cooperative Institute for Research in Environmental Sciences (CIRES), University of Colorado, Boulder, Colo.; Lesley Smith, Ph.D., CIRES, University of Colorado, Boulder, Colo.; Carol Schott, M.A., Science Discovery, University of Colorado, Boulder, Colo. Limit: 50. Fee: US$145; includes course materials and refreshments. CEU: 0.4.

6. Using EarthEdOnline: Online Delivery System for Data-Rich Inquiry Education [506]

Sat., 21 Oct., 8 a.m.–5 p.m.
Cosponsored by *GSA Geoscience Education Division*

This course provides hands-on training in the use of the "EarthEdOnline" software package to deliver data-rich inquiry activities to learners at a wide range of education levels. It will cover the goals and issues involved with presenting inquiry activities, scaffolding of activities to ensure success, online peer review, and configuring EarthEdOnline software. **Participants should bring a laptop computer with wireless capability.**

Faculty: William Prothero, University of California (emeritus), Santa Barbara, Calif.; Ph.D., University of California, San Diego, Calif.; Sabina Thomas, Baldwin Wallace College, Berea, Ohio; Ph.D., Technical University of Berlin. Limit: 20. Fee: US$150; includes course materials and refreshments. CEU: 0.8.

7. Education Research: An In-Depth Look at Qualitative Methods [507]

Sat., 21 Oct., 1 p.m.–5 p.m.
Cosponsored by *GSA Geoscience Education Division*

Participants will learn about qualitative data collection and analysis methods used in geoscience education research. Qualitative research involves the collection and analysis of data from sources such as interviews, classroom observations, and student writings and drawings. It is the building block of and a complement to quantitative education research. Case studies, demonstrations, and hands-on activities will introduce participants to qualitative education research. This workshop is geared for college and K–12 educators, researchers, and students who are conducting or planning education research.

Faculty: Julie Sexton, doctoral fellow, National Science Foundation Center for Learning and Teaching in the West, Colorado State University, Fort Collins, Colo., ju.sexton@colostate.edu. Limit: 55. Fee $140; includes course materials. CEU: 0.4.

8. Using Online Igneous Geochemical Databases for Research and Teaching [508]

Sat., 21 Oct., 1 p.m.–5:30 p.m.
Cosponsored by *GSA Geoscience Education Division*

This course will give students, teachers, and researchers training on geochemical database systems for igneous rocks. The course will include a variety of exercises and short lectures to explore and explain how these systems work. The course is intended to be a blend of education opportunities in the use of geochemical databases and background knowledge about geoinformatics, relational databases, and data reporting. A general knowledge of petrology is required. **Participants should bring a laptop computer with wireless capability** (if unable, please contact instructor Walker at jdwalker@ku.edu).

Faculty: Kerstin Lehnert, Ph.D., Lamont-Doherty Earth Observatory of Columbia University, Palisades, N.Y.; Kent Ratajeski, Ph.D., Department of Geosciences, University of West Georgia, Carrollton, Ga.; Doug Walker, Ph.D., Department of Geology, University of Kansas, Lawrence, Kans. Limit: 55. Fee: US$25; includes course materials and refreshments. CEU: 0.4.

9. Introduction to Geographic Information Systems (GIS) Using ArcGIS9 for Geological Applications [509]

Fri.–Sat., 20–21 Oct., 8 a.m.–5 p.m.

This short course will introduce the use of GIS in geology-related applications through brief lectures and hands-on computer exercises. Concepts in creating a GIS project in geology will be discussed, including creation of data (global position systems, remote sensing, digitizing), conversion of data, metadata, different data formats (vector and raster) and accessing data from several sources (tables, shapefiles, coverages, computer-aided drafting, geodatabases, and grids). Participants do not need to have experience with ArcGIS, but familiarity with Windows OS is beneficial.

Faculty: Ann B. Johnson, Higher Education Manager, Environmental Systems Research Institute, Redlands, Calif.; Ph.D., California State University; Willy Lunch, Instructor, Environmental Systems Research Institute, Denver, Colo.; M.S., University of Utah. Limit: 24. Fee: US$299; includes course manual and lunch. CEU: 1.6.

K–12 SHORT COURSE

GSA K–12 Teacher Members who wish to attend only the GSA short courses are not required to pay the annual meeting registration fee; for all others, annual meeting registration as well as payment of the short course fee are required for participation. Annual Meeting registration for K–12 professionals or for others who will participate only in this short course is US$40 if registered by 18 Sept. and US$45 after 18 Sept.

1. Using Authentic Scientific Ocean Drilling Data for Earth Systems Science Inquiry [601]

Sun., 22 Oct., 9 a.m.–5 p.m.
Cosponsored by *Joint Oceanographic Institutions; GSA Geoscience Education Division*

Through inquiry exercises, educators will discover how accessible and applicable scientific ocean drilling results are to the undergraduate and secondary earth systems science curricula they teach. Published data from 40 years of scientific ocean drilling expeditions can support the teaching of plate tectonics, deep time and age determination, and the history of global climate change. This is an onshore extension of the recent Joint Oceanographic Institutions (JOI) "School of Rock" Expedition (www.joilearning.org/schoolofrock).

Faculty: Kristen St. John, Ph.D., James Madison University, Harrisonburg, Virginia; Mark Leckie, Ph.D., University of Massachusetts, Amherst, Massachusetts; Leslie Peart, JOI, Washington, DC. Limit: 30. Fee: US$25; includes course materials and lunch.

OTHER COURSES

Registration and information can be obtained from the contact person listed.

Core Analysis of Lake Sediments
Sat., 21 Oct., 11 a.m.–5 p.m. GSA Limnogeology Division Workshop. Sponsored by *ExxonMobil*.

Core analysis and comparison of modern lake sediments and fossil lake rock sequences will shed light on sedimentation processes, climatic effects, and the preservation potential of fossils and structures through time and space. Please bring posters and/or cores describing your lake sediments. Posters can also be submitted for the poster session held during the annual meeting. For more information, contact Elizabeth Gierlowski-Kordesch, gierlows@ohio.edu.

Sequence Stratigraphy for Graduate Students
Fri.–Sat., 20–21 Oct., 8 a.m.–5 p.m. Cosponsored by *ExxonMobil; BP*.

This free two-day short course is designed to teach graduate students the principles, concepts, and methods of sequence stratigraphy. Sequence stratigraphy is a methodology that uses stratal surfaces to subdivide the stratigraphic record. This methodology allows for the identification of coeval facies, documents the time-transgressive nature of classic lithostratigraphic units, and provides geoscientists with an additional way to analyze and subdivide the stratigraphic record. Using exercises that utilize outcrop, core, well-log, and seismic data, the course provides hands-on experience in learning sequence stratigraphy. Exercises include classic case studies from which many sequence stratigraphic concepts were originally developed. Instructors: Art Donovan Ph.D. (Colorado School of Mines), BP (British Petroleum); Kirt Campion Ph.D., ExxonMobil Upstream Research Co. Limit: 40. No fee. Preregistration required. For information or to register, please contact art.donovan@bp.com.

Geochronology: Emerging Opportunities
Sat., 21 Oct., 8 a.m.–5 p.m. Sponsored by *The Paleontological Society*.

Study of the history of life is critically dependent on knowledge of the precise times and sequence of events. Accurate estimates of time depend on the quality of radiometric ages and the manner in which they are integrated in stratigraphic correlation and development of time scales. The impetus for this short course came from the work of a 2003 Earthtime workshop. The short course will focus on new windows on the history of life that have been opened by collaboration between paleontologists and geochronologists in estimating geologic ages. Speakers who have agreed to participate include Sam Bowring, Doug Erwin, George Gehring, Felix Gradstein, Brent Miller, Heiko Palike, Troy Rasbury, Paul Renne, and Peter Sadler. Organizers: Thomas Olszewski, Dept. of Geology and Geophysics, Texas A&M University, 3115 TAMU, College Station, TX 77843-3115, USA, +1-979-845-2465, fax +1-979-845-6162, tomo@geo.tamu.edu; Warren D. Huff, Dept. of Geology, University of Cincinnati, P.O. Box 0013, Cincinnati, OH 45221-0013, USA, +1-513-556-3731, fax: +1-513-556-6931, warren.huff@uc.edu.

Philadelphia 2006 K–12 Educational Events

SPECIAL K–12 TEACHER DAY FIELD TRIP AND WORKSHOP SHARE-A-THON
Sat., 21 Oct., 8 a.m.–5 p.m.
Cosponsored by GSA Geoscience Education Division

Calling all K–12 teachers and pre-service students! Join us for a day-long K–12 event. We will begin with an urban field trip through parts of Philadelphia, where we will observe various rocks and other natural building materials as they are used for construction and architectural aesthetics. Search for fossils on building faces, find the rare Pennsylvania bluestone, and measure microclimates and noise that is enhanced or mitigated by building designs. In the afternoon workshop share-a-thon, you can network with fellow teachers and geologists, pick up new lesson ideas, and be inspired by guest speakers who will share their stories. Guest passes to the opening of the Exhibit Hall will be available to participants. The participation fee for the entire day is only US$15 and includes lunch and giveaways. The registration form is available online at www.physics.purdue.edu/gsa/. This promises to be both entertaining and informative, so plan to join us for Teacher Day at GSA!

K–12 SHORT COURSE
Using Authentic Scientific Ocean Drilling Data for Earth Systems Science Inquiry [601]
Sun., 22 Oct., 9 a.m.–5 p.m. Cosponsored by *Joint Oceanographic Institutions; GSA Geoscience Education Division*. See the 2006 Philadelphia Short Courses for description and registration information.

THE GEOLOGICAL SOCIETY OF AMERICA

Minority Student Travel Grants

Application Deadline: 7 September 2006

The GSA Minorities and Women in the Geosciences Committee and the GSA Foundation announce the availability of student travel grant funds for one or more eligible minority students or students with disabilities to attend the GSA Annual Meeting in Philadelphia, Pennsylvania, on 22–25 October 2006.

The primary goal of this travel scholarship is to encourage the visibility of minorities in the geosciences at national meetings. Successful candidate(s) will receive up to US$1,500, to include roundtrip airfare, hotel accommodations, meeting registration, meals, and a 2007 GSA student membership. Undergraduate and graduate students may apply by sending or e-mailing a letter that includes (1) their contact information, student status, and institution; (2) a personal statement regarding how attending the annual meeting will personally benefit them and their future geoscience career; and (3) the name and contact information of the student's departmental advisor. Applicants must be full-time students (undergraduate or graduate) enrolled in an accredited university or college for fall 2006 and majoring in geology or earth science. Preference will be given to students involved in geological research or who will be presenting papers or posters either as primary or secondary authors. GSA membership is not an eligibility requirement.

Send your letter of application (limit two pages) to Deborah Nelson, GSA, P.O. Box 9140, Boulder, CO 80301, USA, dnelson@geosociety.org, by 7 September 2006.

GSA Section Travel Grants

The GSA Foundation has made $4,500 in grants available to each of the six GSA Sections. The money, when combined with equal funds from the Sections, is used to help GSA undergraduate Student Associates and graduate Student Members travel to GSA meetings. For information and deadlines, go to www.geosociety.org/sectdiv/sections.htm or contact your Section secretary.

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GSA Student Travel Fund

GSA is pleased to offer assistance to member undergraduate and graduate students to help cover some of the costs associated with attending the GSA Annual Meeting. A fund has been set up within the GSA Foundation for attendee contributions, and GSA and the Foundation will each contribute US$1,000 for the 2006 Philadelphia Annual Meeting. The number and amount of awards will be solely based on contributions received; 100% of the contributions received will go to help fund student travel. For more information or to apply online, go to www.geosociety.org/meetings/2006.

Student Scholarships For Field Trips

As part of the Roy J. Shlemon Meeting Awards Program, GSA's **Engineering Geology Division** provides funding to graduate and undergraduate students attending GSA field trips. The only criteria are that you must be a student member of the Engineering Geology Division and that you are making satisfactory progress toward your degree. For a detailed description of this program, you can visit http://rock.geosociety.org/egd/index.html and click on "Scholarships." If you need more information, you can reach Rob Larson at ralarson1@dslextreme.com. **Deadline for applications:** 1 August 2006.

GSA's **Structural Geology and Tectonics Division** is offering scholarships to Division-affiliated student members for Division-sponsored field trips. Apply in writing, by e-mail, giving your name, institution, class, specialty, poster or talk title, field trip title, and a one-paragraph rationale to Peter Vrolijk, peter.vrolijk@exxonmobil.com. See the Structural Geology and Tectonics Division newsletter for more information.

Student Scholarships For Short Courses

If you are planning to attend any of the GSA-sponsored short courses (p. 15 of this issue), check here first!

- GSA's **Geoscience Education Division** will subsidize the first five student registrants who are valid division members. The student must pay the full course fee when registering, but will be reimbursed US$50 after the GSA meeting by the Geoscience Education Division.
- GSA's **Engineering Geology Division** will subsidize the first five student registrants who are valid division members. Students must pay the full course fee when registering, but will be reimbursed US$50 after the GSA meeting by the Engineering Geology Division.
- GSA's **Quaternary Geology and Geomorphology Division** will subsidize the first five student registrants who are valid division members. Students must pay the full course fee when registering, but will be reimbursed US$50 after the GSA meeting by the Quaternary Geology and Geomorphology Division.

For more information, contact Karlon Blythe, kblythe@geosociety.org.

New Members: GSA Welcomes You!

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

The 2007–2008 Congressional Science Fellow will be selected from top competitors early in 2007. Prospective candidates should be GSA Members with a broad geoscience background and excellent written and oral communication skills. Minimum requirements are a master's degree with at least five years professional experience or a Ph.D. at the time of appointment.

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

Deadline to apply:
1 February 2007

For application information, visit www.geosociety.org/science/csf/index.htm, or contact Ginger Williams, +1-303-357-1040, gwilliams@geosociety.org.

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2006–2007 Congressional Science Fellow Named: Craig Cooper

Craig Cooper

Craig Cooper has been named the 2006–2007 GSA–U.S. Geological Survey Congressional Science Fellow. Cooper's research examines how biogeochemical cycles impact metal geochemistry in environmental systems. His publications include articles on metal sulfide geochemistry in shallow marine sediments, the impact of microbial iron reduction on metal geochemistry, linkages between the iron and nitrogen cycles in anaerobic systems, and radionuclide fate and transport in the environment. Cooper believes that research into the geosciences can help society to more efficiently utilize natural resources in ways that minimize the impacts of human industry on the environment, thereby helping to improve our quality of life.

Cooper studied chemistry at Clemson University, working as a student intern at Tennessee Eastman Corporation and later as a research assistant in the Department of Environmental Engineering and Science. After earning his B.S. in 1991, he completed a Ph.D. in oceanography at Texas A&M University (1998). While at Texas A&M, Cooper received a Texas Research Foundation Fellowship and studied the Fe and S cycle in sea grass beds and cold seep communities in addition to his Ph.D. work. He performed postdoctoral work at the School of Public and Environmental Affairs at Indiana University and taught chemistry as a visiting assistant professor in the chemistry department at Indiana University before joining the Idaho National Laboratory (INL) in 2000. Since joining the INL, Cooper has supported a range of projects, including investigations of how vadose zone biogeochemical processes impact ^{14}C, ^{3}H, and uranium transport, the impact of ionic strength cycling on metal and radionuclide sorption to soil minerals, and radionuclide decontamination of building material surfaces.

Cooper believes that his broad, diverse scientific background provides unique insight into the dependence of human society and its economic underpinnings on the sustainable use of natural resources. "As geoscientists, we don't often think about how our research impacts people—but it does. Developing natural resources generates wealth, but hasty decisions that sacrifice long-term sustainability for short-term profits threaten to leave our children with a poorer life … The future of the geosciences, and our society, requires that we communicate this message more effectively," said Cooper. Science has become overly politicized, Cooper believes, and he relishes the opportunity to work closely with lawmakers to use science to inform all decisions rather than to advocate a particular policy.

"Energy, water, land use, national security, and climate are all interrelated. We are going to be forced to deal with these issues soon, and the negotiations are going to be contentious. I hope that my experience as a congressional fellow will help strengthen the informative power of the geosciences and enable me to serve society by working at the nexus between science and policy in the years to come." Cooper considers it a great honor and responsibility to participate in the fellowship program, and plans to return to the Idaho National Laboratory after his fellowship experience.

Call for Geological Papers

2007

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

12–13 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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EARTHCACHING

Earth Science Week 2006 GSA EarthCache EventCache

EarthCache GSA

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Help GSA celebrate Earth Science Week by hosting a special EarthCache EventCache!

Earth Science Week is 8–14 October 2006. GSA is looking for volunteers to staff select EarthCache EventCache locations on Sunday, 8 October 2006, in order to explain the location's significance to earth science.

If you have a favorite geologic site you want to share, please consider hosting an EarthCache EventCache! For more information, contact Chris McLelland, educator@geosociety.org, +1-303-357-1082.

EarthCaches are special geocaching sites that can be located using a global positioning satellite device. EarthCachers can obtain site coordinates and educational material from the EarthCache Web page, **www.earthcache.org.**

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Donna L. Russell, *Director of Operations*

GSA FOUNDATION SILENT AUCTION

Soon it will be silent auction time again! We hope you will make it a priority to stop by the Foundation booth in the Exhibit Hall at the Pennsylvania Convention Center on 22–25 October 2006 to participate in our annual silent auction.

Our auction will feature gift certificates for dining and hotels, ski passes, vacation and lodging packages, rock and mineral specimens, wine, jewelry, rare books, and many other items donated by Foundation supporters. So come, place your bids! The holidays will be right around the corner; the Foundation booth is a great place to find those special items and at the same time support the Foundation.

All money will go into the Foundation's **Greatest Needs Fund**, which supports such programs as research grants, student travel grants (domestic and international), education and outreach programs, and GSA publications, to name a few.

Come help us make our seventh silent auction a success!

Have An Item for Our Auction?

Items to donate include fossils, mineral specimens, jewelry, rare geologic books or maps, wine, field supplies, and antiques, just to name a few. **Or, do you have a timeshare that you would be willing to donate?** Last year, bidders enthusiastically pursued timeshares from a variety of places around the country.

Your donations are tax deductible based upon the retail value of the donated item, and your name will be listed as the donor on the auction item when displayed in the Foundation booth.

If you don't have an item, we'd be happy to accept a cash donation. You may mail donations directly to Donna Russell at the GSA Foundation, P.O. Box 9140, Boulder, CO 80301, USA.

Donate Online

It's easy! It's *quick!* It's secure!

Go to www.gsafweb.org

Click on "Make a Donation" and follow the user-friendly instructions today!

THERE'S STILL TIME!

Support GeoScience Day In Philadelphia

If you would like to help support GeoScience Day for minority school children (see the July *GSA Today*), please check the appropriate box on the coupon below and send your contribution to GSA Foundation, P.O. Box 9140, Boulder, CO 80301, USA. You may also donate online at www.gsafweb.org. Just remember to indicate that your gift is for GeoScience Day.

Most memorable early geologic experience:

Discovering crystals of orthoclase and quartz in country rocks with the same properties as mega-crystals in Papoose Flat pluton, California, which supported replacement origin for seemingly igneous minerals.

—Frank W. Dickson

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Upcoming AGU Meetings

2006 AGU Fall Meeting

Mark your calendar! The 2006 AGU Fall Meeting provides an opportunity for more than 12,000 researchers, teachers, students, and consultants to present and review the latest issues affecting the Earth, the planets, and their environments in space. This meeting will cover topics in all areas of Earth and space sciences.

Deadline for Abstract Submission:
7 September 2006

Housing and Pre-Registration Deadline
6 November 2006

For complete registration and deadline information, go to **www.agu.org/meetings/fm06/.**

2006
AGU FALL MEETING
11-15 DECEMBER • SAN FRANCISCO

2007 JOINT ASSEMBLY
ACAPULCO
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22 – 25 MAY

2007 Joint Assembly

Deadline for Session Proposals:
22 September 2006

The Program Committee is developing a Union-wide science program that will cover topics in all areas of the Earth and space sciences. Located in Acapulco, Mexico, 2007 Joint Assembly is sure to offer exciting sessions and a relaxing atmosphere.

For more information and updates about the meeting, log on to **www.agu.org/meetings/ja07/.**

For more information visit
www.agu.org.

AGU

THE GEOLOGICAL SOCIETY OF AMERICA

NOTICE of Council Meeting

Meetings of the GSA Council are open to Fellows, Members, and Associates of the Society, who may attend as observers, except during executive sessions. Only councilors and officers may speak to agenda items, except by invitation of the chair.

The next Council meetings will be held at 1 p.m., Saturday, 21 October, and 8 a.m., Wednesday, 25 October, at the 2006 GSA Annual Meeting in Philadelphia.

ANNOUNCEMENTS

IN MEMORIAM

Samuel S. Adams
Canterbury, New Hampshire
5 May 2006

Miguel Carrillo
Mexico City, México
11 May 2006

John J. Chapman
Sylva, North Carolina
21 March 2006

Lynn Glover III
Blacksburg, Virginia
5 March 2006

William L. Hiss
Albuquerque, New Mexico
12 April 2006

Mario M. Mazzoni
Buenos Aires, Argentina
1 January 2003

Wilferd W. Peak
Sacramento, California
1 August 2005

Paul C. Ragland
Tallahassee, Florida
23 September 2005

Forbes Robertson
Chesterfield, Missouri
20 April 2006

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

MEETINGS CALENDAR

2006

23–30 September	25th Anniversary Conference, National Association of Black Geologists and Geophysicists, Houston, Texas, USA. **Information:** www.nabgg.com.
8–17 October	Earth Science Week 2006, “Be a Citizen Scientist!” **Information:** www.earthsciweek.org.
8–10 December	Earth Planetary Differentiation: A Multi-Planetary and Multi-Disciplinary Perspective, Rohnert Park, California, USA. **Information:** www.lpi.usra.edu or e-mail Chip Shearer, cshearer@unm.edu.

2007

24–28 February	The 2nd International Conference and Exhibition on Geo-Resources in the Middle East and North Africa, Cairo, Egypt. **Information:** www.grmena.com.eg.
26 Aug.–1 Sept.	ISAES-2007, 10th International Symposium on Antarctic Earth Science (ISAES), Antarctica: A Keystone in a Changing World, Santa Barbara, California, USA. **Information:** isaes2007@geol.ucsb.edu and www.isaes2007.geol.ucsb.edu/index.html.

Visit www.geosociety.org/calendar/ for a complete list of upcoming geoscience meetings.

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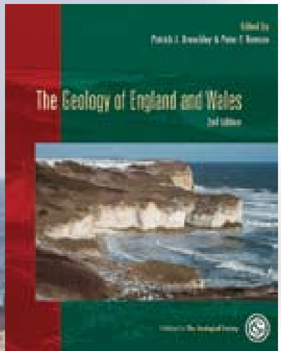

Pre-publication offer

The Geology of England and Wales (2nd Edition)

Edited by P. J. Brenchley and P. F. Rawson

This second edition of The Geology of England and Wales is considerably expanded from its predecessor, reflecting the increase in our knowledge of the region, and particularly of the offshore areas. Forty specialists have contributed to 18 chapters, which cover a time range from 700 million years ago to 200 million years into the future. A new format places all the chapters in approximately temporal order. Both offshore and economic geology now form an integral part of appropriate chapters.

Most of England and Wales is formed from part of a single terrane, Avalonia, and its pre-Cambrian (Neoproterozoic) history is preserved in patches. However the time intervals from the Cambrian to the present day are well represented in our sequences and the Cambrian, Ordovician, Silurian and Devonian systems were all defined here. William Smith's map of England and Wales was the world's first geological map of a country and the British Geological Survey's copy is reproduced in the introductory chapter. This chapter, by the editors, consists of a broad overview aimed particularly at the non-specialist while guiding the reader towards the appropriate succeeding chapters. The volume concludes with a look at the future, from the short-term effects of climate change and sea-level rise to the position of our region in a possible plate tectonic configuration 200 million years hence.

While the authors have taken a 'dynamic' view of the evolution of the area over geological time, they have also ensured that the geological evidence on which the interpretations are based is reviewed thoroughly. Hence the volume provides a valuable resource for both Earth scientists and the broader community.

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•ISBN-10: 1-86239-200-5 (PB)
•ISBN-13: 978-1-86239-200-7 (PB)
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Positions Open

POSTDOCTORAL FELLOWS
DESERT RESEARCH INSTITUTE (DRI), RENO

The Desert Research Institute (DRI) in Reno, Nevada is seeking applicants for 2 postdoctoral positions in soil science and terrestrial surface processes with research experience in the areas of (1) soil database development, and (2) soil mineralogy or chemistry. These positions will support several large research efforts focused on scientific integration of terrestrial soil processes common to deserts and efforts to develop dynamic models for predicting desert terrain conditions.

Applicants are expected to possess appropriate professional experience including a Ph.D. in geology, hydrology, geography, soil science, or a related discipline with strong emphasis on terrestrial soil processes and geomorphology; 4 years experience involving soils and related efforts in at least one of these fields: hydrological, geological or relational database development. Due to security clearance requirements, U.S. citizens are preferred. Additional requirements and application instructions are available at http://jobs.dri.edu. AA/EEO Employer.

BROOKLYN COLLEGE/CUNY

The Department of Geology at Brooklyn College seeks to fill a tenure track position, beginning September 2007, that will compliment our existing strengths in environmental geochemistry, paleontology, petrology, and petrophysics. The successful candidate will be expected to have had experience with GIS applied to geological research, and expand upon initiatives to integrate GIS into the curriculum. Teaching responsibilities would include introductory geology, introductory GIS, and subjects related to the individual's area of expertise. The successful candidate will also be expected to maintain an active research program, contribute to collaborative research within the department, college, and the CUNY Earth and Environmental Sciences doctoral program, and supervise student research. The successful candidate must have a Ph.D., teaching experience, professional recognition in his/her field, a balance of field and laboratory experience, and a history of collaborative research would enhance an application.

Salary is competitive and commensurate with qualifications and experience. Send curriculum vitae, three letters of recommendation, and writing sample or research plan to: Michael T. Hewitt, Assistant Vice President for Human Resource Services, Brooklyn College, 2900 Bedford Avenue, Brooklyn, NY 11210-2889. Review of applications will begin on November 1 and continue until position is filled

An AA/EO/ADA/IRCA Employer.

U.S. GEOLOGICAL SURVEY
MENDENHALL POSTDOCTORAL RESEARCH FELLOWSHIP PROGRAM

The U.S. Geological Survey (USGS) invites applications for the Mendenhall Postdoctoral Research Fellowship Program for Fiscal Year 2008. The Mendenhall Program provides opportunities to conduct research in association with selected members of the USGS professional staff. Through this Program the USGS will acquire current expertise in science to assist in implementation of the science strategy of its programs. Fiscal Year 2008 begins in October 2007.

Opportunities for research are available in a wide range of topics. The postdoctoral fellowships are 2-year appointments. The closing date for applications is 15 November 2006. Appointments will start October 2007 or later, depending on availability of funds. A description of the program, research opportunities, and the application process are available at http://geology.usgs.gov/postdoc. The U.S. Geological Survey is an equal opportunity employer.

EARLHAM COLLEGE:
TENURE TRACK ASSISTANT PROFESSOR
SURFACE PROCESSES

The Departmnt of Geosciences at Earlham College invites applications for a tenure track position beginning Fall 2007 in the general area of geomorphology/surface processes. Course responsibilities include participation in introductory geoscience and environmental science courses, as well as upper-class courses such as geomorphology, GIS, soil science, field methods, or other upper-level specialty courses. We expect that the candidate will be interested in helping define an Environmental Geology curriculum, supervising undergraduate student research projects, and participating in the senior capstone seminar. A Ph.D. is required and previous teaching experience at the undergraduate level is preferred. Women, underrepresented minorities, and Quakers are especially encouraged to apply. Interested candidates should send curriculum vitae, statements of teaching philosophy, and research interests, along with the full contact information of at least three references to: Dr. Meg Streepey, Department of Geosciences, Earlham College, 801 National Rd. West, Richmond, IN 47374; +1-765-973-2168 (phone); streeme@earlham.edu. Applications will be reviewed as received. For expanded information, please visit www.earlham.edu/geosciences.

GEOLOGIST/ASSISTANT PROFESSOR
(SEDIMENTOLOGY/STRATIGRAPHY)
WISCONSIN GEOLOGICAL AND
NATURAL HISTORY SURVEY

Full-time, tenure-track faculty position to conduct fundamental and applied research in the areas of sedimentology and stratigraphy through field-based investigations, including geologic mapping, focusing on the stratigraphic and hydrostratigraphic framework of the Paleozoic rocks of Wisconsin. Work is performed in cooperation with other WGNHS staff, university personnel, and collaborating governmental agencies whose interests include geology, geophysics, hydrogeology, and mineral/energy resources. Ph.D. in geology or closely related field is preferred; Master's degree in geology or related field with 4 years experience also acceptable. $50,000 minimum salary with excellent benefits package. Office located in Madison. For a complete position description and instructions on how to apply, see **www.uwex.edu/ces/hr**.

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VISITING ASSISTANT PROFESSOR IN GEOLOGY
ALLEGHENY COLLEGE

The Geology Department invites applicants for a three-semester full-time, non-tenure-track position from January 2007 through May 2008. We seek an enthusiastic teacher with expertise in hydrogeology, geomorphology, or a related field of earth-surface processes. The teaching load for the position is two lab courses per semester with the possibility to advise senior research projects. The successful candidate will be expected to teach introductory physical geology and an upper level course in her/his field of expertise. Other courses may include introductory environmental geology and a college-wide freshman/sophomore seminar that emphasizes writing and speaking. Allegheny College is a selective private liberal arts college with an emphasis on teaching. The Geology Department has a strong record of student-faculty research and emphasizes field-based learning. More information about Allegheny College can be found at www.allegheny.edu. To apply please send a letter that describes your qualifications for the position, a curriculum vitae, teaching and research statements, and three letters of reference. Send materials to: Ron Cole, Chair; Dept. of Geology; Allegheny College; 520 N. Main St.; Meadville, PA 16335. A Ph.D. is preferred but A.B.D. applicants are welcome. Applications will be reviewed beginning 25 August 2006 and will continue until the position is filled. Allegheny College is an Equal Opportunity Employer: Women and minorities are encouraged to apply.

ILLINOIS STATE GEOLOGICAL SURVEY
GEOPHYSICIST

Located on the campus of the University of Illinois Champaign-Urbana campus, ISGS is one of the largest and oldest regional geoscience research agencies in the nation. State-of-the-art facilities and equipment support our 3-D geologic mapping program, an active electrical resistivity research and service program, and a drilling program to support geological and geophysical research, including fully operational p- and s-wave land-streamer and shallow water-borne reflection systems, down hole geophone and hydrophones, and support personnel. Join our team effort to take these programs to the next level of excellence. Starting salary: $40,000 to $60,000 per year commensurate with education and experience. Closing date: 9/1/06. For required application form and more information contact walston@isgs.uiuc.edu or visit www.isgs.uiuc.edu EEO/ADA Employer.

VISITING ASSISTANT PROFESSOR OF GEOLOGY
UNION COLLEGE

The Geology Department at Union College seeks to fill a 1 2/3-yr position from January 2007 through June 2008. We seek a dynamic teacher and scholar with a research background in one or more of the following fields: Geomorphology, Glacial Geology, Oceanography, Paleoclimatology, and/or Paleolimnology. The successful candidate will be expected to teach introductory level courses in Environmental Geology, Global Climate Change, Natural Disasters, or Oceanography, and upper level courses in their areas of expertise. Union College is a selective liberal arts college with a strong tradition of science and engineering at the undergraduate level. The Geology Department is very well equipped with analytical instrumentation, and has a strong record of student-faculty research. More information about Union College is available on the Web at **www.union.edu.**

We will begin reviewing applications on 15 August 2006. To apply, please send a cover letter along with resume, list of publications, teaching and research statements, and a list of contact details for three references. Send application material to: **John I. Garver, Chair, Department of Geology, Union College, 807 Union St., Schenectady NY 12308-2311, USA.**

Union College is an equal opportunity employer and strongly committed to student and workforce diversity.

Opportunities for Students

Nine Funded Research and Teaching Assistantships (starting Jan. 2007) recently became available for M.S. and Ph.D. students at UNLV. The Department of Geoscience at the University of Nevada Las Vegas (UNLV) has funding for Research Assistantships in Hydrogeology and Structural Geology (a total of 4 assistantships), as well as 5 Teaching Assistantships. These positions are available for students who begin their graduate program in January 2007; the deadline for applying for spring admission is 1 October 2006. An application checklist can be found at www.unlv.edu/Colleges/Sciences/Geoscience/Students/Grad_admission_checklist.pdf. Teaching assistants may work with any of the 17 faculty members in the department. For information on our graduate program, departmental areas of expertise, faculty members, and other relevant information, please visit our Web site at http://geoscience.unlv.edu. For additional information please contact Dr. Andrew Hanson, the departmental graduate coordinator, at andrew.hanson@unlv.edu or via phone at +1-702-895-1092.

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