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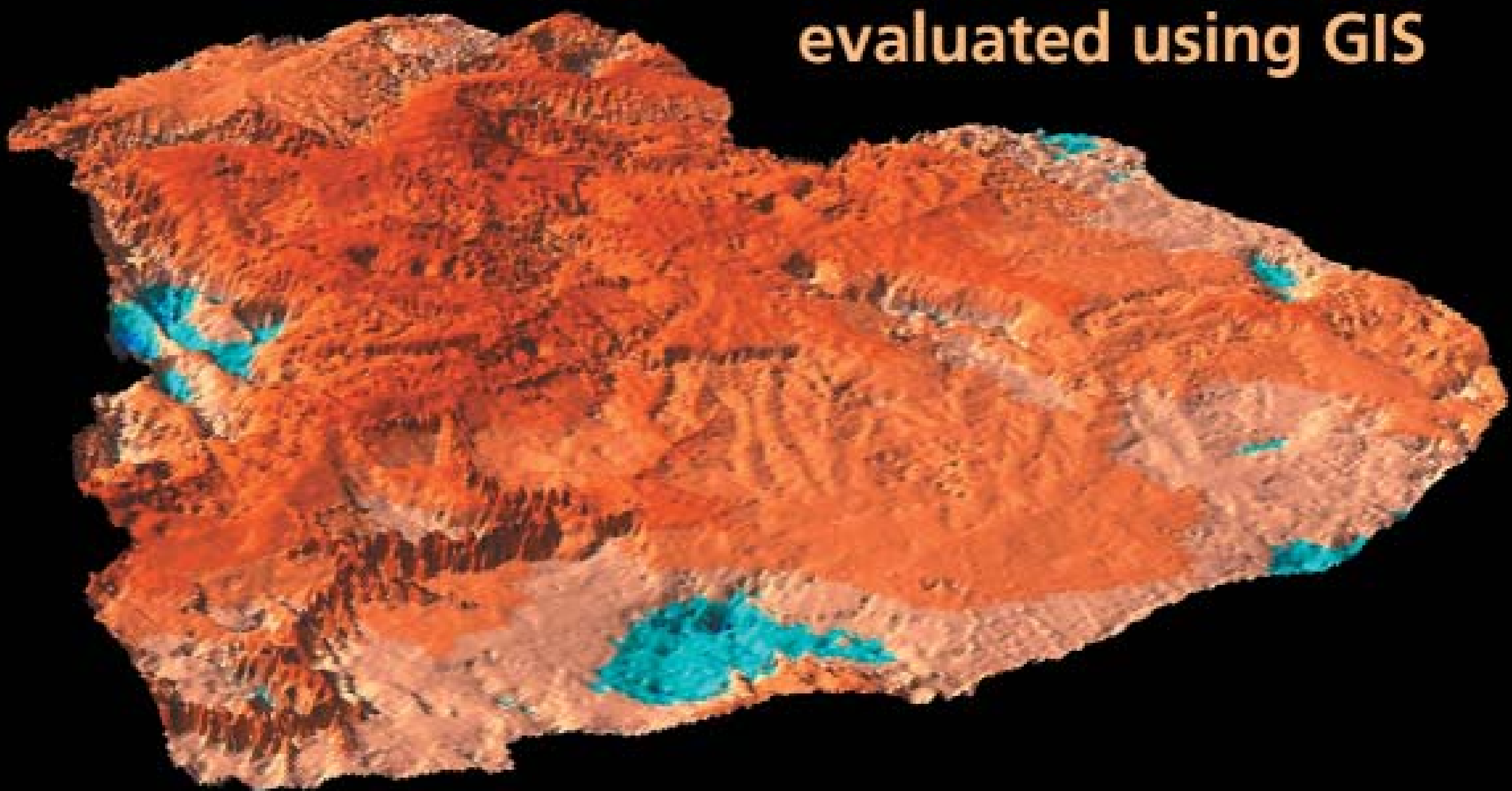
Colorado Plateau uplift and erosion evaluated using GIS



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The Great Sand Dunes, Colorado. Photo by Martin Miller

On the cover: Obique three-dimensional view looking northeast onto the Colorado Plateau showing estimated erosional exhumation since ca. 30 Ma. Note the high erosion following Grand Canyon at bottom left of image. The canyon appears inverted because of high erosion along its axis and low values in the surrounding rim country. Negative values shown in blue are places of net deposition since ca. 30 Ma, such as the Quaternary San Francisco volcanic field near Flagstaff, Arizona, at the bottom center of image. Erosional unloading of the Colorado Plateau over the middle-late Cenozoic should cause significant rock uplift through isostatic rebound. Image by J.L. Pederson. See "Colorado Plateau uplift and erosion evaluated using GIS," by J.L. Pederson et al., p. 4–10.

Colorado Plateau uplift and erosion evaluated using GIS

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ABSTRACT

Study of the interaction between uplift and erosion is a major theme of our science, but our understanding of their interplay is often limited by a lack of quantitative data. A classic example is the Colorado Plateau, for which the starting and ending points are well known: The region was at sea level in the Late Cretaceous, and now, the deeply eroded land surface is at ~2 km. The path of the landscape between these endpoints is less clear, and there has been longstanding debate on the mechanisms, amounts, and timing of uplift and erosion. We use a geographic information system to map, interpolate, and calculate the Cenozoic rock uplift and erosional exhumation of the Colorado Plateau and gain insight into its landscape development through time.

Initial results indicate uplift and erosion are highly spatially variable with mean values of 2117 m for rock uplift and 406 m for net erosional exhumation since Late Cretaceous coastal sandstones were deposited. We estimate 843 m of erosion since ca. 30 Ma (a larger value because of net deposition on the plateau over the early Cenozoic), which can account for 639 m of post-Laramide rock uplift by isostatic processes. Aside from this isostatic source of rock uplift, paleobotanical and fission-track data from the larger region suggest the early Cenozoic Laramide orogeny alone should have caused more than the remaining rock uplift, and geophysical studies suggest mantle sources for additional Cenozoic uplift. There is, in fact, less uplift on the plateau than proposed sources can supply. This suggests Laramide uplift of the plateau was significantly less than that of the Rocky Mountains, consistent with its prevalent sedimentary basins, and/or that there has been little or no post-Laramide uplift beyond erosional isostasy.

INTRODUCTION

Pioneering geologists such as John Wesley Powell, Clarence Dutton, G.K. Gilbert, and William Morris Davis pondered the Colorado Plateau landscape evolution, and questions still puzzle researchers today. In particular, what is the explanation for the plateau's mild structural deformation compared to surrounding areas, its high average elevation, and its dramatically incised landscape (Fig. 1)?

Hypotheses for uplift of the Colorado Plateau include mechanisms such as flat-slab subduction, crustal thickening, and anomalous mantle properties during two stages of activity: (1) early Cenozoic (Laramide) uplift; and (2) middle-late Cenozoic epeirogeny (e.g., Hunt, 1956; Morgan and Swanberg, 1985; Humphreys, 1995; Spencer, 1996; McQuarrie and Chase, 2000). The earliest researchers visiting the Colorado Plateau saw the deep incision of its spectacular canyons and concluded that erosion has been driven by recent—and ongoing—uplift (e.g., Powell, 1875; Dutton, 1882; Davis, 1901; Hunt, 1956). This conclusion was in keeping with W.M. Davis' influential model that large-scale cycles of uplift and erosion end with landscapes denuded to a peneplain near sea level, and with the related assumption that incision must be driven by subsequent uplift rather than other means of lowering base level for streams. The concept of a plateau denuded to near sea level after Laramide time, and then epeirogenically uplifted later in the Cenozoic to account for canyon incision, has persisted, but most workers recognize that the elevational history and the timing of erosion of the Colorado Plateau are still unknown.

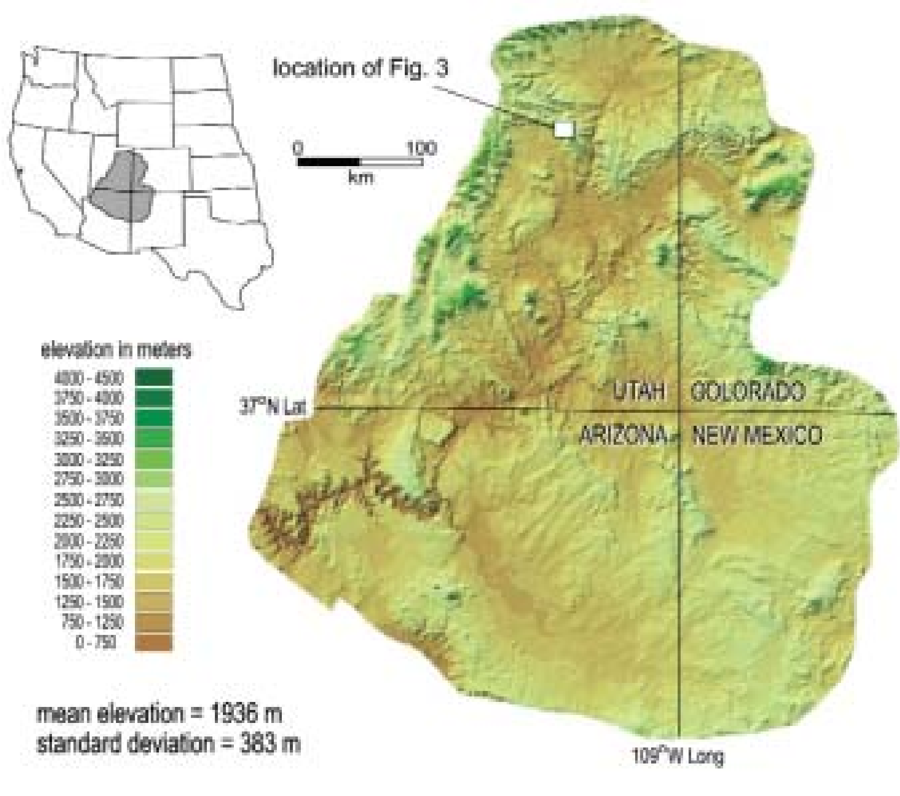

Figure 1. Physiographic extent of the Colorado Plateau according to Hunt (1956), which is used here for all discussion and analyses. Mean elevation is taken from merged 90 m digital elevation models (NAD83).

Isostatic response to the erosional exhumation of the plateau over the middle-late Cenozoic should itself result in significant rock uplift, but this has not been adequately considered in evaluating the above ideas. Several well-known studies have investigated this effect in other areas using approaches different from those used here (e.g., Molnar and England, 1990; Montgomery, 1994; Tucker and Slingerland, 1994; Small and Anderson, 1995, 1998; Whipple et al., 1999). Here we use a straightforward approach of directly measuring rock uplift and exhumation using information preserved in the landscape and the stratigraphic record. We first quantify mean Cenozoic rock uplift for the plateau. Then, by estimating erosional exhumation, we evaluate how much of this uplift can be accounted for by "passive" isostatic response to erosion. The remaining amount of uplift is what must be accounted for by Laramide events and other mechanisms for post-Laramide epeirogeny.

Our focus here is specifically on rock uplift and erosional exhumation, and we use definitions of these terms after England and Molnar (1990), as illustrated in Figure 2. Rock uplift (U_R) is the vertical displacement of rock relative to a datum (e.g., the geoid), exhumation (ε) is the thickness of rock removed through tectonism and/or erosion, and the resultant change in ground-surface elevation constitutes surface uplift ($U_S = U_R - \varepsilon$) or lowering (when U_S is negative). In an erosional setting, rock uplift may drive significant exhumation and thus results in less surface uplift (Fig. 2A). Likewise, after "active" uplift, exhumation is typically several times the resultant surface lowering because of isostatic response (Fig. 2B).

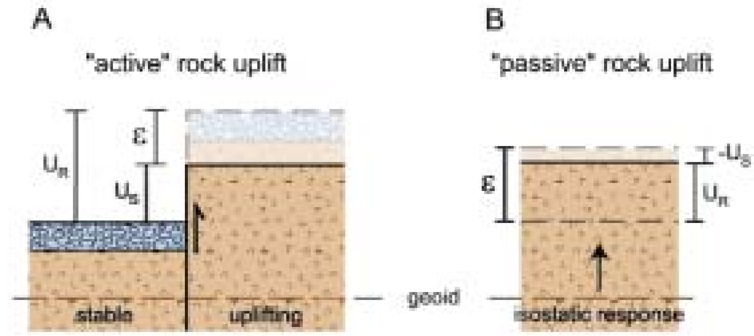

Figure 2. Illustrations of terms as described in text: U_R = rock uplift, U_S = surface uplift (surface lowering when negative), ε = exhumation. A: The case of "active" tectonic rock uplift. B: "Passive" rock uplift due to isostatic response to exhumation.

Early Cenozoic Rock Uplift

The Paleozoic and Mesozoic sedimentary sections of the Colorado Plateau contribute ~3 km to its 40–45-km-thick crust (Keller et al., 1998; Lastowka et al., 2001). This sedimentary package was generally formed near sea level but now outcrops far above sea level, and thus there has been uplift (quantified below) since the Mesozoic. Proposed mechanisms for uplift of the region in the early to middle Cenozoic include both crustal and mantle modifications to provide crustal thickening or changed lithospheric buoyancy. There was no appreciable thickening of the plateau's upper crust in the Laramide orogeny (Spencer, 1996), but McQuarrie and Chase (2000) have suggested that weak midcrustal material flowed eastward from the thick Sevier orogen providing Laramide crustal thickening and uplift. Changes in lithospheric buoyancy have been attributed to low-angle subduction of a relatively buoyant slab and its aftereffects (Humphreys, 1995). This includes mechanical thinning of the mantle lithosphere and its subsequent modification by upwelling asthenosphere (Bird, 1984; Humphreys, 1995; Spencer, 1996). Bird (1984) suggested complete removal of mantle lithosphere during low-angle subduction, but isotopic and geophysical studies suggest preservation of some thickness of mantle lithosphere (Livaccari and Perry, 1993; Spencer, 1996; Lastowka et al., 2001). Paleobotanical studies from the region, including those from the northern plateau, suggest that in the middle-late Eocene after the Laramide uplift, regional surface elevations were as high or higher than now (Gregory and Chase, 1992; Wolfe et al., 1998). Middle Eocene flora from the Green River Formation are interpreted to indicate surface elevations of 1.5–3 km (Wolfe, 1994; Wolfe et al., 1998). This provides a minimum estimate of early Cenozoic rock uplift, since surface elevation at the close of the Laramide orogeny would be less than total rock uplift because of concurrent exhumation (Fig. 2A).

Middle-late Cenozoic Epeirogenic Uplift

Post-Laramide events have continued to alter the landscape of the western United States. The broad-scale drainage patterns on the central and northern plateau are thought to have developed by the Oligocene (Hunt, 1969), though development of present-day drainage off the southwest margin of the plateau, and probably most erosion, postdates Miocene structural differentiation between it and the Basin and Range. Studies of Cenozoic deposits on the southern and southwestern margins of the Colorado Plateau document that drainages flowed northeast away from Laramide highlands onto the plateau during the early Cenozoic. These drainages were disrupted by normal faulting along the Basin-and-Range transition zone, and then the Colorado River was integrated off this escarpment, reversing surface drainage to the southwest after 6 Ma (e.g., Lucchitta, 1972; Young and Brennan, 1974; Young and McKee, 1978; Pierce et al., 1979; Cather and Johnson, 1984; Potochnik and Faulds, 1998). This drainage change resulted in a significant effective base-level drop for streams, driving late Cenozoic incision that probably accounts for most erosion on the plateau. A key debate has been whether neighboring Basin-and-Range basins have undergone faulting and subsidence relative to an already high plateau, whether the plateau has been uplifted relative to the Basin and Range, or whether both have been uplifted (cf. Lucchitta, 1979; Hamblin, 1984; Pederson et al., 2002). Discussion hinges on geophysical evidence (e.g., Morgan and Swanberg, 1985; Parsons and McCarthy, 1995), the marine versus continental origin of Neogene deposits along the lower Colorado River corridor (cf. Lucchitta,

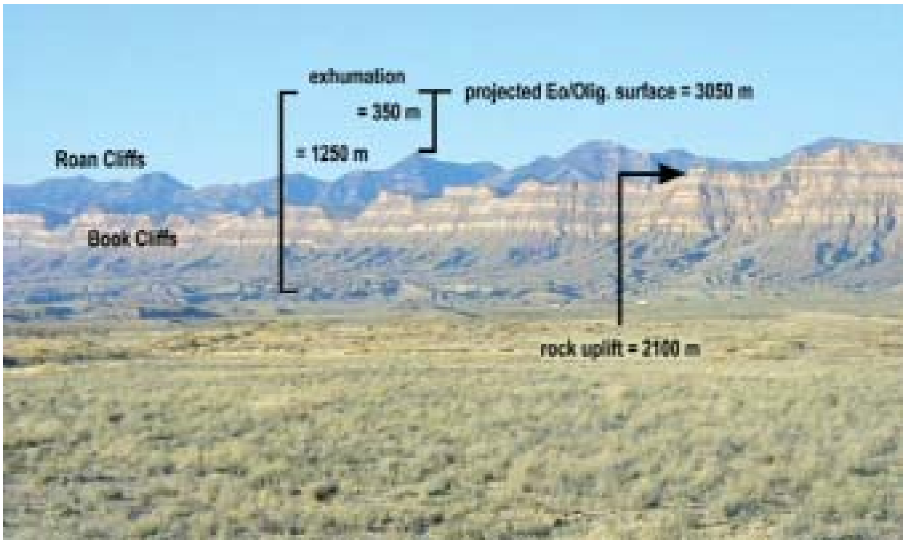

Figure 3. Book and Roan Cliffs between Price and Green River, Utah, as an example of estimated rock uplift and post-Laramide exhumation, looking north at ~900 m of relief over dual escarpment. Local marker of Cenozoic rock uplift is uppermost Castlegate Formation coastal sandstone of Cretaceous Interior Seaway—the last known point in stratigraphy when region was at sea level. The reconstructed Eocene-Oligocene stratigraphic boundary projects ~350 m above the peaks of the Roan Cliffs based on southward extrapolation of the middle Cenozoic stratigraphy preserved farther north in Uinta Basin. Thus we estimate there has been ~350 m of post-Eocene erosional exhumation above the peaks, but ~1250 m of exhumation at toe of escarpment in foreground.

1979; Spencer and Patchett, 1997; Faulds et al., 2002), and paleoelevation studies (e.g., Wolfe et al., 1998).

Mechanisms proposed to drive later-Cenozoic epeirogeny of the overall plateau include anomalous compositional or thermal properties of the lithospheric and asthenospheric mantle related to magmatism or the fate of the Farallon slab, as partly described above (e.g., Morgan and Swanberg, 1985; Humphreys and Dueker, 1994; Lowry et al., 2000; Lastowka et al., 2001). For example, analysis of crustal thickness and buoyancy and mantle properties of the region suggest that anomalously buoyant or dynamic asthenosphere is required to support the present elevation of the plateau (Lowry et al., 2000; Lastowka et al., 2001) and this may supply a fraction of the total rock uplift. Isostatic rebound from erosional exhumation of the Colorado Plateau can also provide some rock uplift, as evaluated in the following section, but this results in surface lowering rather than surface uplift.

The competing hypotheses posed for uplift of the plateau underscore considerable uncertainty in our understanding of the uplift and erosional history of the region. Baseline data sets quantifying total rock uplift and erosion in the plateau are essential for testing these ideas.

STRATIGRAPHIC-GEOMORPHIC-GIS EXERCISE

Uplift and erosion can be directly reconstructed in the Colorado Plateau using geologic evidence. Geographic information systems (GIS), for example, provide a tool for data compilation and spatial calculations of this sort, and the wealth of existing research and data on the plateau's stratigraphy enables landscape reconstruction precise enough to capture the spatial variability in rock uplift and erosion within the region. Two stratigraphic markers key to our effort are: (1) Late Cretaceous coastal marine strata that originally covered nearly the entire Colorado Plateau and represent the last known time surface elevation was at sea level; and (2) the Eocene-Oligocene stratigraphic boundary, which is the most important datum we use to approximate the land surface before its transition from internal drainage and sediment accumulation to overall erosion of the plateau landscape. The timing of this transition certainly varied with locality. Hunt (1969) hypothesized that the Uinta and Piceance basins of the northern plateau became externally drained at about this time, but it arguably occurred in Miocene time in the southwestern plateau. For our purposes, the paleosurface we reconstruct, generalized as ca. 30 Ma, everywhere predates the major incision that has subsequently defined the landscape. In uplands of the neighboring Rocky Mountains, the late Eocene–early Oligocene is represented by the "late Eocene erosion surface" that formed as Laramide highlands were eroded to relatively low relief and basin sedimentation slowed (e.g., Epis and Chapin, 1975). Though much of the Colorado Plateau was a depositional basin, there are volcanic edifices and Laramide uplifts that must have been marked by an erosional rather than depositional surface in the Oligocene, which we take into account in our reconstruction. Through spatial reconstruction of the present elevation of Late Cretaceous coastal deposits, we quantify the total amount of Cenozoic rock uplift. Through reconstructing the post-Laramide terrain, we can calculate subsequent erosional exhumation of the plateau by subtracting present-day elevation from it (Fig. 3), and then estimating the resultant isostatic uplift.

Interpolation Methods

We produce two spatially oriented data sets of point values and then interpolate a continuous three-dimensional surface from each. The best interpolation method for this was evaluated by doing an analogous exercise for present-day topography. One hundred locations representative of topographic variability were chosen, and spot elevations at these places were extracted from the base digital elevation model (Fig. 4A). By comparing the mean elevation and standard deviation of the interpolated surface to actual topography, we found that a surface fit as a tensioned spline using the five nearest points to interpolate the value of a given cell (cell diameter = 1 km) worked well (Fig. 4B). Surfaces interpolated in this manner are smoother and have longer wavelengths than present-day topography, but so do the paleosurfaces we are reconstructing.

Calculating Total Rock Uplift

We derive Cenozoic rock uplift through reconstructing the present depositional marker of upper Cretaceous

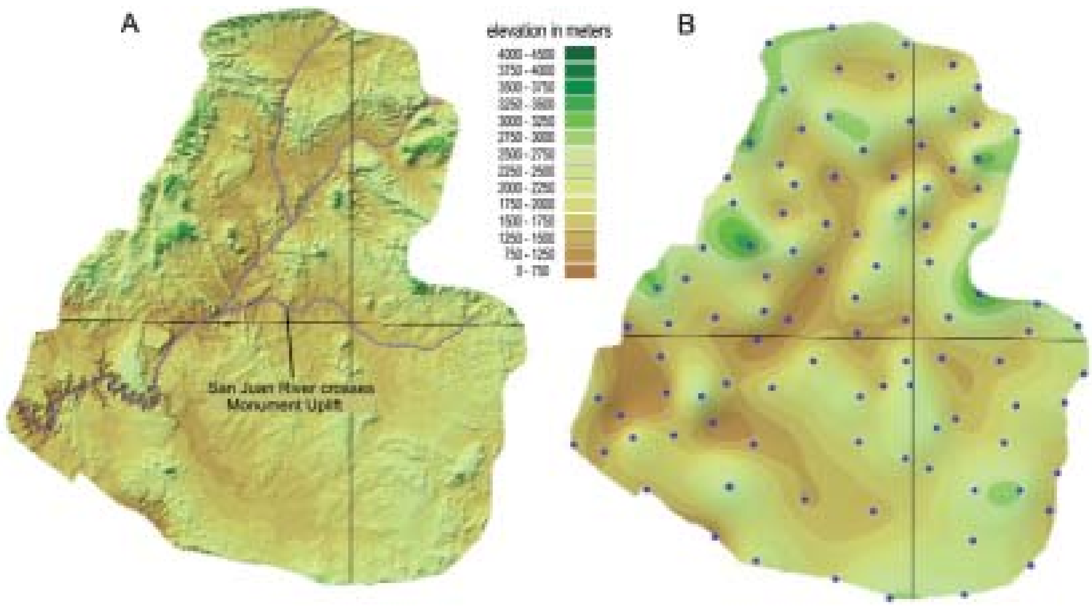

Figure 4. Illustration of interpolation methods using present-day topography. One hundred elevations were extracted from the present-day topography (A), and a surface interpolated as described in text (B). Paleosurfaces being reconstructed are smoother and have longer wavelengths than present-day topography, as do our interpolated surfaces. Major rivers and example of superimposed drainage shown in A.

coastal marine strata (Table DR1[1]). Cretaceous strata on the plateau have been intensely studied and provide a marker of the last known point in the stratigraphy when and where a given location was at sea level—its present elevation is thus a true measure of subsequent rock uplift. Late Cretaceous global sea level varied from 200 to 250 m higher than now (Haq et al., 1987), so we subtract 225 m from the resulting surface to calculate rock uplift. Where upper Cretaceous strata are exposed, we simply use spot elevations. For example, the Castlegate Sandstone exposed along the east-west–trending Book Cliffs provides the youngest local datum recording part of the broad-scale retreat of the Cretaceous Interior Seaway (Fig. 3). Coastal deposition ceased and uplift began at different times in different places, and we use the highest possible coastal marker in the Cretaceous stratigraphy of a given location instead of just one older marker strata everywhere. This minimizes the tendency to underestimate uplift when using older strata, which results from the inclusion of postdepositional subsidence that occurred before early Cenozoic uplift. In all possible locations, 75–85 Ma (Campanian) strata were used, but target strata are older (the oldest are Turonian) to the south and west on the plateau because younger transgressions of the Cretaceous Interior Seaway did not cover this area. Data are distributed to provide even coverage and capture regional-scale uplifts and basins. Where marker strata are in the subsurface or eroded (locations in red on Fig. 5), their elevation relative to present topography is estimated either by reconstructing missing stratigraphy using information from neighboring areas where it is still preserved, or by projecting stratigraphy

[1]GSA Data Repository item 2002042, Tables DR1 and DR2, is available from Documents Secretary, GSA, P.O. Box 9140, Boulder, CO 80301-9140, editing@geosociety.org, or at www.geosociety.org/pubs/ft2002.htm.

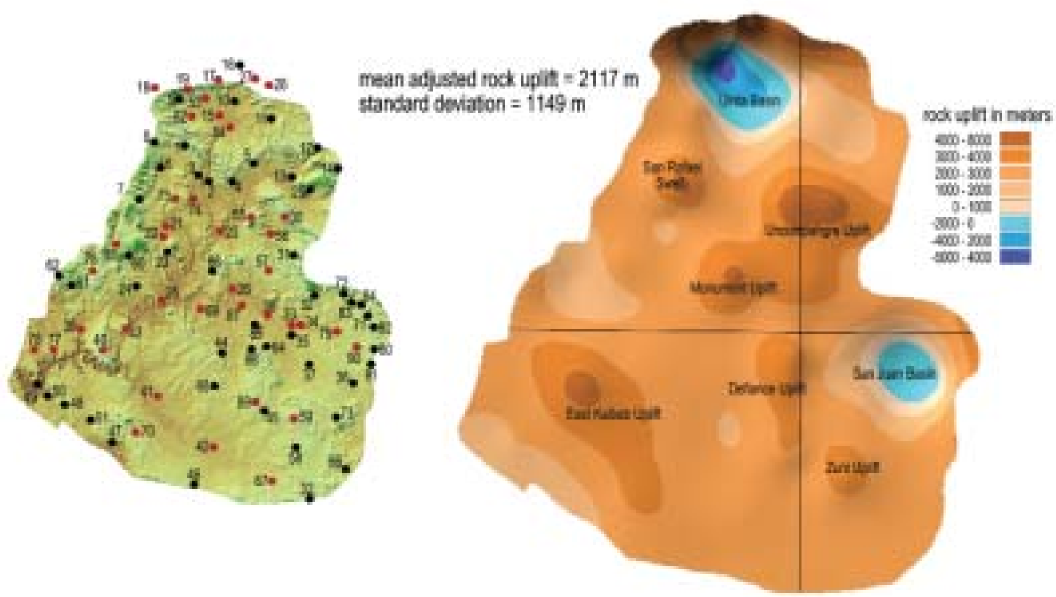

Figure 5. Rock uplift on the Colorado Plateau. Location and identification of data points on left is keyed to Table DR1 (see footnote 1). Black dots mark locations where outcropping stratigraphy is utilized, red marks where reconstructed or in subsurface. Image at right is interpolated present elevation of Late Cretaceous surface—essentially a structural contour or relief map adjusted for Late Cretaceous high sea level.

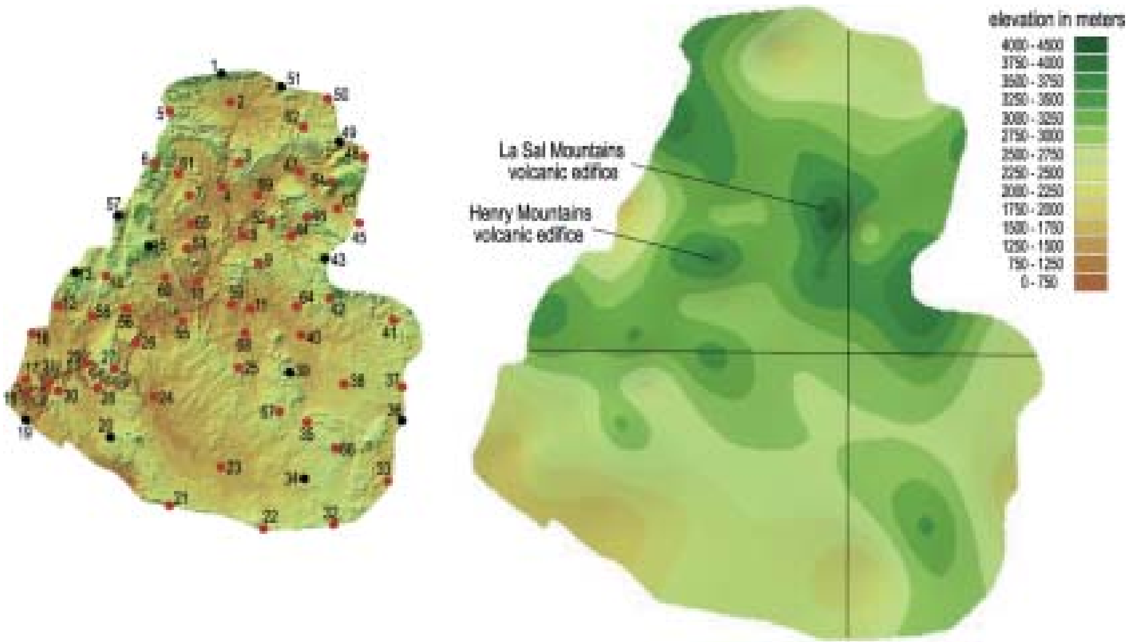

Figure 6. Reconstruction of ~30 Ma terrain relative to today's topography. Black dots mark locations where Eocene-Oligocene stratigraphic boundary is preserved, red marks where it has been reconstructed as described in text. Highest areas of central-eastern plateau are related to volcanic edifices, mostly represented by exhumed subsurface remnants today (e.g., Henry and La Sal Mountains).

into the subsurface, respectively. The stratigraphic literature provides measured sections, subsurface data, and information on original thicknesses and depositional extent of units (e.g., Caputo et al., 1994).

Results. Our surface representing total rock uplift on the Colorado Plateau since the Late Cretaceous is based upon 90 data points (Fig. 5), and the result is essentially a structural contour or relief map of uppermost Cretaceous strata minus the sea-level adjustment. Most major uplifts and basins are resolved, and the mean rock uplift on the plateau, adjusted for higher sea level, is 2117 m. Values along the southwestern margin of the plateau underestimate true uplift, partly due to the use of older marker strata as mentioned above and partly because of late Cenozoic normal faulting and subsidence along the plateau's western margin. This local underestimation does not significantly reduce the overall mean uplift. Mean rock uplift may be less than expected by many workers, partly due to the influence of the central Uinta and San Juan basins where Late Cretaceous rocks still lie kilometers below sea level. This variability is emphasized by the large standard deviation in rock uplift (Fig. 5).

Reconstruction of Post-Laramide Topography and Calculation of Erosion

Topographic surfaces are commonly reconstructed through extrapolation of erosional remnants, but much of the plateau was characterized by deposition rather than erosion ca. 30 Ma, and few erosional remnants are still preserved. Previous workers have done mass-balance exercises of restoring sediment to eroded source areas through deconvolution of basin stratigraphy (e.g., Hay et al., 1989; Pazzaglia and Brandon, 1996). Yet mass removed from the Colorado Plateau cannot be reconstructed by this method because the fate of sediment and its transport paths off of the plateau since the Oligocene are complex and not understood. We instead reconstruct the post-Laramide land surface using a set of landscape clues described below. Although this exercise is a work in progress and somewhat subjective, we believe our data provide a good first-order estimate, and we take a conservative approach when determining individual values (Table DR2, see footnote 1).

Reconstruction of the elevation of the Oligocene surface at sample points uses the following methods or guidelines:

1. Data from areas where the Eocene-Oligocene stratigraphic boundary is still preserved in the landscape are utilized directly (locations in black on Fig. 6). An example from the

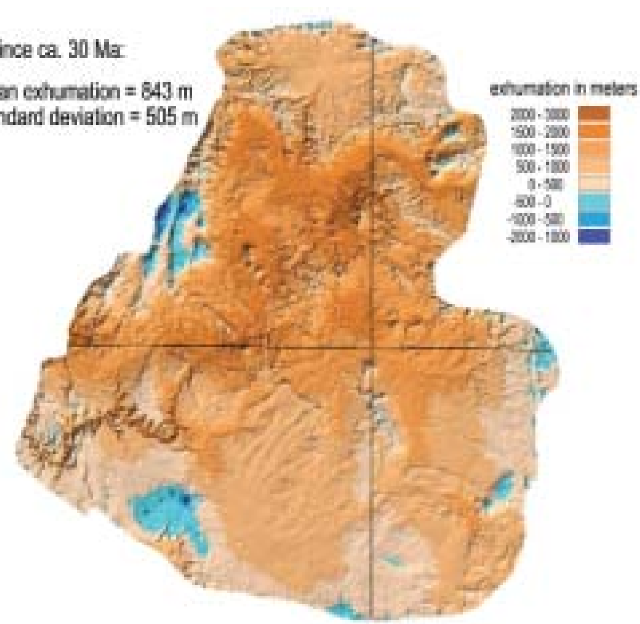

Figure 7. Difference map of reconstructed ca. 30 Ma surface minus present-day topography, i.e., minimum post-Laramide erosion. At least 639 m of mean rock uplift should be due to isostatic rebound in response to this erosion. Mean net erosional exhumation since the Late Cretaceous is only 406 m because of net Paleocene and Eocene deposition on plateau.

Uinta Basin is the contact between the upper Eocene Uinta Formation and the overlying Duchesne River Formation.

2. Early Oligocene laccoliths (Nelson et al., 1992) indicate the land surface must have been, at a minimum, above them before and at the time of their emplacement. Similarly, the San Juan Mountains of southwestern Colorado and the Aquarius Plateau of southern Utah include Oligocene volcanic rocks, the basal contacts of which can be used to approximate early Oligocene paleotopography.
3. Superimposed or antecedent drainages crossing uplifts are common on the plateau, and when carefully considered, they enable inference of the general paleoslope direction of the land surface before significant incision began (Hunt, 1969). For example, the San Juan River in southeastern Utah crosses the Monument Uplift as it flows from east to west, making the famous incised meanders of the "goosenecks of the San Juan." We can suppose that the ancestral San Juan river, just before becoming entrenched in its present canyon, must have been a consequent stream flowing from higher ground to the east to lower ground to the west in this area (Fig. 4A).
4. With the aid of existing stratigraphic literature and extrapolation from known neighboring points, we estimate the thickness of section missing in some areas (Fig. 3) and the depth to the subsurface stratigraphic boundary in others. Useful references in this work have included summary works (e.g., Mallory, 1972; Jenney and Reynolds, 1989; Nations and Eaton, 1991), the dozens of field trip guidebooks for the region, and published U.S. Geological Survey and state survey maps and studies.

Results. Our first-order reconstruction of the post-Laramide land surface presently includes 69 data points (Fig. 6). The resultant interpolated surface represents an estimate of the terrain of ca. 30 Ma as it sits relative to the present-day topography with a mean elevation of 2779 m. The highest areas are related to volcanic edifices now represented only by remnants. Laramide highlands and basins are still somewhat evident, as is the downwarping of the surface by subsequent normal faulting along the southwest edge of the plateau, which actually used to rise toward a central Arizona highland (e.g., Young and McKee, 1978).

Subtraction of present-day topography from this reconstructed surface results in a difference map representing a minimum estimate of "post-Laramide" erosion since ca. 30 Ma (Fig. 7). The thickness of removed section is highly variable, with a mean of 843 m. The greatest values are in the Canyonlands region of the north-central plateau and along the axis of Grand Canyon (<2000 m), whereas areas with negative values have experienced net accumulation rather than erosion. Relief has clearly increased through time, and exhumation is generally greatest along the trunk of the Colorado River system and diminishes toward the edges of the plateau. This is consistent with incision driven by base-level lowering to the southwest, where the river debouches into the Basin and Range.

Although this first-order estimate of post-Laramide erosion is interesting and useful, more important for the following discussion is net exhumation since the Late Cretaceous, which allows us to evaluate isostatic rebound over the same time scale as our measurement of rock uplift. Mean net exhumation since the Late Cretaceous is 406 m (surface of Fig. 5, *not* including adjustment for sea level, minus present topography). This value is less than post–30 Ma erosion because the plateau was a site of net deposition in the Paleocene and Eocene.

Because erosion is not evenly distributed, one would expect to see differential flexural response to unloading, with significantly more at the center of the plateau and little at the edges. In our case of imagining mean exhumation distributed across the entire ~500-km-wide plateau, flexural support of topography isn't important and we can assume local isostasy. Assuming constant lithospheric mantle buoyancy, rock uplift due to erosional unloading is simply a function of crustal buoyancy:

$$U_\varepsilon = \varepsilon\,(\rho_c / \rho_m), \qquad (1)$$

where ε is exhumation, and ρ_c and ρ_m are density of the eroded crust and the mantle, respectively. We use 2500 kg/m^3 for the eroded sedimentary rock (ρ_c) and 3300 kg/m^3 for ρ_m. The minimum of 843 m of post-Laramide exhumation results in 639 m of rock uplift (and 204 m of surface lowering). Important for our discussion is the net Cenozoic exhumation of 406 m, which results in 308 m of rock uplift. This latter figure leaves ~1800 m of Cenozoic rock uplift to be accounted for by means other than erosional exhumation.

DISCUSSION

Potential sources for this remaining Cenozoic rock uplift on the Colorado Plateau include Laramide tectonism or later Cenozoic epeirogeny caused by changes in mantle buoyancy or dynamic asthenosphere. This paper does not provide a direct answer for which of these dominated, but our initial data have important implications. If paleobotanical estimates for late Eocene surface elevations of 1.5–3 km are true (a minimum estimate for Laramide rock uplift), values of Laramide rock uplift alone should be greater than this remaining ~1800 m. The same is true if we accept that the Rocky Mountains and Colorado Plateau have similar elevational histories. It is estimated that the Rocky Mountain Front Range, with a mean surface elevation ~400 m higher than the plateau, has 5–7 km of rock uplift based on using the apatite fission track partial-annealing zone as a datum through time (Pazzaglia and Kelley, 1998; Kelley and Chapin, 2002). About half of this is estimated to be related to Laramide uplift (or increased mantle buoyancy) and half due to passive erosional unloading. Based on our initial results, we therefore suggest two end-member scenarios:

1. All rock uplift on the Colorado Plateau has been provided by only ~2 km of Laramide uplift (of whatever mechanism) and subsequent erosional isostasy, with no other sources of later Cenozoic uplift. Note that, in this case, restoring our estimated 204 m of post–30 Ma surface lowering to the present-day elevation results in a paleosurface elevation of ~2140 m, which is consistent with paleobotanical estimates of post-Laramide elevation.
2. Alternatively, proposed mantle sources of middle-late Cenozoic uplift are valid, but then with isostatic rebound

from erosion included, Laramide uplift of the Colorado Plateau must be minor (<500 m). This suggests that paleobotanical studies overestimate the paleoelevation.

In either scenario, Laramide uplift of the Colorado Plateau is much less than that in the neighboring Rocky Mountains, which may be expected considering the plateau contains the Uinta, Piceance, and San Juan sedimentary basins that have subsided, not uplifted, since the Cretaceous. Ironically, the problem with the Colorado Plateau is that there are proposed sources for more uplift than there is actual uplift. Something must give. Our initial data support a resolution wherein early Cenozoic events provided the bulk of uplift by whatever mechanism, with little but passive erosional isostasy in the later Cenozoic. Further work compiling these databases, flexural modeling using the spatially variable exhumation data, and complementary thermochronologic studies will contribute more to this debate.

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DIALOGUE

Overcoming Obstacles to Incorporating Experiential Learning into the Geology Curriculum

Robert C. Thomas, *University of Montana—Western*

Early in my career at The University of Montana—Western, I noticed that by the second week of my introductory geology classes, approximately 30% of the students were no longer attending. One day, I overheard several students talking about their plan of action. "You go to the English class, you go to history, and I'll go to psychology." It was clear that students were able to divide the responsibility of their academic schedules because my colleagues and I only required them to memorize and regurgitate lecture notes. Even in labs, the canned exercises appeared to inspire the least amount of effort. Students were not active participants in their education; they had no ownership of their education, and our traditional approach instilled little passion for learning.

To kill the apathy, the faculty in the Environmental Sciences Department began to look for active-learning models to engage students in meaningful projects. We threw out the notion that students must know every factoid and term in the book. Then we identified the most fundamental and important concepts and designed projects that would enhance the students' understanding of those concepts. Ultimately, we relied upon these projects to generate the need-to-know additional information and terminology.

All the data showed that the system worked. Students attended class regularly and were eager to spend out-of-class time on projects, and employers commented that they had exceptional skills and the confidence to take on projects with minimal supervision. The biggest obstacle to our reforms was the academic schedule, which was clearly designed to efficiently transfer information and terminology from the professor to the students in 50-minute blocks. We asked our administrators for longer blocks of time, and they granted our request, initially agreeing with the benefits of this approach

We quickly took advantage of this opportunity and scheduled each class with a 50-minute briefing on one day, followed by a four-hour block for project work on a different day. Recognizing that students do a better job when they know their work will be seen and used by people outside of the classroom, we incorporated a service-learning component that engaged the students in actual environmental problems facing the Dillon community. We started by working on projects in cooperation with local government, federal agencies, and private businesses. In return for financial support for our projects, cooperating agencies or companies received a service at a greatly reduced cost. For example, students in an environmental geochemistry course conducted a regional groundwater nitrate study that saved Beaverhead County thousands of dollars while providing the students with applications of the concepts they had learned in class.

Unfortunately, as more of the faculty in the department used the longer blocks of time, scheduling conflicts arose. With the administration breathing down our necks, we found a time-tested model to eliminate the scheduling conflicts: teach one class at a time (OCAAT). OCAAT scheduling has worked well for Colorado College and a few other private liberal arts colleges, but it has never been tried at a public university in the United States. In fall 2001, The University of Montana—Western, led by GSA member Sheila Roberts, received a Fund for the Improvement of Post-Secondary Education grant from the Department of Education to try the OCAAT model. In fall 2002, 75 freshmen will take general education courses one at a time as the first test of this scheduling model at a public university in the United States. We plan to present the results of Western's OCAAT experiment at the GSA 2003 Annual Meeting in Seattle.

Alternative scheduling turned out to be the way to overcome our primary obstacle to incorporating experiential learning into the geology curriculum. However, there must be many other solutions to this problem, and we encourage interested colleagues to join us in generating a symposium or session on this topic for the GSA 2003 Annual Meeting. If you are interested, please contact me at r_thomas@umwestern.edu.

ATTENTION
Voting Members:

LAST CHANCE TO VOTE!

Vote by August 30, 2002

The success of GSA depends on the work of the elected officers who serve on its Executive Committee and Council. Make your wishes for GSA known by voting.

You should have received a postcard in July with instructions on how to access a secure Web site and your electronic ballot listing officer nominees for 2003 and councilor nominees for the term 2003–2005. Biographical information on each candidate and the 2001 and 2002 Annual Reports also are available on the site.

If you did not receive these instructions, or if you need paper copies of the ballot, candidate information, and/or the 2001 and 2002 Annual Reports, contact Member Services, (303) 447-2020, option 3, 1-888-443-4472, or member@geosociety.org.

Your vote is vital to GSA! Please take a few minutes and vote today. Ballots must be submitted electronically or postmarked by August 30, 2002.

GSA Establishes Limnogeology Division

The newest GSA division, established this year, is the Limnogeology Division. The main goal of this division is to bring together all researchers interested in lake or lacustrine systems, including modern lakes (lakes with water), ancient lakes (analyzed through sediment cores from modern lakes), and fossil lakes (sediments that are now rocks).

Insight into lacustrine ecosystems through space and time will improve our understanding of the evolution of biotic, sedimentary, and chemical frameworks of the broad spectrum of lake types. Each lake is unique because its setting and the controls governing its existence are extremely variable. Settings include tectonic basins (rift, strike-slip, foreland, etc.), glacial regimes, and volcanic areas, as well as coastal and karstic environments. Controls on the physical and chemical parameters of a lake system include source rocks, latitude, climate, basin geometry, tectonic influences, and basin hydrology.

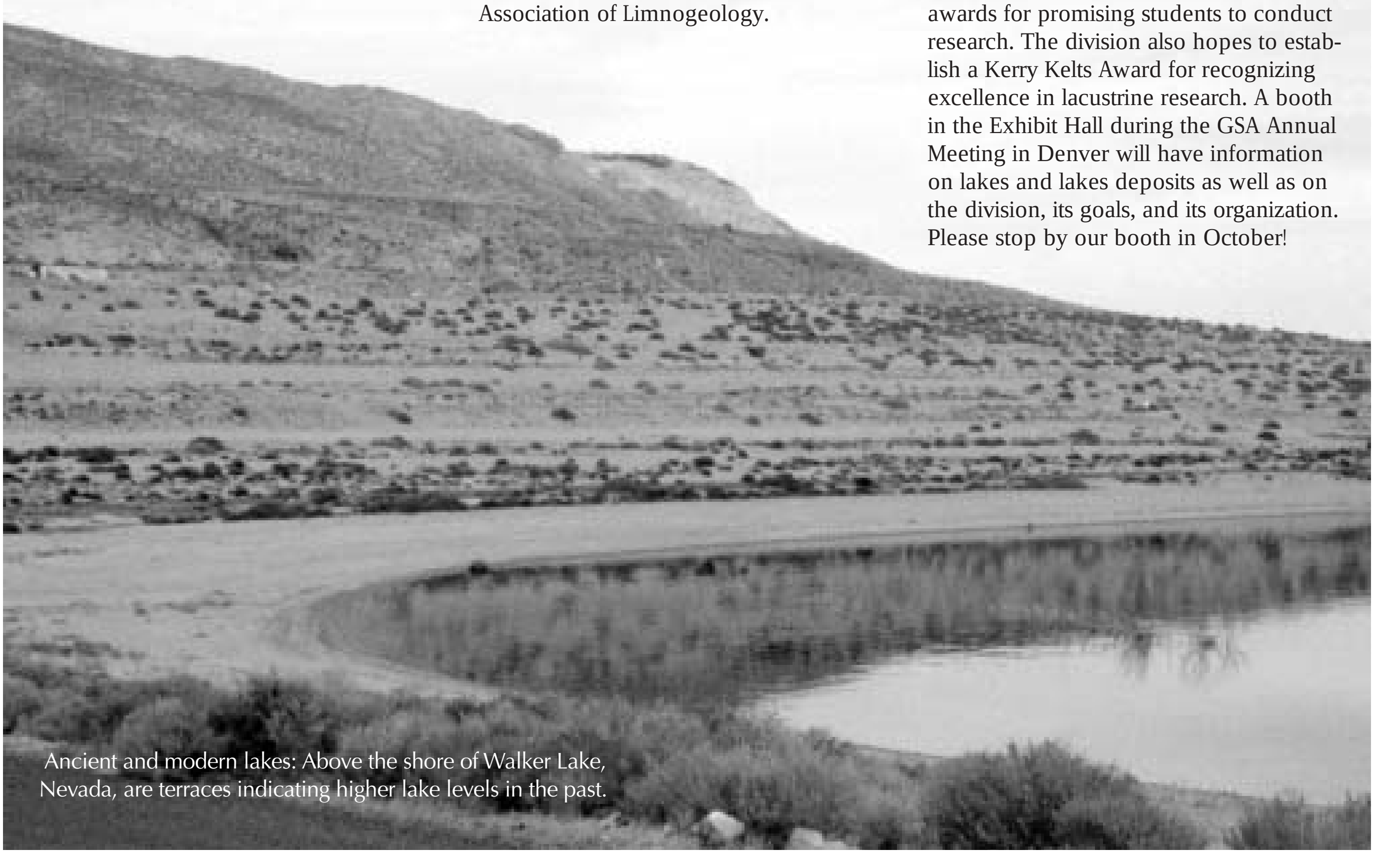
Lakes are certainly NOT small oceans! The challenge in lake studies for the twenty-first century is to establish physical, biologic, and chemical models to understand how all lakes work. With this knowledge, we can then more easily confront the problems of contaminants from surface waters and groundwaters as well as the effects of climate change.

With these goals in mind, the GSA Limnogeology Division will promote research on lakes and lake deposits around the world, especially collaboration among scientists across all disciplines of lake research, from biological and environmental limnology to paleolimnology and lacustrine paleontology. A multidisciplinary approach will benefit research and give insight into understanding lake frameworks. The Limnogeology Division will also encourage the presentation and publication of lake research through the sponsorship of symposia, meetings, and field trips. In addition, student mentoring will be crucial in advancing studies of lake systems. Global links with international colleagues will be encouraged and maintained through the International Association of Limnogeology.

The first business meeting of the GSA Limnogeology Division will be held at the 2002 GSA Annual Meeting in Denver on Monday, October 28. The elected officers of the executive committee (two-year terms) will be installed, and lake researchers can mingle and find common ground. Officers include: Elizabeth Gierlowski-Kordesch, Chair, Ohio University; Thomas Johnson, Vice-Chair, University of Minnesota, Duluth; Lisa E. Park, Secretary, University of Akron; and Kevin Bohacs, Treasurer, ExxonMobil. Annual dues will be set at $8 for professionals and $5 for students.

The division also is sponsoring two topical lake sessions at the Denver meeting: (1) Geochemical and Mineralogical Records from Ancient Lake Sediments (T28), and (2) The Green River Formation Revisited: Crucible for New Concepts and Advances in Paleoclimatology, Tectonics, Chronostratigraphy, Sequence Stratigraphy, Isotope Geochemistry, and Paleontology (T108).

In order to attain its goal of mentoring students, the GSA Limnogeology Division wishes to establish scholarships and awards for promising students to conduct research. The division also hopes to establish a Kerry Kelts Award for recognizing excellence in lacustrine research. A booth in the Exhibit Hall during the GSA Annual Meeting in Denver will have information on lakes and lakes deposits as well as on the division, its goals, and its organization. Please stop by our booth in October!



Ancient and modern lakes: Above the shore of Walker Lake, Nevada, are terraces indicating higher lake levels in the past.

Call for Geological Papers: 2003 GSA Section Meetings

South-Central–Southeastern Sections Joint Meeting

March 12–14, 2003
University of Memphis, Memphis, Tennessee
Abstract deadline: December 10, 2002
Information: Dan Larsen, Dept. of Earth Sciences, University of Memphis, 421 J.M. Smith Bldg., Memphis, TN 38152, (901) 678-4358, dlarsen@memphis.edu.

Northeastern Section

March 27–29, 2003
Westin Hotel, Halifax, Nova Scotia
Abstract deadline: December 18, 2002
Information: Jane Barrett, Dept. of Earth Sciences, Dalhousie University, Halifax, NS B3H 3J5, Canada, (902) 494-1473, jmbarret@is.dal.ca.

Cordilleran Section

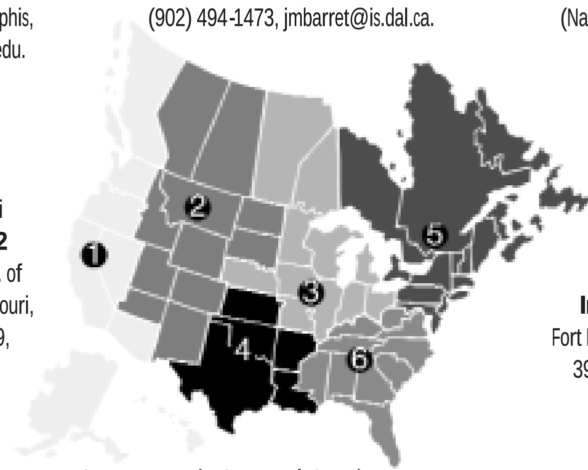
April 1–3, 2003
Hotel NH Krystal, Puerto Vallarta, Mexico
Abstract deadline: December 16, 2002
Information: Elena Centeno-García, Instituto de Geología, Universidad Nacional Autónoma de México, (National Autonomous University of Mexico), Ciudad Universitaria, México, D.F. 04510, México, centeno@servidor.unam.mx.

North-Central Section

March 24–25, 2003
Kansas City Airport Hilton, Kansas City, Missouri
Abstract deadline: December 10, 2002
Information: Raymond M. Coveney Jr., Dept. of Geosciences, 420 Flarsheim Hall, University of Missouri, 5110 Rockhill Rd., Kansas City, MO 64110-2499, (816) 235-2980, coveneyr@umkc.edu.

Rocky Mountain Section

May 7–9, 2003
Fort Lewis College, Durango, Colorado
Abstract deadline: January 30, 2003
Information: James Collier, Dept. of Geosciences, Fort Lewis College, 1000 Rim Dr., Durango, CO 81301-3999, (970) 247-7129, collier_j@fortlewis.edu.



1. Cordilleran Section
2. Rocky Mountain Section
3. North-Central Section
4. South-Central Section
5. Northeastern Section
6. Southeastern Section

Birdsall-Dreiss Distinguished Lecturer for 2003 Announced

Jean Bahr of the University of Wisconsin—Madison (UW) has been selected as the 2003 Birdsall-Dreiss Distinguished Lecturer, sponsored by the GSA Hydrogeology Division and funded by the GSA Foundation. At the request of interested institutions, she will present one of two lectures for audiences interested in broad geologic aspects of groundwater resources.

Bahr received a B.A. in geology and geophysics from Yale University and then spent four years working in geotechnical and hydrogeologic consulting, including two years with a groundwater resources inventory project in West Africa. She continued her education with graduate training in hydrogeology at Stanford University, earning an M.S. and Ph.D. in applied earth sciences. During her graduate work, Bahr participated in field studies of contaminant transport in Canada and modeling studies through an appointment with the U.S. Geological Survey Water Resources Division in Menlo Park, California.

Jean Bahr

Following completion of her Ph.D. in 1987, she joined the faculty at UW and is currently a professor in the Department of Geology and Geophysics. Bahr teaches courses in hydrogeology, contaminant hydrogeology, field hydrogeology, and environmental geology. She is also member of the governance faculty for the Institute for Environmental Studies (IES) and of the program faculty for Geological Engineering. From 1995 to 1999, she served as chair of the IES Water Resources Management graduate program. Her research interests include interactions between physical and biogeochemical processes in groundwater, effects of heterogeneity on solute transport, groundwater–surface water interactions, and paleohydrogeology. During a six-year term as a member of the National Research Council's Board on Radioactive Waste Management, Bahr was involved in reviews of various aspects of the planned high-level radioactive waste repository at Yucca Mountain. She now chairs the National Research Council Committee on Restoration of the Greater Everglades Ecosystem.

To request a visit to your institution, contact Jean Bahr, Department of Geology and Geophysics, UW—Madison, 1215 W. Dayton St., Madison, WI 53706, 606-262-5513, jmbahr@geology.wisc.edu. The Hydrogeology Division is particularly interested in including liberal arts colleges in the itinerary. The division will pay transportation expenses and the host institution will provide local accommodations.

Talk Topics

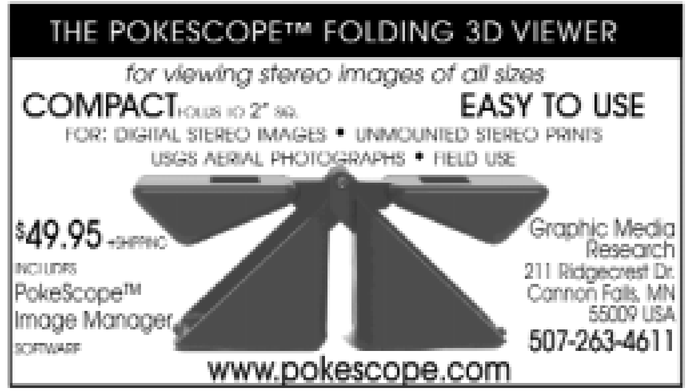
"Groundwater as an Ecosystem Resource." Management of groundwater resources has traditionally focused on human needs for domestic, industrial, and agricultural water supply. In recent years, however, there has been an increasing recognition of the importance of the "ecological services" provided by groundwater discharge to streams, wetlands, and lakes. This comes at a time of increasing human demands resulting from population growth, and as expanding urban areas limit rates of groundwater recharge. In the United States, water shortages have been experienced both in the arid west and in areas generally considered to be water rich (e.g., the Midwest, Florida). While management strategies that allow for temporary overdraft of aquifers may offer an economically efficient option to satisfy human needs, ecosystems that rely on groundwater discharge can be sensitive to even small declines in water levels. Developing groundwater management strategies that meet human needs while protecting critical ecosystems is a delicate balancing act and requires improved understanding of the relationships between ecosystem function and groundwater hydrology and geochemistry.

This talk covers several case histories related to the role of groundwater in ecosystem preservation and restoration. Research projects in several watersheds near Madison, Wisconsin, have explored the hydrogeologic controls on spring flow and the effects of municipal pumping and reduced recharge on the springs. Results of these studies are being used in an interdisciplinary effort to identify urbanization alternatives that minimize negative hydrologic impacts on springs and wetland habitat.

A study in a lowland savannah along the Lower Wisconsin River demonstrates the effects of stage control by upstream dams on spatial patterns of groundwater discharge to the river and adjacent floodplain. Groundwater discharge into wetland areas results in loss of agriculturally derived nitrate. This suggests strategies for restoration of riparian wetlands and dam management that could reduce nitrogen fluxes from the Upper Midwest to the Mississippi River. The final case history will review groundwater management strategies included in a $7.8 billion, 20+ year program to restore the Florida Everglades.

"Geochemical Heterogeneity of Groundwater in Uncontaminated and Contaminated Aquifers." Hydrogeologists are accustomed to finding large spatial and temporal variations in groundwater chemistry as a result of contaminant migration. During characterization of "background" conditions in these aquifers, however, it is often assumed that only one or a small number of wells are adequate for assessing pristine groundwater chemistry.

This talk presents results of multilevel sampling in shallow aquifers in a variety of hydrogeologic settings that demonstrate the prevalence of fine-scale spatial and short-term temporal variability in major ions and redox sensitive species such as oxygen, nitrate, and iron. The sites include several in unconsolidated sediments and two in fractured bedrock: one a carbonate aquifer in Wisconsin and the other in a shale-carbonate aquifer in Tennessee. The geochemical heterogeneity of groundwater at these field sites reflects a combination of distinct flow paths and geochemical and biogeochemical reactions that occur during transport. In many cases, the observed geochemical signatures can be used as natural tracers to delineate flow paths. Identification of the background heterogeneity, as well as understanding the controlling physical and geochemical processes, is important to interpretation of changes induced by introduction of contaminants. A case study of gasoline contaminants in a sandy aquifer in Wisconsin demonstrates the applications of these principles to assessing the potential for intrinsic and enhanced biodegradation under aerobic and anaerobic conditions.



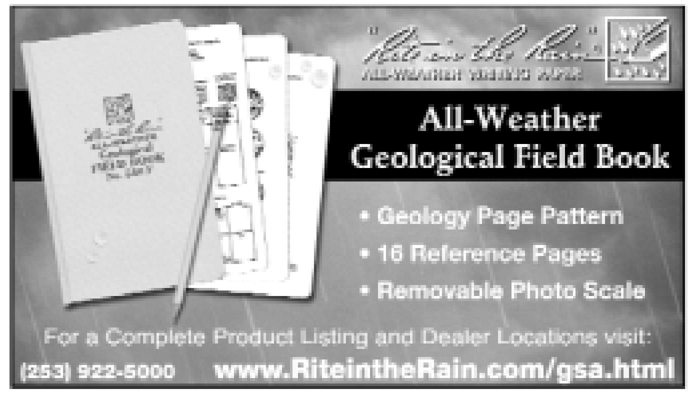
E&EG SCIENCE CO-EDITOR NAMED

Alan Fryar

GSA Council approved the appointment of Alan Fryar to a three-year term as science co-editor for the journal Environmental & Engineering Geoscience (E&EG).

Fryar is associate professor of geological sciences at the University of Kentucky, where he teaches hydrogeology and environmental geology. He previously was a research associate at the Bureau of Economic Geology at the University of Texas at Austin. His research interests include chemical evolution during groundwater recharge and flow; delineation of rates and sources of recharge and discharge; groundwater–surface-water interactions; and natural attenuation of contaminants. He is an associate editor of Ground Water and serves on GSA's Joint Technical Program Committee. Fryar received a B.S. in geology and history from Duke University, an M.S. in geology from Texas A&M University, and his Ph.D. in geology from the University of Alberta. He can be reached at afryar1@uky.edu or (859) 257-4392.

GSA copublishes E&EG with the Association of Engineering Geologists. The quarterly journal publishes original research, new methods, and case histories in engineering geology, environmental geology, and hydrogeology. Fryar, who began his term in June, joins co-editor Abdul Shakoor of the Department of Geology, Kent State University.



Call for Applications:

Apply for the GSA–USGS Congressional Science Fellowship for 2003–2004

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

The Congressional Science Fellow will be selected from top competitors early in 2003. Successful candidates are **GSA members** who possess either a:

Ph.D. in the earth sciences (or a related field); or a

Master's degree in the earth sciences (or a related field) with at least five years of professional experience.

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

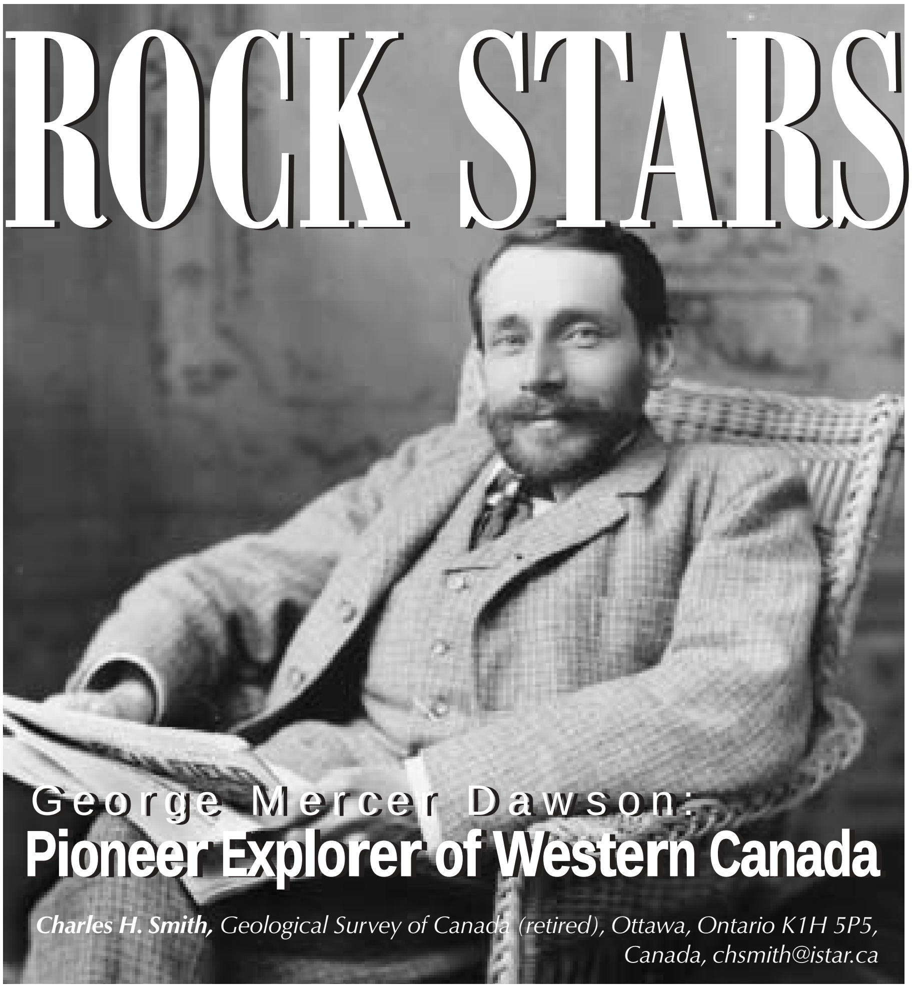
Deadline to apply: January 24, 2003.

For application information, check our Web site at www.geosociety.org/science/csf/index.htm or contact Karlon Blythe, Program Officer, GSA Headquarters, (303) 357-1036, kblythe@geosociety.org.

ROCK STARS

George Mercer Dawson: Pioneer Explorer of Western Canada

Charles H. Smith, Geological Survey of Canada (retired), Ottawa, Ontario K1H 5P5, Canada, chsmith@istar.ca



George Mercer Dawson, May 1885 (age 36). National Archives of Canada. PA26689

In a short life of 51 years, as a geologist, botanist, anthropologist, and director of the Geological Survey of Canada, George Mercer Dawson (1849–1901) rendered an extraordinary service in exploring the geology and resources of western Canada—on the prairies, in the foothills, and in the mountains of British Columbia and the Yukon. His dedication and spirit overcame his considerable physical limitations. He was remarkable among the men of his day.

Early Years

George Dawson was born in Pictou, Nova Scotia, on August 1, 1849. His father, James William Dawson (see "Rock Stars," *GSA Today*, September 1998) had been schooled in geology at the University of Edinburgh. Dawson's father was then superintendent of education for Nova Scotia and, as time permitted, immersed in studies of its geology and mineral deposits. At an early age, Dawson was attracted to his father's collections of fossils, shells, and rocks. In 1855, his father was appointed principal of McGill College (later McGill University), and the family moved to Montreal. Nurtured by his father's interest in education and natural history, Dawson developed as the distinguished son of paleobotanist Sir William Dawson.

At nine, Dawson showed symptoms of an illness that would permanently affect his life. He was stricken with a rare and serious form of tuberculosis, affecting the spinal vertebrae (Pott's disease). For several years he was bedridden and wore a body truss. He was left with "the torso of a hunchback," the "stature of a ten year old," and recurring headaches, impediments which make his later achievements all the more extraordinary. Regular schooling was impossible, so he continued his studies with tutors at home. In this environment, he was able to pursue a wide variety of subjects beyond the normal school curriculum, including using the microscope and blowpipe, photography, and drawing. He absorbed knowledge readily, satisfying his avid intellectual curiosity, and never complaining about his disabilities.

In 1868, Dawson entered McGill as a part-time student, attending lectures in English, chemistry, and geology. A year later, he sailed to England to attend London's Royal School of Mines (RSM). His father provided a special "invalid's chair" for his use while studying, and Dawson coped quite well. At the RSM, affiliated with the British Geological Survey (BGS), his instruction in geology, mining, metallurgy, and chemistry was overseen by leading British scientists, including A.C. Ramsey (geology) and T.H. Huxley (paleontology). Charles Lyell provided generous hospitality. Dawson worked with a BGS field party in 1871. Following three years of instruction, he graduated as an associate, with honors, and he was first in his class. His mind was set on returning to Canada, and pursuing a geological career.

George Mercer Dawson, age 24 (third from right in back row) with members of the British North America Boundary Commission, 1873. National Archives of Canada (PA74675).

Geologizing the 49th Parallel

Dawson returned to Canada in 1872, and was temporarily employed in surveys of Nova Scotia coal mines and lecturing. But this was a period when the newly acquired and largely unknown Canadian West presented a huge challenge—its resource potential was largely undefined. He was soon offered two government positions, both directed at this western challenge—one with the Geological Survey of Canada (GSC), and the other with the British North America Boundary Commission (BNABC). Each would involve long absences from family in Montreal and arduous working conditions. On his father's advice, he chose the BNABC, starting in 1873, while the GSC waited until 1875.

As geologist and botanist to the Boundary Commission, Dawson single-handedly took responsibility for reporting on the natural history of an 800-mile section of the international boundary from western Ontario to southern British Columbia. His purpose was "to make the forty-ninth parallel a geological base line with which future investigation could be connected." Over two years, he traveled by horseback and on foot, collecting scientific data and drawing conclusions on this little known, central region of the North American continent. His 387-page report, "Geology and Resources of the Region of the Forty-ninth Parallel, from the Lake of the Woods to the Rocky Mountains, with Lists of Plants and Animals Collected, and Notes on the Fossils," is considered a classic in Canadian geology. It was published in 1875 with other supplementary reports when he was only 26, and it established his scholarly credentials.

Geological Survey Years

Dawson joined the GSC in 1875. For the next 20 years, he explored the remote parts of western Canada, principally in British Columbia, and adjacent parts of Alberta and the Yukon. He demonstrated an aptitude for hard work, and an innate ability to observe and reach sound conclusions. He zigzagged his way through difficult terrain, by foot, horseback, or canoe, making observations and generalizations that still stand the test of time. His field notebooks, written in a clear hand, are interspersed with sketches and observations on people, flora and fauna, and the weather. He soon established his reputation broadly, in geology and geography, the study of native peoples, and history.

Much of Dawson's exploratory work was directed toward the search for coal and for information of use in constructing the transcontinental railway. As a result, a fairly clear picture of western coal potential emerged. He applied knowledge gained at the RSM to assess the potential for other mineral deposits, particularly placer gold. He implemented a series of periodic reports on the economic minerals and mines of British Columbia.

One remarkable field season, in 1887, involved a seven-month reconnaissance of northern British Columbia and the Yukon along the swift waters and dangerous canyons of the Stikine, Dease, Liard, Frances, Pelly, and Yukon Rivers and finally the crossing of Chilkoot Pass. Geological features were outlined along a 1,332-mile route, involving portages up to 70 miles. Boats and canoes were built, abandoned, and rebuilt along the way. Dawson's report on the Yukon Territory was in great demand during the Klondike gold rush that followed, and Dawson City (then the Yukon capital) was named in his honor.

Dawson's reconnaissance studies made significant contributions to scientific knowledge of the west. He provided a general knowledge of the stratigraphy and structure over vast areas. He described the glacial phenomena, diverging from his father's floating ice theory by providing evidence for widespread continental ice sheets, and naming the Cordilleran and Laurentide Ice Sheets. Along the way, he found time to compile extensive reports on the native populations he encountered, in particular the Haida Indians, their customs, and their vocabularies. These and related contributions established him as a leader in Canadian anthropology.

Dawson never married. He was probably happiest while in the field. He withstood severe weather, rough terrain, mosquitoes, and physical discomfort without complaint. From time to time, his thoughts were reflected in poems, penned in his notebook or on scraps of paper, some of a geological flavor and others reflecting the majesty of the wilderness:

Contorted beds, of unknown age,
My weary limbs shall bear,
Perhaps a neat synclinal fold
At night shall be my lair.....

Dawson's field studies and his prolific writings spread his reputation across North America and England. In 1891, he was elected to the Royal Society of London and was awarded the Bigsby Medal of the Geological Society of London. For service as a commissioner on the Bering Sea seal fisheries, Queen Victoria named him a Companion of the Order of St. Michael and St. George (C.M.G.). In 1893, he was elected president of the Royal Society of Canada. He received honorary doctorates from various universities, including Princeton (1877), Queen's (1890), McGill (1891), and Toronto (1897).

In 1895, Dawson was appointed director of the GSC, an appointment that received glowing tributes in the newspapers and from the mining community. For six hard years he administered a GSC strapped for funds, with consequent effect on staff morale. No time was left for personal fieldwork. He deployed his staff as best he could across the country, and insisted on high standards of achievement. He struggled to fund the museum collections in ethnology, anthropology, and zoology. He showed skills in dealing with the government, the mining industry, and the public, which brought the GSC recognition and support, but not necessarily new funds. While director, Dawson maintained his contacts with the world of science in a number of ways, including serving as GSA president in 1900. At the Albany meeting in December of that year, his President's Address, "The Geological Record of the Rocky Mountain Region in Canada," summarized his work on Cordilleran geology. The following March, at age 51, he died suddenly of acute bronchitis.

Legacy

George Dawson's delicate constitution did not prevent him from tackling the most arduous tasks, whether on the trail or mountainside, or as a leader and dedicated public servant. He combined brilliance with self-discipline, and he strove for excellence in his own work and in that of others. He published widely, lucidly, and frequently, for academic, political, and public audiences. He rightly earned the esteem of his countrymen and the international scientific community.

Further Reading

Adams, F.D., 1901, George M. Dawson: Geological Society of America Bulletin, v. 13, p. 497–509.

Cole, D., and Lockner, B., eds., 1989, The Journals of George M. Dawson, British Columbia, 1875–1878: Vancouver, University of British Columbia Press, 2 volumes.

Dawson, G.M., 1901, Geological Record of the Rocky Mountain Region in Canada: Geological Society of America Bulletin, v. 12, p. 57–92.

Winslow-Spragge, L., 1993, No Ordinary Man: Toronto, Natural Heritage/Natural History Inc., 208 p.

Zeller, S., and Avrith-Wakeam, G., 1994, Dawson, George Mercer, in Dictionary of Canadian Biography, Volume XIII: University of Toronto Press, p. 257–261.

"Rock Stars" is produced by the GSA History of Geology Division. Editorial Committee: Robert Dott, Robert Ginsburg, Gerard Middleton, and Peter von Bitter (editor of this profile).

George Mercer Dawson (age 30) and Geological Survey of Canada survey party, Fort MacLeod, British Columbia, 1879. National Archives of Canada (C18100).

James S. Kahn Appointed to the Foundation Board

The GSA Foundation welcomes James S. Kahn to the Foundation's Board of Trustees for a five-year term.

Kahn brings to the Foundation's Board more than 35 years of broad, diverse, and outstanding executive experience as a leader, scientist, technologist, management expert, change agent, entrepreneur, and administrator of large, multimillion-dollar institutions.

Born in New York City in 1931, Kahn received his B.S. in 1952 from the College of the City of New York, his M.S. in 1956 from Pennsylvania State University, and his Ph.D. from the University of Chicago. His career began as a faculty member at the University of Rhode Island. Kahn served as managing director with the Physic International Company in California, and, while at the University of California, he served as group leader of Experimental Physics, division leader in Geophysics, deputy associate director of Human Resources and Labor Relations, associate director of the Nuclear Test Program, and lastly as deputy director (chief operating officer). He also served as president, chief executive officer, and director of the Museum of Science and Industry in Chicago. His leadership and vision transformed the museum into a renowned twenty-first century science educational center.

Kahn now has his own consulting business, the James S. Kahn Group. Specialties include short-term management assignment focusing on strategic planning; analysis and identification of complex corporate management issues; and problem solving and facilitation of changes in large, diverse organizations. He lives with his wife in Reno, Nevada. He has received many honors and much recognition during his career, and he has served on many committees and boards. His career, accomplishments, and vision will serve the Foundation well.

Welcome aboard, James!

Most memorable early geologic experience

At Columbia University, in the spring of 1942, Professor Douglas Johnson, geomorphologist, marked up my M.A. thesis on underfit meanders. One note read thus, "Horses are gentle. Dips are not."

—Robert J. Wright

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So, please try out the new site (www.geosociety.org/gsaf/) and see how easy it is to contribute to the Foundation. Your continued support of the Foundation and GSA programs is sincerely appreciated!

Got an Item for Our Auction?

The Foundation is looking for items for the Silent Auction that will be held during the GSA Annual Meeting in Denver in October. Our past three auctions have been successful and fun, and if you have something that you would like to donate to this exciting event, it will be appreciated. Here's how it works:

You can donate items for the auction such as rare books, pictures, fossils, gift certificates from bookstores or chain restaurants, antiques, just to name a few. (We will list your name as the donor on the auction item displayed at the Silent Auction.)

Your donation is tax deductible based on the value of the donated item.

You will receive a confirmation letter acknowledging your gift.

Proceeds from the auction will be placed in the Foundation's Unrestricted Fund to support GSA's greatest needs!

For further information, please contact
Donna Russell, drussell@geosociety.org.

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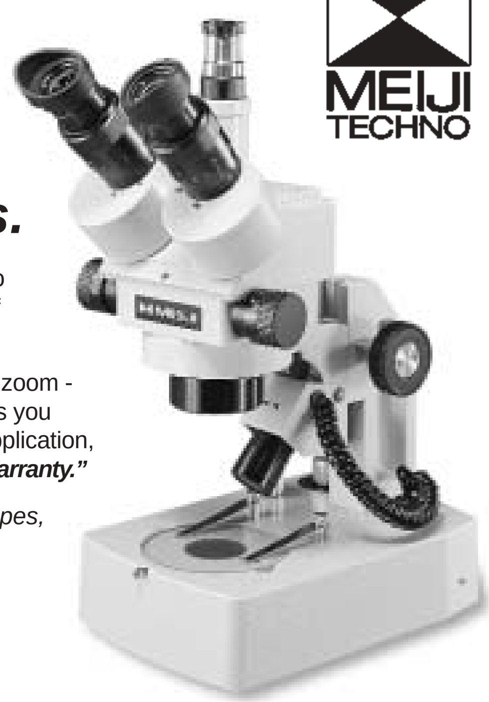

ANNOUNCEMENTS

MEETINGS CALENDAR

2002

Sept. 30–Oct. 4	6th International Conference on Diffuse Pollution, Amsterdam, The Netherlands. Information: r.r.kruize@inter.nl.net, www.nva.net.
October 1	Rocky Mountain Association of Geologists, RMAG Innovative Gas Exploration Concepts, Denver Colorado. Information: Sandi Pellissier, (303) 573-8621, RMAGdenver@aol.com, www.pttcrockies.org, www.rmag.org.
November 18–22	First International Symposium on Transboundary Waters Management, Monterrey, N.L. México. Information: Mexican Hydraulics Association, asmexhca@podernet.com.mx, www.aguamh.com, www.TransboundaryWatersMexico.org.
December 9–11	Organic-carbon burial, climate change and ocean chemistry (Mesozoic-Paleogene), London. Information: Geological Society (London), www.geolsoc.org.uk/template.cfm?name=MSG2447, www.earthsci.ucl.ac.uk/conferences/GSLC.
September 21–22	2002 First Workshop of IGCP Project #463, Upper Cetaceous Oceanic Red Beds: Response to Ocean/Climate Global Change, Ancona, Italy. Information: 86-28-4078892 or 39-071-220-4531, wcs@cdut.edu.cn.
November 4–6	International Symposium on Environmental Geology for Land Use Planning, Puerto Varas, Chile. Information: Servicio Nacional de Geología y Minería, Oficina Técnica de Puerto Varas, La Paz #406, Puerto Varas, Chile, 56-65-233856 or 56-65-233857, fax 56-65-232202, sernageomin@surnet.cl.

2003

October 7–9	6th Petroleum Geology Conference: North West Europe & Global Perspectives, Institute of Petroleum, Petroleum Exploration Society of Great Britain and The Geological Society of London, London. Information: www.geolsoc.org.uk/template.cfm?name=6th_Petroleum_Geology_Conference.
Nov. 30–Dec. 3	Copper 2003 (Cobre 2003), Santiago, Chile. Information: Organizing Committee (Chilean Institute of Mining Engineers and Metallurgical Society of the Canadian Institute of Mining, Metallurgy and Petroleum), info@cu2003.cl, www.cu2003.cl.

About People

In recognition of his distinguished and continuing achievements in original research, GSA member **John P. Grotzinger** was elected to the National Academy of Sciences at the Academy's 139th annual meeting.

Erhard M. Winkler

GSA Fellow **Erhard M. Winkler** was awarded the first Daniel W. Kessler Award by the ASTM International for his continuous and outstanding contributions to the work of ASTM Committee C18 on Dimension Stone, a technical standards–writing committee.

In Memoriam

Robert H. Barton
Houston, Texas

John G. Broughton
Albany, New York
April 19, 2002

S. Warren Carey
Sandy Bay, Tasmania, Australia
March 20, 2002

Alfred Clebsch
Lakewood, Colorado
January 2002

William V. Conn
Atlanta, Georgia

Stephen Jay Gould
Cambridge, Massachusetts
May 20, 2002

Charles E. Graham
Durango, Colorado
March 16, 2002

Howard W. Jaffe
Amherst, Massachusetts
May 13, 2002

Gordon J. F. MacDonald
Cambridge, Massachusetts
May 14, 2002

David J. Roddy
Flagstaff, Arizona
March 21, 2002

Paul J. Roper
Spring, Texas
May 13, 2002

Andrew G. Warne
Guaynabo, Puerto Rico
March 24, 2002

Dean C. Wellman
Denver, Colorado

Please contact the GSA Foundation for information on contributing to the Memorial Fund.

RIDGE 2000: The Next Decade of Innovative Studies and Discoveries at the Mid-Ocean Ridge

The RIDGE 2000 Steering Committee

RIDGE 2000 (R2K) is a new, National Science Foundation (NSF)–sponsored research initiative to understand Earth's spreading ridge system as an integrated whole, from its inception in the mantle to its manifestations in the biosphere and water column. Although the goals of R2K, anticipated to be a 12-year program, have been defined, exciting opportunities exist for investigators to plan its detailed program and to carry out R2K projects.

Since 1988, the RIDGE Program has fostered major advances in our understanding of the global mid-ocean ridge system through focused interdisciplinary studies. Outlined by community workshops over the past two years, R2K builds directly on the scientific and technological successes of the RIDGE Program. The scientific motivation for the R2K Program is encapsulated in the phrase "from mantle to microbes," expressing the inextricable linkages between processes of planetary renewal in the deep ocean and the origin, evolution, and sustenance of life in the absence of sunlight.

The R2K Science Plan aims for a comprehensive understanding of the relationships among the geological processes of plate spreading at mid-ocean ridges and the seafloor and subsurface ecosystems that they support. Research carried out under this new program will be structured within an integrated, whole-system approach that will encompass a wide range of disciplines. Specific geographic areas will be the focus of detailed studies to yield new insights into the links among the biological, chemical, and geological processes that are involved in crustal accretion and subsequent ridge crest processes. The R2K Program will support the following two main research themes.

Time-Critical Studies

The goal of the Time-Critical Studies element is to understand the nature, frequency, distribution, and geobiological impacts of magmatic and tectonic events along the global mid-ocean ridge system. To this end, the theme focuses on the immediate biological, chemical, and geological consequences of active processes on the seafloor. Such processes generally occur as transient events and include volcanic eruptions and intrusions of magma at the ridge axis and faulting related to seafloor spreading.

Under the R2K Program, Time-Critical Studies are dedicated to facilitating rapid-response missions that can observe, record, and sample critical transient phenomena in the ocean above the mid-ocean ridge and on the seafloor itself. In the initial phases of this element, the program will be restricted to the northeast Pacific where real-time detection is possible through the SOSUS array (the Navy's cabled hydrophone system in the northeastern Pacific Ocean) and where the facilities are available for a rapid response.

Integrated Studies

The Integrated Studies theme is a program of focused, whole-system research of global mid-ocean ridge processes, addressing the complex, interlinked array of processes that support life at and beneath the seafloor as a consequence of the flow of energy and material from Earth's deep mantle, through the volcanic and hydrothermal systems of the oceanic crust, to the overlying ocean. Integrated Studies will consist of multidisciplinary research that is focused on a small number of preselected "type" areas that are designed to characterize segments of the mid-ocean ridge system, with the objective of developing quantitative, whole-system models through coordinated and interdisciplinary experiments. R2K scientists will need to understand the interactions and linkages among the volcanic, tectonic, geochemical, and biological systems to achieve this goal.

The Integrated Studies theme will initially focus on three sites (centered on a portion of 9–10°N segment of the East Pacific Rise; the Endeavour Segment of the Juan de Fuca Ridge; and either the East or Central Lau Basin Spreading Center) chosen on the basis of a community vote and a review by an R2K Integrated Site Selection Panel (http://R2K.bio.psu.edu/ISPANELRPT.htm).

R2K Program Status

All biologists, chemists, earth scientists, engineers, and physicists who are interested in mid-ocean ridge science are encouraged to participate in R2K. Two workshops for the general community held in early 2002—one for scientific background and one for planning—provided opportunities for a broad cross section of scientists and engineers to share information about the Integrated Study sites and to help plan the implementation of the research program.

A detailed implementation plan will be required for each Integrated Study site. These site plans are being developed as a result of an open community workshop held on April 7–8 in Albuquerque, New Mexico. Each will identify a geographic focus about which all the nested components of the Integrated Study will be centered and provide the guidelines for the components that will comprise the set of Integrated Studies necessary at each site. Planning will also consider time lines, site administration, and data sharing.

Proposals for funding work at the three Integrated Study sites will be considered beginning with the August 15, 2002, Ocean Sciences target date. Results of the Community Education and Implementation Plan Workshops are posted at http://R2K.bio.psu.edu and should be used by proponents to guide in proposal preparation. R2K proposals are subject to the normal peer-review process and will be reviewed by the regular NSF Ocean Science Division Panels. Additionally, the R2K Steering Committee will perform a relevancy review of all R2K proposals.

Along with the program elements discussed above, R2K also sponsors a postdoctoral fellowship program intended to foster cross-disciplinary fertilization by providing opportunities for individuals to broaden their research expertise as well as to expand the breadth of ridge science.

For more information, or to join the R2K mailing list, e-mail ridge2000@psu.edu, visit http://R2K.bio.psu.edu, or call 814-865-RIDG.

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Field Trips

Field Trips: Where Discovery Begins

Enrich your meeting experience with a field trip. For complete trip descriptions, registration details, and information, see the June issue of *GSA Today* or visit www.geosociety.org. All trips begin and end at the Colorado Convention Center unless otherwise indicated.

Preregistration deadline: September 20
Cancellation deadline: September 27
Register online: www.geosociety.org

Questions?

Contact the field trip's leader or Edna Collis, GSA Program Officer, (303) 357-1034, ecollis@geosociety.org.

1. Paleontology and Geology of the Green River Formation, Utah and Wyoming [401]

Tues.–Fri., Oct. 22–25. Cosponsored by *GSA Sedimentary Geology Division*. Arvid K. Aase, Fossil Butte National Monument, P.O. Box 592, Kemmerer, WY 83101, (307) 877-4455, fax 307-877-4457, arvid_aase@nps.gov; Alan Carroll; H. Paul Buchheim; Meredith Rhodes. Max.: 42; min.: 12. Cost: $315. *Begins and ends in Salt Lake City, Utah.*

2. Middle and Late Jurassic Dinosaur Fossil–Bearing Horizons: Depositional Settings and Implications for Dinosaur Paleoecology, Northeastern Bighorn Basin, Wyoming [402]

Wed.–Sat., Oct. 23–26. Erik P. Kvale, Dept. of Geological Sciences–Indiana Geological Survey, Indiana University, 611 N. Walnut Grove, Bloomington, IN 47405, (812) 855-1324, fax 812-855-7899, kvalee@indiana.edu; Debra Mickelson; Steve T. Hasiotis; Gary D. Johnson. Max.: 22; min.: 12. Cost: $495.

3. Cleanup at Summitville—The Superfund Mine Site That Changed Colorado [403]

Thurs.–Sat., Oct. 24–26. Cosponsored by *GSA Hydrogeology Division*. D. Kirk Nordstrom, U.S. Geological Survey, 3215 Marine St., Suite E-127, Boulder, CO 80303-1066, (303) 541-3037, fax 303-447-2505, dkn@usgs.gov; Geoff Plumlee; Harry Posey. Max.: 22; min.: 12. Cost: $280.

4. High Plains to Rio Grande Rift: Late Cenozoic Evolution of Central Colorado [404]

Thurs.–Sat., Oct. 24–26. Cosponsored by *GSA Sedimentary Geology Division*. Eric Leonard, Dept. of Geology, Colorado College, Colorado Springs, CO 80903, (719) 389-6513, fax 719-389-6910, eleonard@coloradocollege.edu; Mary Hubbard; Emmett Evanoff; Shari Kelley; Christine Siddoway. Max.: 30; min.: 10. Cost: $225.

5. Key Rocks and Seminal Thinkers: Classic Rocky Mountain Localities That Influenced Tectonic Thought [405]

Thurs.–Sat., Oct. 24–26. Cosponsored by *GSA History of Geology Division*. A.M. Celâl Şengör, İTÜ Maden Fakültesi, Jeoloji Bölümü, Ayazaga, Istanbul 80626, Turkey, sengor@itu.edu.tr; Tim Lawton. Max.: 44; min.: 12. Cost: $220. *Begins in Salt Lake City, Utah, and ends in Denver*.

6. Active Incision-Driven Evaporite Tectonism, Glenwood Springs, Colorado [406]

Fri. and Sat., Oct. 25–26. Bob Kirkham, Colorado Geological Survey, 5253 County Road, 1 South, Alamosa, CO 81101, (719) 587-0139, fax 719-587-2187, rmk@amigo.net; Mark Hudson; Bruce Bryant. Max.: 22; min.: 12. Cost: $160.

7. Formation, Reactivation, and Evolution of Proterozoic Shear Zones in the Colorado Rocky Mountains: From Continental Assembly to Intracontinental Orogeny [407]

Fri. and Sat., Oct. 25–26. Colin A. Shaw, Dept. of Earth and Environmental Sciences, New Mexico Institute of Mining and Technology, Socorro, NM 87801, (505) 835-5657, fax 505-835-6436, colins@nmt.edu; Karl E. Karlstrom. Max.: 36; min.: 12. Cost: $185.

8. Neotectonics of the Rio Grande Rift in Colorado [408]

Fri. and Sat., Oct. 25–26. Cosponsored by *GSA Quaternary Geology and Geomorphology Division* and *GSA Structural Geology and Tectonics Division*. Jim McCalpin, GEO-HAZ Consortium, P.O. Box 837, Crestone, CO 81131, (719) 256-5227, fax 719-256-5228, mccalpin@geohaz.com; Alan Nelson; Dean Ostenaa; Andrew Valdez. Max.: 45; min.: 24. Cost: $170.

9. Structure and Stratigraphy of the Southern Colorado Front Range–Cañon City Syncline, Colorado [409]

Fri. and Sat., Oct. 25–26. Cosponsored by *GSA Sedimentary Geology Division*. Paul R. Krutak; P. Krutak Geoservices International, P.O. Box 369, 2118 Main Street, Rye, Colorado 81069-0369, telephone and fax (719) 489-2282, pkrutakgeos@hotmail.com. Max.: 24; min.: 8. Cost: $160.

10. Borehole Image Logging in Geology and Hydrogeology [410]

Sat., Oct. 26. Cosponsored by *GSA Hydrogeology Division*. John H. Williams, U.S. Geological Survey, 425 Jordan Road, Troy, NY 12180-8349, (518) 285-5670, fax 518-285-5601, jhwillia@usgs.gov; Carole Johnson; Roger Morin; Fred Paillet; John Stowell. Max.: 24; min.: 12. Cost: $95.

11. Debris Flows Along the I-70 Corridor, Floyd Hill to the Eisenhower Tunnel [411]

Sat., Oct. 26. Jeff Coe, U.S. Geological Survey, Denver Federal Center, MS 966, Box 25046, Denver, CO 80225, (303) 273-8606, fax 303-273-8600, jcoe@usgs.gov; Jonathan Godt. Max.: 24; min.: 12. Cost: $85.

12. Eco-Geo Hike Along the Dakota Hogback North of Boulder, Colorado [412]

Sat., Oct. 26. Peter Birkeland, Dept. Geological Sciences, University of Colorado, Boulder, CO 80309 (retired), birkelap@stripe.Colorado.edu; Ralph Shroba; Ven Barclay; Parker Calkin; Edwin Larson; Mary McMillan. Max.: 21; min.: 7. Cost: $35. *Begins and ends in Boulder*.

13. Environmental and Engineering Geology of the I-70 Corridor Denver–Eisenhower Tunnel [413]

Sat., Oct. 26. Cosponsored by *GSA Engineering Geology Division*. Ed Nuhfer, Center for Teaching & Learning, Idaho State University, Pocatello, ID 83209, (208) 282-3662, fax 208-282-4847; William Savage. Max.: 36; min.: 12. Cost: $65.

14. Geoarchaeology of South Park: A Prairie Ecosystem in the Rocky Mountains [414]

Sat., Oct. 26. Cosponsored by *GSA Archaeological Geology Division*. Tom Lincoln, Bureau of Reclamation, Office of Policy, Denver Federal Center, Bldg. 67, P.O. Box 25007 (D-5300), Denver, CO 80225-0007, (303) 445-3311, tlincoln@do.usbr.gov. Max.: 30; min.: 10. Cost: $70.

15. Geologic Reconnaissance of the Denver Front Range and Dinosaur Ridge [415]

Sat., Oct. 26. Cosponsored by *GSA Geoscience Education Division*. Norb Cygan, Friends of Dinosaur Ridge, 16831 W. Alameda Parkway, Morrison, CO 80465, (303) 697-3466, fax 303-697-8911, necygan@aol.com; “T” Caneer; Betty Rall; Duff Kerr; Bob Raynolds; Pete Modreski; Susan Landon. Max.: 45, min.: 12. Cost: $70.

16. Laramide Structure and Synorogenic Sedimentation of the Colorado Front Range [416]

Sat., Oct. 26. Cosponsored by *GSA Sedimentary Geology Division*. Edward J. (Ned) Sterne, Savant Resources, 730 17th Street, Suite 410, Denver, CO 80202, (303) 592-1905, ext. 103, fax 303-592-1909, nedsterne@savantresources.com; Robert G. (Bob) Raynolds; Christine Smith Siddoway. Max.: 36, min.: 12. Cost: $65.

17. Modern-Day Consequences of Historic Coal Mining in the Foothills and Boulder and Weld Counties, Colorado [417]

Sat., Oct. 26. Cosponsored by *GSA Coal Geology Division*. Christopher J. Carroll, Colorado Geological Survey, 1313 Sherman St., Room 715, Denver, CO 80203, (303) 866-3501, fax 303-866-2461, Chris.Carroll@state.co.us; Celia Greenman; Nicole Koenig. Max.: 24; min.: 8. Cost: $80.

Field Trip Itineraries: *Just a Click Away*

Once you’ve received the confirmation of your field trip registration from GSA, go to: www.geosociety.org/meetings/2002/ftrip_logon.asp. Use the ID number from your confirmation or your e-mail address to access your trip itinerary sheet(s). You can download the itineraries for the trips you’ve registered for, and you can fill out your individual information sheet to submit back to GSA Headquarters.

18. Tepee Buttes: Fossilized Methane-Seep Ecosystems [418]

Sat., Oct. 26. Cosponsored by *GSA Geobiology and Geomicrobiology Division*. Russell S. Shapiro, Dept. of Geology, Gustavus Adolphus College, 800 W. College, St. Peter, MN 56082, (507) 933-7335, fax 507-933-7041, rshapiro@gustavus.edu; Henry Fricke. Max.: 20 (*firm*); min.: 7. Cost: $80.

19. Tour of U.S. Geological Survey Mapping and Geologic Facilities, Denver Federal Center [419]

Tues., Oct. 29, 12:30–5 p.m. Peter J. Modreski, U.S. Geological Survey, MS 915, Box 25046, Denver Federal Center, Denver, CO 80225-0046, (303) 202-4766, fax 303-202-4742, pmodreski@usgs.gov; Joseph J. Kerski. Max.: 24; min.: 8. Cost: $25.

20. Permian-Triassic Depositional Systems, Paleogeography, Paleoclimate, and Hydrocarbon Resources in Canyonlands and Monument Valley, Utah [420]

Thurs.–Mon., Oct. 31–Nov. 4. Cosponsored by *GSA Sedimentary Geology Division*. Jacqueline E. Huntoon, Dept. of Geological Engineering and Sciences, Michigan Technological University, Houghton, Michigan 49931, (906) 487-2412, fax 906-487-3371, jeh@mtu.edu; Russell F. Dubiel; John D. Stanesco; Debra Mickelson. Max.: 20; min.: 7. Cost: $615.

21. Approaches to Characterizing Complex Geology for Watershed Investigations in Fractured Crystalline Bedrock: The Idealized and the Reality [421]

Thurs., Oct. 31. Jonathan Saul Caine, U.S. Geological Survey, P.O. Box 25046, MS 973, Denver, CO 80225-0046, (303) 236-1822, fax 303-236-3200, jscaine@usgs.gov; Clifford Bossong; Geoffrey Thyne. Max.: 30; min.: 10. Cost: $85.

22. Consequences of Living with Geology: A Model Field Trip for the General Public [422]

Thurs., Oct. 31. Cosponsored by *GSA Engineering Geology Division*, *GSA Geoscience Education Division*, and *American Institute of Professional Geologists*. David M. Abbott Jr., Consulting Geologist, 2266 Forest St., Denver, CO 80207, (303) 394-0321, fax 303-394-0543, dmageol@msn.com; David C. Noe. Max.: 90; min.: 42. Cost: $65.

23. Field Trip to Glenwood Caverns–Fairy Cave, Glenwood Springs, Colorado: An Introduction to CO_2 and H_2S Speleogenesis [423]

Thurs., Oct. 31. Cosponsored by *GSA Hydrogeology Division*. Fred G. Luiszer, Dept. of Geological Sciences, University of Colorado, Campus Box 399, Boulder, CO 80309-0399, (303) 492-5251, fax 303-492-2606, luiszer@spot.colorado.edu; Harvey DuChene. Max.: 45; min.: 22. Cost: $95.

24. Structural Geometry and Thermal History of Pseudotachylyte from the Homestake Shear Zone, Sawatch Range, Colorado [424]

Thurs., Oct. 31. Cosponsored by *GSA Structural Geology and Tectonics Division*. Joseph L. Allen, Dept. of Physical Sciences, Concord College, Athens, WV 24712-1000, (304) 384-5238, fax 304-384-6225, allenj@concord.edu; Kieran D. O’Hara; David P. Moecher. Max.: 33; min.: 12. Cost: $75.


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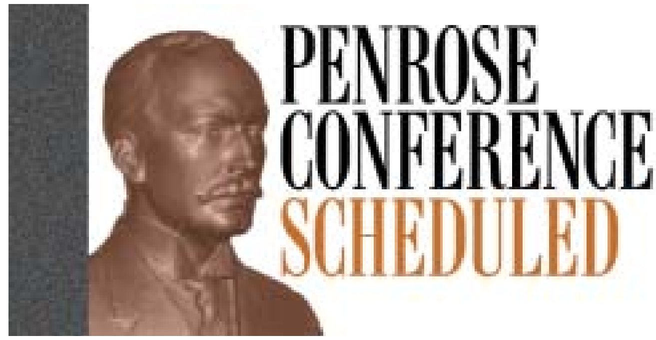

Tectonics, Climate, and Landscape Evolution

January 13–17, 2003
Taroko National Park, Taiwan

http://olympus.geology.washington.edu.

This past decade has seen considerable interest in the coupling between tectonics, climate, surface processes, and the evolution of Earth's topography. General acceptance of the principles of the tectonic origin of topography, the increase in erosion rates with relief, and the importance of climate as a modulator between uplift and erosion has evolved into a desire for understanding of the processes, their rates, and the mechanisms of feedback implicit to these principles. This conference will examine progress made through geomorphological, geophysical, geochemical, and atmospheric studies and will assess the current state of knowledge of the dynamic earth surface system.

APPROXIMATE COST: $975, including room and board.

REGISTRATION, APPLICATIONS, AND INFORMATION: Contact Sean Willett, Department of Earth and Space Sciences, University of Washington, Seattle, WA 98125, USA, (206) 543-8653, fax 206-543-0489, swillett@u.washington.edu.

For complete information on this Penrose Conference, see the June 2002 issue of *GSA Today*, or visit www.geosociety.org (go to "Meetings and Excursions," then to "Penrose Conferences").

GeoVentures

2002 Grand Canyon Memories

Geology of the Grand Canyon—Lee's Ferry to Diamond Creek

April 21–28, 2002

Leader: Carol M. Dehler, Utah State University, Logan, Utah

Grand Canyon 2002. Photo by Mario Wannier.

"Nearly a week has passed since returning from the 2002 Grand Canyon GeoTrip along the Colorado River, and I am still glowing with the memory! Truly it was a highlight of my geological lifetime. Our leader, Carol Dehler, made the week a rousing success!"

—James T. Neal, Prescott, Arizona

"This GeoTrip was truly an experience that I will certainly hold in high regard and share with my family and others for the rest of my life!"

—Rudolph V. Matalucci, Albuquerque, New Mexico

"From my experience on various kinds of scientific and/or technical oriented trips over a span of almost 50 years, I can honestly say that Carol Dehler was a superb trip leader."

—David B. Duane, New Bern, North Carolina

TECTONICIST

QUEEN'S UNIVERSITY AT KINGSTON, ONTARIO

The Department of Geological Sciences & Geological Engineering at Queen's invites applications for a faculty position in the field of integrated quantitative neotectonics and paleotectonics. The position is part of the Ontario Research Centres in Earthquake Hazards and Continental Dynamics, a network involving also Western Ontario and Carleton universities and the Ontario Challenge Fund. This post relates to the theme "integrated analysis and modelling of continental dynamics", which will foster full integration of geological knowledge with geophysical monitoring developments in the province (www.polarisnet.ca). Hence the successful candidate will be a geologist who can combine a sound understanding of regional/global tectonics with inferences drawn from geomechanical and geophysical techniques, and thus can contribute to practical advances in natural hazard mitigation and mineral resource discovery.

The holder of the position will be expected to teach at the undergraduate and graduate levels, to develop a vigorous program of high quality, externally-funded research, and to supervise graduate students at the M.Sc. and Ph.D. levels. Candidates should hold a Ph.D. in an appropriate field and demonstrate research excellence by a successful record of peer-reviewed publication.

All qualified candidates are encouraged to apply; however Canadians and permanent residents will be given priority. The University is committed to employment equity and welcomes applications from all qualified women and men, including visible minorities, aboriginal people, persons with disabilities, gay men, and lesbians.

Applicants should send a curriculum vitae, statements of research and teaching interests, and samples of research writing to the following address. Arrangements should also be made for at least three letters of reference to be forwarded to the same address. Review of completed applications will begin on 20 September, 2002.

H. Helmstaedt, Head, Geological Sciences & Geological Engineering,
Queen's University, Kingston, ON Canada K7L 3N6

Additional information about the Department can be obtained from the WWW at http://geol.queensu.ca

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Ph.D. field geologist, K–16 educator and wilderness guide seeks job. 1996 UNM Ph.D. on Grand Canyon tectonics; 2000 New Zealand postdoc on Alpine fault; field scientist for New Mexico Bureau of Geology; director Grand Canyon and New Zealand field education programs; 8 years NAU summer field geology instructor; 30+ Grand Canyon natural history trips; K–16 teaching experience; river and mountain guide. Contact Brad Ilg at brad.ilg@nzfi.org or dial 011-644-970-9811 from US.

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

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

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

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

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Contact: Dr. Michael Basel, Haley & Aldrich, Inc., 8700 Monrovia, Suite 310-AD, Lenexa, KS 66215-3500, 913.599.5802, fax 913.599.5822.

TENURE TRACK POSITION IN ENGINEERING GEOLOGY or SURFICIAL PROCESSES

The Department of Geosciences at SFSU invites applications for a tenure-track faculty position at the assistant professor level in Engineering Geology or Surficial Processes, beginning January or August 2003. The position requires a Ph.D. in geology, strong quantitative and field skills, and a commitment to excellence in teaching at graduate (M.S.) and undergraduate levels. We seek someone to teach advanced-level engineering geology and/or surficial processes courses, and general education courses in natural hazards or earth systems. Excellence in research that involves both graduate and undergraduate students is also required. Preference will be given to applicants who have applied experience with a geotechnical or environmental firm and experience in teaching and in applying GIS technologies.

The Department of Geosciences includes geology, meteorology, and oceanography and consists of 13 faculty members from these fields. The department offers B.S. and B.A. degrees in Geology, a B.S. degree in Atmospheric and Oceanic Sciences, and an M.S. degree in Applied Geosciences.

San Francisco State University, a member of the California State University system, serves a multi-cultural, ethnically diverse student body of 27,000 students, offering bachelor's degrees in 117 academic areas and master's degrees in 95 fields of study. Excellence in teaching and research are central to the University's mission and SFSU faculty are expected to demonstrate high levels of professional achievement and growth through research, publications, and community involvement.

To apply, send a curriculum vitae, a statement of teaching and research interests, and names and addresses of three references to: Lisa White, Dept. of Geosciences, San Francisco State University, San Francisco, CA 94132. Applications should be received before September 30, 2002. San Francisco State University is an Equal Opportunity / Affirmative Action employer.

TULANE UNIVERSITY—SEDIMENT TRANSPORT

The Department of Geology at Tulane University invites applications for a tenure track Assistant Professor position to begin in the Fall, 2003 in the field of sediment transport. Applicants will be expected to develop an externally funded research program that builds upon the expertise of a growing, interdisciplinary department (http://tulane.edu/~geology) and the Institute for Earth and Ecosystem Sciences (http://tulane.edu/~iees) conducting basic and applied research in fluvial, deltaic, and/or coastal environments. In particular, we seek applicants who utilize field observations in concert with numerical or laboratory modeling in one or more of the following areas: (1) suspended sediment transport, (2) bedform migration, (3) surface water hydrology, or (4) fluvial geomorphology. Candidates will have completed their Ph.D. by the start date, and will be expected to teach undergraduate and graduate courses in their field of expertise, and to mentor graduate students. Applicants should send a letter of application, statement of research and teaching interests, current curriculum vitae and the names, addresses, and telephone numbers of 3 references to Dr. George C. Flowers, Chair, Department of Geology, Tulane University, New Orleans, Louisiana 70118, e-mail flowers@tulane.edu. The closing date for applications is November 15, 2002, although the search will remain open until the position is filled. Tulane University is an affirmative action/equal opportunity employer. Women and minorities are encouraged to apply.

STABLE ISOTOPE GEOCHEMIST
SYRACUSE UNIVERSITY
DEPARTMENT OF EARTH SCIENCES

The Department of Earth Sciences invites applications for a tenure-track assistant professor in the field of stable isotope geochemistry. We seek an individual with analytical expertise in carbonate, water, organic and other stable isotopic systems to complement established research and teaching programs in paleoclimatology, hydrogeology, paleobiology, and tectonics. The department houses a stable isotope laboratory equipped with a Finnegan Matt 252 stable isotope mass spectrometer with dual viscous flow inlet systems and collector systems for H/D, CO_2, N_2, SO_2, or O_2. The system also includes a Kiel III Automated carbonate preparation device, HDO II $CO_2/H_2/H_2O$ equilibrator device, and a ConFlo II continuous flow interface. The Earth Sciences Department has established research collaborations with the SU Biology and Civil and Environmental Engineering Departments, and the SUNY College of Environmental Science and Forestry. The successful candidate will be expected to establish an externally funded research program, and contribute to the department's teaching mission at the advanced (e.g., stable isotope geochemistry, aqueous geochemistry) and introductory levels.

To apply, send a curriculum vitae, statement of research and teaching interests, and names of three references to: Search Committee Chair, Department of Earth Sciences, 204 Heroy Geology Laboratory, Syracuse University, Syracuse, NY 13244-10170. The search committee will begin reviewing applications on October 15, 2002. The search will remain open until the position is filled. Syracuse University is an AA/EOE. Minorities and women are encouraged to apply.

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

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

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

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

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

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

BELOIT COLLEGE

Beloit College invites applications for a full-time, tenure-track position (beginning mid-August 2003) at the assistant professor rank in geology, with expertise in tectonics/igneous and metamorphic petrology. Course responsibilities include an introductory course in physical geology, mineralogy, petrology, structural geology (on a rotating basis), and selected advanced courses (e.g., tectonics, geochemistry, isotope geology). The successful candidate will also be expected to teach a six-week summer field-geology course on a rotating basis, participate in the departmental field-trip program, and supervise undergraduate research projects. Finally, the successful candidate will contribute to all-college programs (e.g., first-year seminars, interdisciplinary courses, writing program, and international education).

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

Applicants should have a Ph.D. by the time of appointment. Send a letter of application, a statement of teaching and research interests, a vita, college-level transcripts, and three letters of reference by 15 October 2002 to Carl Mendelson, Geology Search Committee, Beloit College, 700 College St., Beloit, WI 53511. Inquiries may be directed to Prof. Mendelson (608-363-2223 or mendelson@beloit.edu). Preliminary interviews for this position will be conducted at the GSA annual meeting in Denver (October 2002). For more information, see http://geology.beloit.edu/.

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

WASHINGTON AND LEE UNIVERSITY

Tenure track position starting fall 2003. The Geology Department at Washington and Lee University seeks applicants in any specialty complementing our current faculty, with teaching interests in Sed/Strat and Historical Geology. W&L is a nationally ranked, highly selective liberal arts college. Our department (geology.wlu.edu) is a member of the Keck Geology Consortium, and is ideally situated for field studies in the Valley and Ridge of southwestern Virginia. We seek a colleague who is dedicated to diverse teaching approaches, interested in making the most of our field setting, committed to collaborative undergraduate research, and enthusiastic about teaching intensive major/non-major field geology courses during spring term. A resume, statements of teaching interests/experience and research interests, and 3 letters of reference should be sent by Sept. 1, 2002, to David Harbor (harbord@wlu.edu), Geology Department, Washington and Lee University, Lexington, VA 24450. We encourage women and minority candidates to apply.

STRUCTURAL GEOLOGIST

The Center for Nuclear Waste Regulatory Analyses Geology and Geophysics group seeks an individual in geology, tectonics, or related discipline for a two-year limited term position.

The successful candidate will participate in the qualitative and quantitative assessment of faults and fractures and the quantitative modeling of geologic structures and their relationships to movement of water and oil; provide support for geomechanical evaluations of the problems related to petroleum exploration, including influence of rock properties on origin of geologic structures and the implementation of geomechanical techniques into 3DStress™ software; conduct independent and team-based investigations of natural deformation processes, including field investigations in remote areas; present results of investigations in written peer-reviewed publications and presentations; and participate in proposal development.

Requirements: B.S., M.S., and Ph.D. in geology or related field with emphasis on structural geology or tectonics. Experience with solving problems in structural geology or tectonics is desirable. Superior oral and written skills are required.

SPECIAL CONSIDERATIONS: All applicants must pass a conflict of interest evaluation and be qualified for a NRC clearance.

Send a current vitae, a statement of research interests, and names of three references to:

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TECTONIC GEODESY
UNIVERSITY OF CALIFORNIA AT SANTA BARBARA

The Department of Geological Sciences at the University of California at Santa Barbara invites applications for a tenure-track position at the assistant professor level in Tectonic Geodesy for an appointment to begin July 1, 2003. We seek a broadly trained geoscientist who utilizes geodesy (primarily GPS and interferometry) for creative research in the fields of quantitative crustal deformation, plate tectonics, and/or surface processes. Individuals with additional expertise in numerical modeling or field geology are especially encouraged to apply. The successful applicant should complement departmental strengths in structural geology, tectonics, seismology, and surface processes. The appointee to this position will teach both undergraduate and graduate courses and is expected to maintain a vigorous, externally funded research program.

A Ph.D. is required at the time of appointment. The deadline for applications is September 1, 2002. Applicants should submit a letter of application, curriculum vita, and description of teaching and research objectives and accomplishments. Applicants should request that three referees send letters of evaluation directly to the search committee by the September deadline. Applicants should also provide the names, email addresses and contact information of those referees. All materials should be sent to: Geodesy Search Committee, Department of Geological Sciences, University of California, Santa Barbara, CA 93106-9630.

UCSB is an Equal Opportunity/Affirmative Action employer.

Opportunities for Students

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

Call for Applications and Nominations for

GEOLOGY CO-EDITOR

GSA is soliciting applications and nominations for the position of co-editor of Geology, an international geosciences journal for rapid publication of leading research. The co-editor will serve a four-year term, beginning in fall 2002 (exact start date to be negotiated), and will be one of a three-editor team. A co-editor with expertise and broad interests in geochemistry/hydrology/economic geology would best complement the continuing editors' strengths, but fields are flexible.

Desirable characteristics for the successful candidate include:

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

Non–North Americans and women are particularly encouraged to apply, but the position will be offered to the most suitable candidate.

GSA provides the editor with a small stipend, as well as expenses for administrative assistance, mail, and telephone/online. The editor will work out of his/her current location at work or home—no move is necessary.

If you wish to be considered, please submit a curriculum vitae and a brief letter describing why you are suited for the position. If you wish to nominate another, please submit a letter of nomination and the individual's permission and CV. Send nominations and applications to Jon Olsen, Director of Publications, GSA, P.O. Box 9140, Boulder, CO 80301, jolsen@geosociety.org, no later than September 1, 2002.

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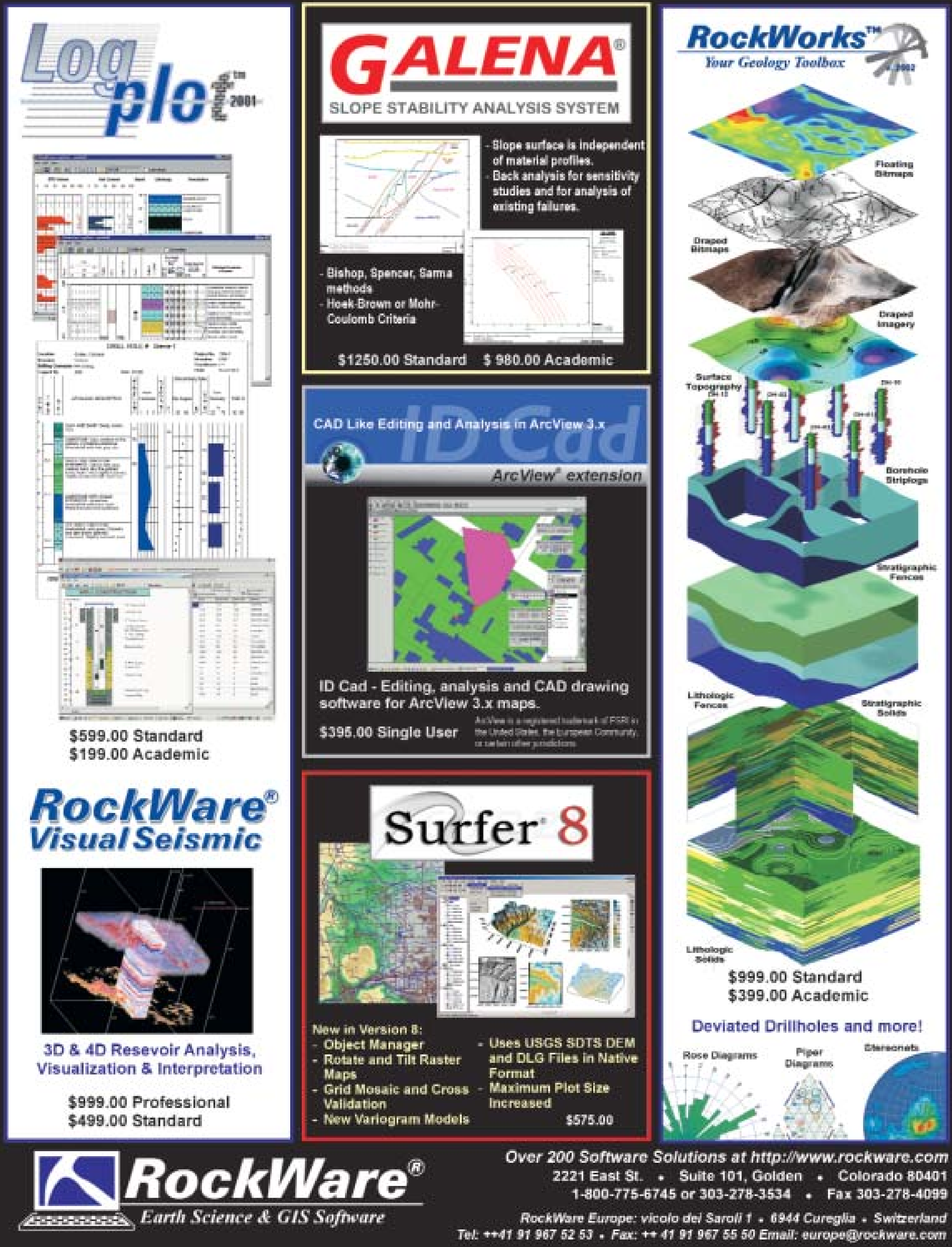
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