Vol. 2, No. 6 June 1992

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INSIDE

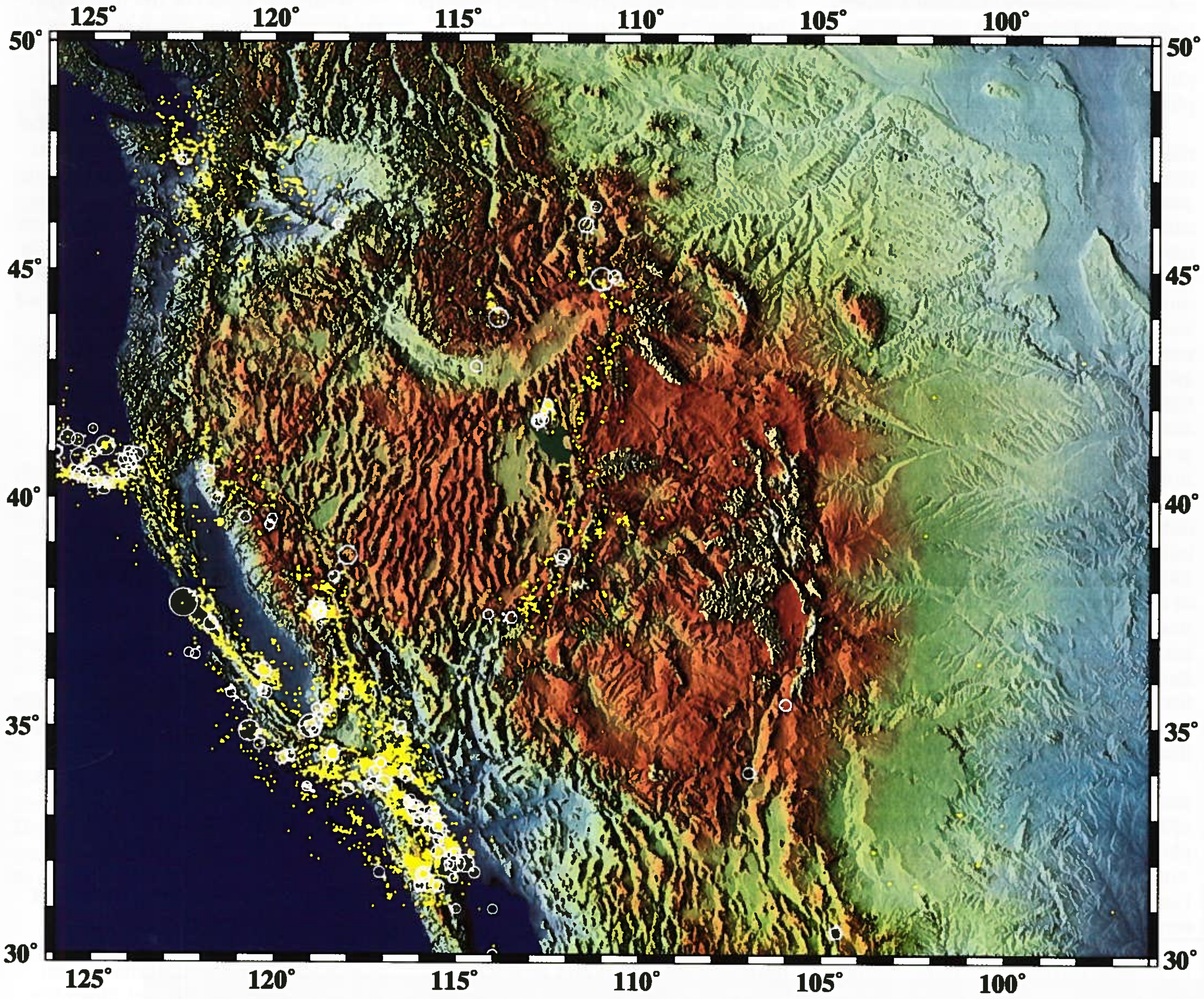

Figure 1. Topography and seismicity of the western United States. Shading mimics illumination from the west. Open white circles, with size scaled to magnitude, are 118 large earthquakes with magnitude greater than 6, 1900–1975. Yellow dots are 1807 earthquakes of magnitude greater than 2.5, 1970–1985. Epicentral data are from the Decade of North American Geology (DNAG) catalog of Engdahl and Rinehart (1989).

Editor's Note:

In March 1991, we published a science article that was a first report of the results of the Magellan Venus orbiter, which has been sending back images of Earth's neighbor since September 1990. At this time, Magellan is on its third complete coverage of the Venusian surface. As a result of this successful and exciting space mission, we have a comprehensive view of almost the entire surface of Venus. Paradoxically, therefore, we have a much better view of Venus's solid surface than we do of Earth's. There are two reasons for this state of affairs: One is that most of Earth's surface is covered by water, which is even harder to see through than the clouds that surround Venus. The other is that the amount of money spent on the Magellan mission vastly exceeds the amount ever spent on imaging, high or low tech, Earth's surface. Efforts are underway, however, to provide remote sensing images of Earth's surface that compare in quality and coverage with those of the Magellan radar images of Venus. The article by Richard Pike in November 1991 *GSA Today* was an example of this kind of approach, using digital topography (in that case of the conterminous United States). The article in this issue, by Simpson and Anders, is a complementary approach to the use of such imaging for geologic analysis of a specific region. We will publish others in the future.

—Eldridge Moores

Tectonics and Topography of the Western United States—An Application of Digital Mapping

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ABSTRACT

The most evident expression of the tectonic processes that have shaped Earth is the topography of its surface. From global divisions between continents and oceans to regional divisions between mountains and plains to subtle offsets in landscape that reflect fault motion, topographic data are rich in geological information. Maps created from digital topographic data can be manipulated to maximize the geologic information inherent in such data. Such maps can be used for tectonic interpretations over a range of scales. Features stand out or are subdued depending upon their orientation with respect to the illumination direction in digitally produced relief maps. At a regional scale, the topography of individual provinces of the western United States reflects their tectonic histories, such as the extensional faulting of the Basin and Range province or the limits of Mesozoic thrusting. At a more local scale, the topography of the northeastern Basin and Range province shows a close correlation with patterns of historic faulting. Finally, digital topographic analysis can be used to assess tectonics on the scale of individual mountain ranges, such as the Wasatch Range of central Utah.

INTRODUCTION

The ancient art of map making is being revolutionized by the increasing variety and quality of digital data describing Earth's surface and by the availability of computer software and hardware capable of handling the resulting large volumes of high-resolution data. All of the traditional components of maps—topography, outlines of lakes and rivers, locations of cities, roads, and other cultural features—are becoming available in digital form. Various geological and geophysical data are also being converted into digital form from existing maps or are being collected by digital means. The advent of Earth-looking satellites such as Landsat and SPOT, weather satellites, and special missions of the Space Shuttle are providing new synoptic views of Earth. Taken alone, these new data are fundamentally valuable, but combined with the ease of manipulation of digital data on computers and with the ability to incorporate data from diverse sources to create new maps, they become revolutionary. From the higher density and accuracy of digital data, new perspectives can be obtained. Our study of the topography of the western United States demonstrates these capabilities.

The amount of detail that a topographic map can portray depends on the density of the measurements available. Global elevation coverage is available in 5 minute (approximately 10 km) averages of topography and bathymetry from the National Oceanic and Atmospheric Administration's (NOAA) DBDB5 data set. Complete coverage of the United States (derived from the contour information on existing 1:250,000 topographic maps) is available at point spacing of 30 arc seconds (approximately 1 km). The U.S. Geological Survey National Cartographic Information Service currently provides detailed coverage, at point spacing of 30 m, for selected areas and plans to cover the entire United States at this resolution.

The shaded relief maps of Pike and Thelin (1989), Thelin and Pike (1991), and Pike (1991) spectacularly demonstrate that moderate-scale topographic data can resolve continental scale variations in topographic fabric. Here we present a color version of a similar map for the western United States (Fig. 1) and show how the topographic data can be combined with other types of data in tectonic studies.

Map Preparation

We have selected digital elevation data from the Geophysics of North America CD-ROM compilation, distributed by NOAA. The processing of the data is a simplified version of that carried out by Pike and Thelin (1989). The original data, equally spaced in latitude and longitude, are re-sampled on a rectangular grid with the east-west direction compressed by the cosine of the average map latitude. This produces a map projection similar to Mercator, but considerably simpler to execute. The shaded relief effect is produced by determining the west-to-east gradient in the topography using a simple difference operator. The elevation and gradient information are combined using color to represent absolute elevation and intensity to represent the gradient. The color scheme designates blue at sea level, ranges up to green and orange, and finally attains white at the highest elevation. Each primary component of color (red, green, and blue) for each point is then multiplied by a value corresponding to the gradient at that

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point. We use a full 24-bit representation of the color to produce a smooth modulation with height and gradient. Points (earthquake epicenters), vectors (faults), and annotation are laid over the topographic raster, using the techniques described by Wessel and Smith (1991) and Davis (1990) and additional software developed at Lamont-Doherty Geological Observatory. The final figures are printed on a high-resolution (300 dot per inch, 24-bit color) ink-jet plotter (IRIS Graphics Model 3024).

As pointed out by Pike (1991), the gradient calculation (or sun angle illumination) accentuates features with a strong grain transverse to the direction of the gradient and subdues those parallel to it. This can distort the significance of directional features and must be chosen carefully. In Figure 2, we show gradient maps whose illumination directions vary by 45°. Broad areas with strong structural grain and high relative relief, such as the Basin and Range province, retain the same general appearance under all illuminations. Narrow linear features, such as the San Andreas fault system, stand out clearly in transverse illumination, but are much less obvious when the illumination is along strike. In areas of moderate relief with less obvious lineation (the Snake River Plain, Columbia Plateau, northwestern Basin and Range province, and eastern Montana), texture and the apparent orientation of grain can substantially change with illumination direction.

The earthquake data used in Figures 1 and 4 are from the compilation of Engdahl and Rinehart (1989) prepared for the Geological Society of America's Decade of North American Geology. For this compilation, epicenters from a variety of historical and instrumental catalogs were combined to provide relatively uniform coverage over the United States. Larger earthquakes from historical and recent catalogs indicate areas of major seismicity, whereas lower magnitude seismicity, from regional networks operating over the past 15 years, shows more clearly the details of spatial trends in activity.

The color map (Fig. 1) provides the absolute elevation information missing in gray-shade digital relief maps or satellite images. It also provides a basis for comparing elevation of widely separated regions—for example, the relative elevations of the Sierra Nevada and the Rockies or the Great Plains. Subtle regional changes in elevation such as the gradual eastward increase in elevation in the eastern Snake River Plain can also be easily discerned. Moreover, regional elevation patterns of tectonic origin become evident, such as the dramatic steplike drop in elevation from the northern Basin and Range province to the region between the Colorado Plateau and the southern Sierra Nevada (including the region labeled "Mojave Desert" in Fig. 2) which then drops in mean elevation to the southern Basin and Range south of lat 34° N.

All of the above topographic features are observable on conventional topographic maps, but detailed digital maps provide a clarity that previously was available only on satellite images; at the same time, they provide important relative elevation information. Furthermore, these topographic features can be quantitatively compared by generating digital elevation profiles across any of these regions, as is shown in Figure 3. Average elevation of one of these regions or average elevation along a strip can be determined in order to compare one region to another.

Topography and the Tectonic History of the Western United States

The western United States is part of an orogenic belt that has undergone significant tectonism from the latest Proterozoic through the Phanerozoic. During the late Proterozoic and Early Cambrian the western margin of North America underwent continental-scale rifting associated with development of a passive margin (Stewart, 1972; Bond and Kominz, 1984; Levy and Christie-Blick, 1991). From the middle Paleozoic to the Eocene, the western United States underwent a series of tectonic shortening events that increased both its areal extent and its thickness (Burchfiel and Davis, 1975; Oldow et al., 1989; Levy and Christie-Blick, 1989). Continental landmass was increased by the addition of exotic terranes (Coney et al., 1980), and regional crust was thickened by the emplacement of east-directed thrust sheets. Following the cessation of shortening in the Eocene, extensional tectonism has dominated in the central and southern parts of the western United States, and strike-slip tectonism has dominated along the southwestern margin of the continent. Throughout the Phanerozoic, magmatism has contributed significant volumes of material to large areas of the western United States. Magmatism has varied in composition and in temporal and spatial patterns of emplacement. The tectonic history of shortening, extension, and magmatism has left an indelible mark that can be easily identified by their physiographic expressions.

A notable aspect of the physiography of this orogenic belt is the close correspondence between high mean elevation and the limits of thrusting. This correspondence is best illustrated in the northeast part of Figure 1 by the sharp drop in elevation along the eastern boundary of the Rocky Mountains, where the elevated rocks of the Idaho-Montana thrust belt form a precipitous contact with the unfaulted lower-lying sediments of the western Great Plains. Although the mean elevation of the western United States was most certainly increased during the shortening event, the subsequent extension has reduced the elevation. Currently, broad patterns in mean topography are supported by buoyancy forces, which vary from one region to another, depending on the relative thickness of the lithosphere (Eaton et al., 1978; Eaton, 1982). The relative heights of many of the highest mountain ranges (white in Fig. 1) are caused by a complex interaction between changes in lithospheric buoyancy, erosion, magmatism, and lithospheric rigidity.

The Basin and Range province provides one of the best examples of the effects of a complex tectonic history on topography. Within this province there are many north-trending fault blocks that are bounded by Tertiary high-angle normal faults, many of which have been active during the Quaternary. Generally, the pattern of magmatism and extension began in the Eocene in the south-central Canadian Rockies, western Montana, and central Idaho and migrated down the central region of the northern Basin and Range now defined by the topographic high between lows once occupied by Pleistocene Lakes Lahonton and Bonneville (Cross and Pilger, 1978; Wernicke, 1992). From the Oligocene to the present, within the northern Basin and Range there has been an outward migration of magmatism and extension whose limit is

Tectonics *continued on p. 120*

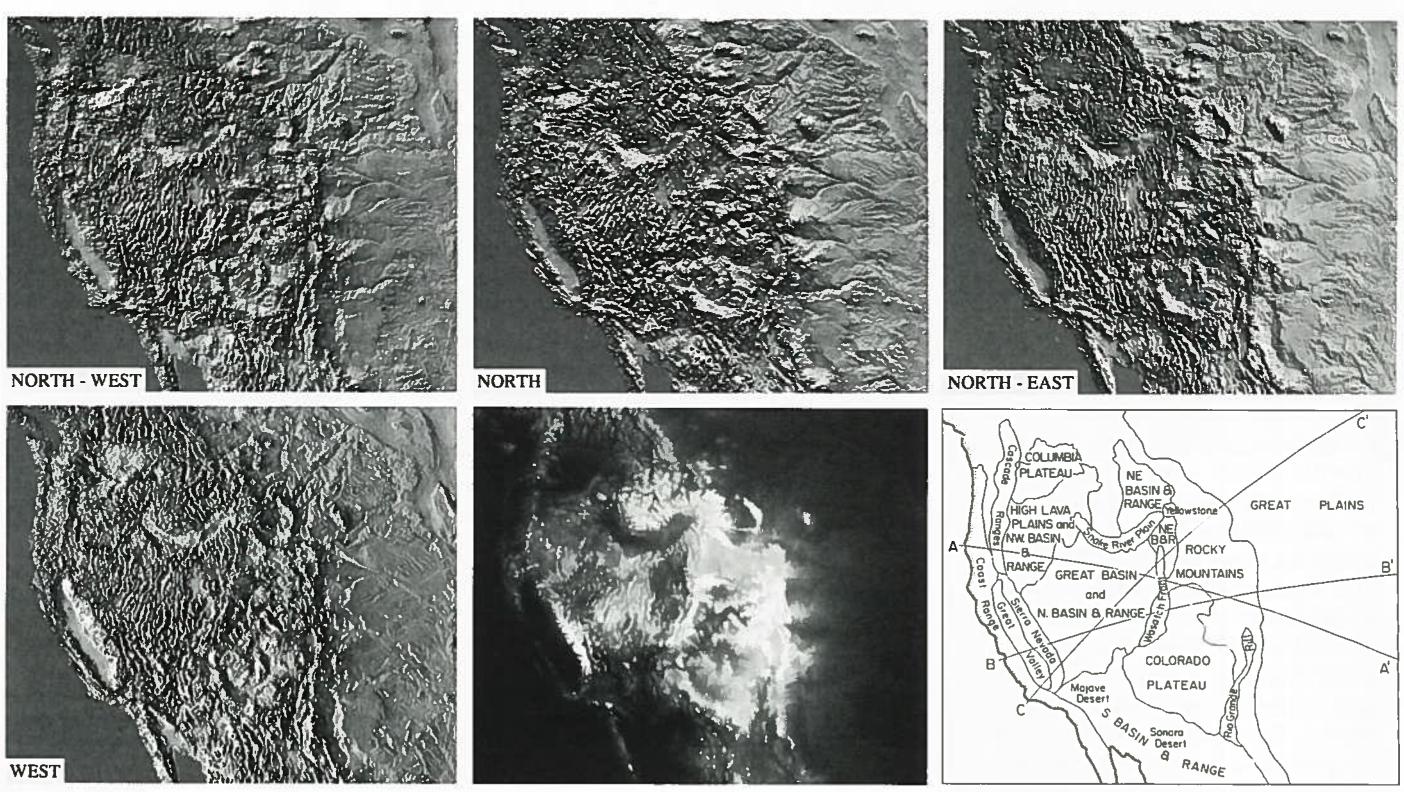

Figure 2. Gradient maps for the western United States, with illumination from different compass directions (lower left panel and top left, center, and right panels). Gray-scale map of the topography of the western United States (lower center panel). Figure 1 was created by combining a colored version of this map with the gradient map in the lower left panel. Major physiographic features of the western United States are shown in lower right panel. Lines A-A', B-B', and C-C' indicate the profiles used for the cross sections of topography shown in Figure 3.

FORUM

Bruce Molnia

Forum is a regular feature of *GSA Today* in which many sides of an issue or question of interest to the geological community are explored. Each Forum presentation consists of an informative, neutral introduction to the month's topic followed by two or more opposing views concerning the Forum topic. Selection of future Forum topics and participants is the responsibility of the Forum Editor. Suggestions for future Forum topics are welcome and should be sent to: Bruce F. Molnia, Forum Editor, U.S. Geological Survey, 917 National Center, Reston, VA 22092, (703) 648-4120, fax 703-648-4227.

ISSUE: Confrontational Geology II

The Perspectives presented here expand the discussion, first presented in the December *GSA Today* Forum, about the growing conflict between "science," the environment, and public perception.

PERSPECTIVE I: Response to "An Encounter at Sea"

Carol Alexander, Greenpeace, Seattle, Washington

We thank the editor of the Forum for offering the opportunity to respond to H. Edward Clifton's article, "An Encounter at Sea." Although I do not wish to cloud the fundamental issue under discussion with a lengthy response to Clifton's description of Greenpeace activities, there are several inaccuracies that I feel compelled to address before proceeding with the more important concern at hand.

Greenpeace: The Organizational Identity. Greenpeace is an international environmental organization that has employed nonviolent civil disobedience for more than 20 years. The decision to exercise civil disobedience is usually a last resort—after we have exhausted administrative, judicial, legislative, and grassroots venues —and not one we make lightly.

The moment of peaceful protest is preceded by weeks, sometimes months, of careful preparation, training, and consideration of all possible ramifications. Greenpeace employees who participate in civil disobedience undergo extensive training in marine safety and climbing safety, as well as nonviolence training. The crew of the Greenpeace flagship, the *Rainbow Warrior*, are skilled and disciplined; they must be, as they have put themselves in the way of dangers ranging from harpoons to nuclear submarines.

We are sometimes injured as a result of accidents or the actions of others, and we are of course subject to arrest, imprisonment, and financial penalties. But our overriding concern through 20 years of peaceful civil disobedience has ALWAYS been safety and the absolute adherence to nonviolence.

It is, therefore, troubling to read Clifton's characterization of the committed men and women of the *Rainbow Warrior* as threatening and dishonest, as capable of jamming the *Aloha*'s radio communications, of "repeatedly spitting" on an officer of the U.S. Coast Guard. Perhaps Clifton has been misinformed and so is not responsible for the inaccuracy of these allegations. I would like to clarify the following for him:

- The *Rainbow Warrior* did not communicate to anyone that it would not react to the presence of the *Aloha*. We truthfully advised the Coast Guard of the *Warrior*'s destination, San Francisco, where she was bound for dry dock after many months at sea in the North Pacific. When questioned as to whether we intended to enter Coos Bay Harbor, or to block the bar into the harbor, we truthfully answered no.

  Months before the *Aloha* reached Oregon waters, Gregory McMurray of the Oregon Department of Geology and Mining Industries (DOGAMI) telephoned me at my Seattle office to inquire what action, if any, Greenpeace was planning. I told him that we had not yet decided, but that we were definitely organizing a public rally. McMurray asked me to "promise" him that we would not interfere with the loading of equipment onto the *Aloha* while she was docked in Coos Bay, because of potential danger. I assured him that we had no such intentions. That was the entire extent of a Greenpeace definition of what we would and would not do.
- The fishing vessels present offshore Gold Beach (23, not 12) had been cautioned by me personally to not cross the Coast Guard–imposed security zone. I took a Zodiac to Port Orford the day before the Gold Beach arrests to advise the fishing community that for safety reasons, and because of the severity of criminal and civil penalties possible, it would be unwise for them to enter the zone. They agreed.The fishing vessels were present to bear witness to their deep concern for the health of the sea, their livelihood, their way of life.

  It was actually quite difficult to maintain the security zone, as the *Aloha* frequently changed course without advising other vessels. The F/V *Top Gun* (which was alleged to cross the zone, and was boarded and impounded) was only one of many fishing vessels that found themselves occasionally within the zone through no fault of their own. The captain of the *Rainbow Warrior* radioed the *Aloha* and requested that they advise us when they intended to change position, to no avail. The Coast Guard also radioed instructions to the *Aloha* to advise other vessels of their movements. The Greenpeace inflatables, of course, deliberately entered the security zone.
- The two Greenpeace activists who boarded the *Aloha* did so with the express purpose of chaining themselves to the A-frame to prevent further use of the coring apparatus. We had carefully determined where this could be done on the vessel without endangering any of the *Aloha*'s equipment. One of the two was able to chain herself to the A-frame as planned, and remained chained there for several hours; the other was, as Clifton

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marked by the Quaternary volcanism as well as by the pattern of historic seismicity (Fig. 1) on its eastern and western margins (Armstrong et al., 1969; Christiansen and McKee, 1978). Coeval with the southward migration in the northern Basin and Range, magmatism and extension in the southern Basin and Range province migrated north. Both trends converged in what is called the central Basin and Range province (between lat 37° and 34°N) in the middle Miocene (Axen, 1991; Wernicke, 1992). From the late Miocene to the present, extension in many parts of the Basin and Range province has been accommodated on high-angle faults and the concomitant tilted blocks that form a pattern on topographic maps resembling "snakes slithering south." This northerly trend reflects a shift to a roughly east-west extension direction in the middle Miocene from the previous southwest-northeast extension direction (Eaton et al., 1978; Wernicke, 1992), although local variability in extension direction existed throughout the Basin and Range province during the Cenozoic.

Tectonic Analyses Using Digital Maps: Northeastern Basin and Range Province

The northeastern Basin and Range province underwent significant northeast-directed thrusting from the Jurassic to the early Eocene. Subsequently, it has experienced several extension events. These include extension directed east-west to northwest-southeast from the early Eocene to the Oligocene in its western part (Hait, 1984; Wust, 1986; Janecke, 1991). Overprinting some of the earlier events are the Miocene-to-present high-angle normal faults that include areas to the east unaffected by the earlier Tertiary events. These younger faults are clearly seen as the north- to northwest-trending mountain ranges in Figure 4.

Prominent in Figure 1 is a northeast-trending topographic depression oriented perpendicular to the mountain ranges within the northeastern Basin and Range. This feature, the eastern Snake River Plain, is underlain by several kilometres of rhyolitic volcanic rocks interbedded by sediments that are capped by 1–3 km of basalt. Intruded within the crust are another 5–10 km of basaltic material. As discussed by Armstrong et al. (1975), a succession of rhyolitic volcanic eruptions followed by basaltic eruptions has migrated to the northeast across the entire length of the eastern Snake River Plain during the past 17 m.y. Morgan (1972), Smith and Sbar (1974), and Suppe et al. (1975) have suggested that the Snake River Plain is the track of a hotspot that lies beneath the Yellowstone Plateau (the region northeast of the Snake River Plain that is dominated by earthquake epicenters in Figs. 1 and 4). Seismicity in the circum-eastern Snake River Plain forms a pattern that is symmetric about the track of the migrating Yellowstone hotspot. This shape has variously been defined as an "arc" (Myers and Hamilton; 1964), a "V" (Scott et al., 1985; Smith et al., 1985), and a "parabola" (Anders et al., 1989). Although surrounded by intense seismic activity, the eastern Snake River Plain, as well as some of the mountainous areas adjacent to the plain, is a region of tectonic quiescence called a "collapse shadow" (Anders and Geissman, 1983). The quiescence has been attributed to mechanical strengthening by magmatic intrusion (Anders et al., 1989) and/or by overpressuring from magmatic intrusion (Parsons and Thompson, 1991).

Figure 4 shows the pattern of historic seismicity and major late Cenozoic normal faults superimposed upon the relief map of the northeastern Basin and Range province. It can be clearly seen that the distribution of historic and latest Quaternary faulting mimics the symmetric pattern of seismicity about the axis of the eastern Snake River Plain. Furthermore, there is a close correlation between high peaks and historic and latest Quaternary faulting (red and purple). This close correspondence between elevation and the age of faulting suggests a mechanistic link between normal faulting and topography. As we discuss below, elevation patterns can provide important clues about the growth and development of normal faults like the ones found in the northeastern Basin and Range province.

Tectonic Analyses Using Digital Topographic Data: Normal-Fault Segmentation

Many of the higher mountain ranges within and bordering the Basin and Range province are associated with high-angle normal faults. As first discussed by Vening Meinesz (1950), normal faulting results in isostatic-elastic footwall uplift. Mountain-building associated with normal faulting produces a distinctive topographic pattern that is easily identified. Faulting-induced uplift results in a characteristic wedge-shaped profile evidenced in the physiography of several mountain ranges in the western United States (Figs. 1 and 3). Good examples of this type of topographic expression are the Sierra Nevada along the western boundary of the Basin and Range province and the Wasatch Range along the eastern boundary. The Sierra Nevada is bounded on the east by a steep escarpment formed by displacement on the Owens Valley fault and on the west by a gently dipping slope that grades into the Great Valley of California. The shape of the Sierra Nevada and the close timing between the start of faulting (3–6 Ma; Bacon et al., 1982) and the start of the bulk of uplift (about 5 Ma; Unruh, 1991) suggest isostatic-elastic uplift; however, this interpretation is controversial. Others have suggested that uplift is caused by low-angle normal faulting (Jones, 1987), by tectonic release of a suppressed buoyant root (Chase and Wallace, 1988), or sinking of the upper mantle via a mantle "drip" (Humphreys, 1987).

The pattern of footwall uplift is more clearly demonstrated on fault blocks having a shorter flexural wave length than that of the Sierra Nevada. The Wasatch Range, which bounds the eastern side of the northern Basin and Range province along a steep 300-km-long west-dipping fault escarpment, exemplifies such a shorter wavelength wedge-shaped feature. The eastern slope dips gently to the east, merging with the Colorado Plateau, and the western slope dips steeply westward and is bounded by the Wasatch fault. As suggested by Zandt and Owens (1980), the topographic profile of the Wasatch Range is consistent with isostatic-elastic footwall uplift.

If isostatic-elastic uplift is proportional to fault displacement, as suggested by Vening Meinesz (1950), then the displacement history of a normal fault can be read by the elevation patterns of the adjacent mountain ranges. Of course, removal of material by erosion degrades the profile, thus making the technique more useful for estimating fault displacement for geologically recent uplifts. Older footwall uplifts, like those associated with the Triassic border faults of the Atlantic margin, are not as useful in assessing displacement, because they have been significantly eroded. Many younger normal faults, typically less than 10–15 m.y., that bound mountain ranges within the Basin and Range province are pristine enough to be used to estimate the fault displacement history. Examples of relatively young uplifts are the Sierra Nevada, postdating about 5 Ma, and the Wasatch Range, younger than about

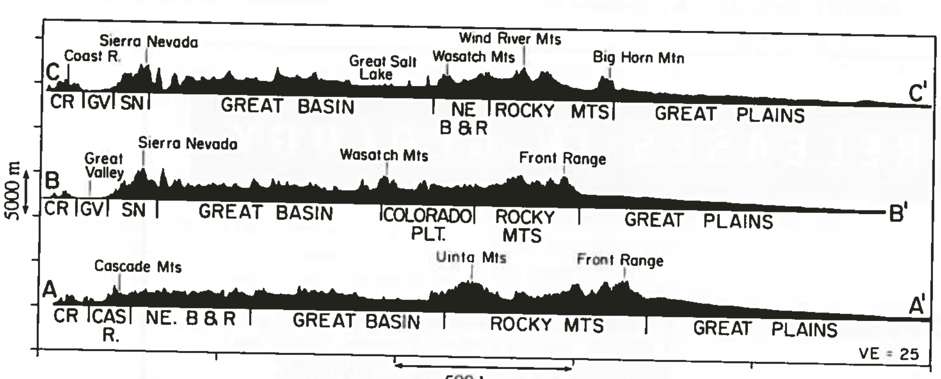

Figure 3. Cross sections of topography for the profiles shown in Figure 2 lower right panel. Major physiographic provinces are indicated. Profiles are plotted with a vertical exaggeration of 25:1.

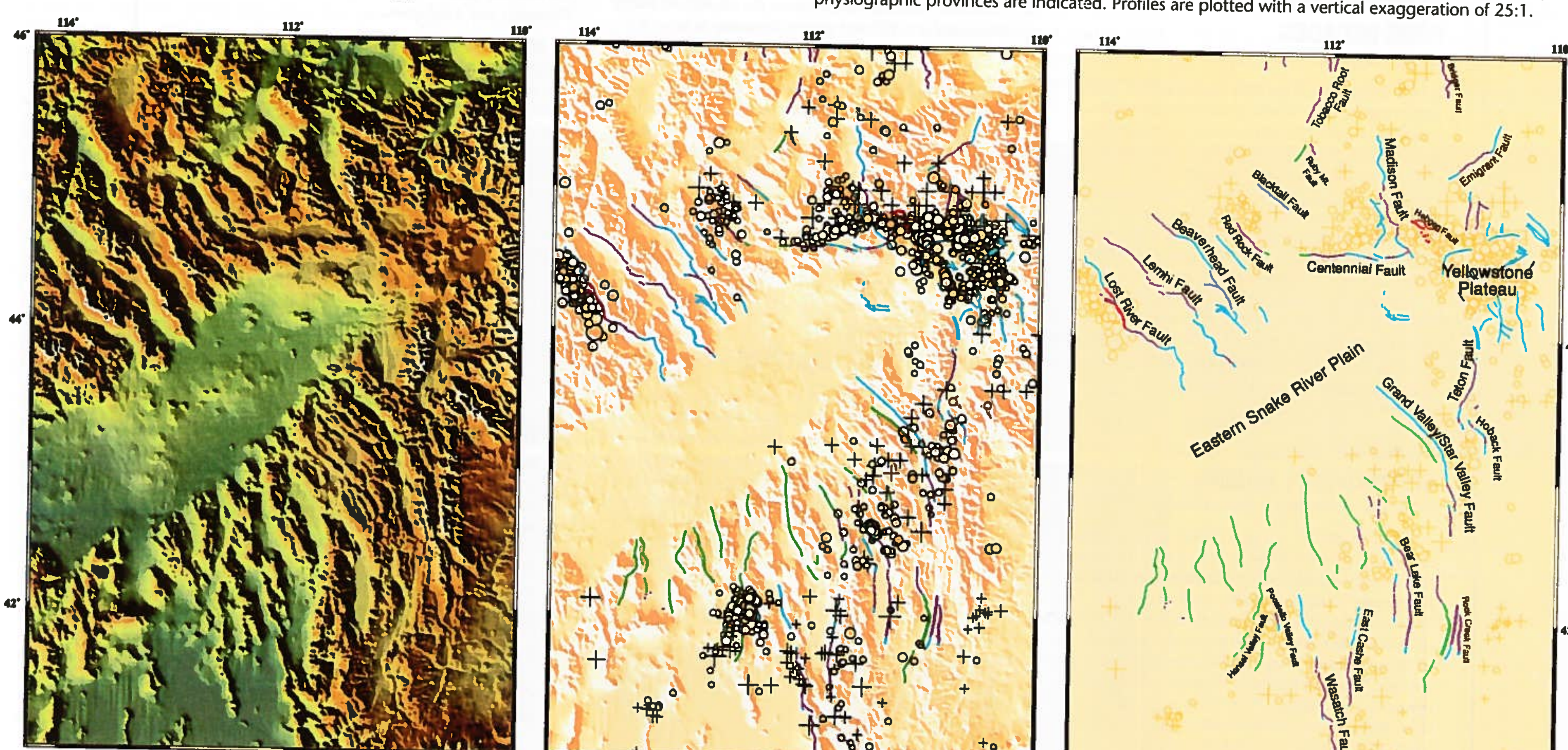

Figure 4. Left: Topographic map of the northeastern Basin and Range province. Center: Seismicity and faulting in the northeastern Basin and Range province, superimposed on a map of the topographic gradient. Right: Earthquake epicenters for historical earthquakes are shown as crosses, recent earthquakes as circles. Earthquake data are from the DNAG compilation, most of the recent seismicity in this area being reported by the University of Utah seismographic network. Faults are color-coded by age: red for historical ruptures, purple for latest Quaternary (<15 ka), light blue for Quaternary, and green for late Cenozoic (roughly later than middle Miocene).

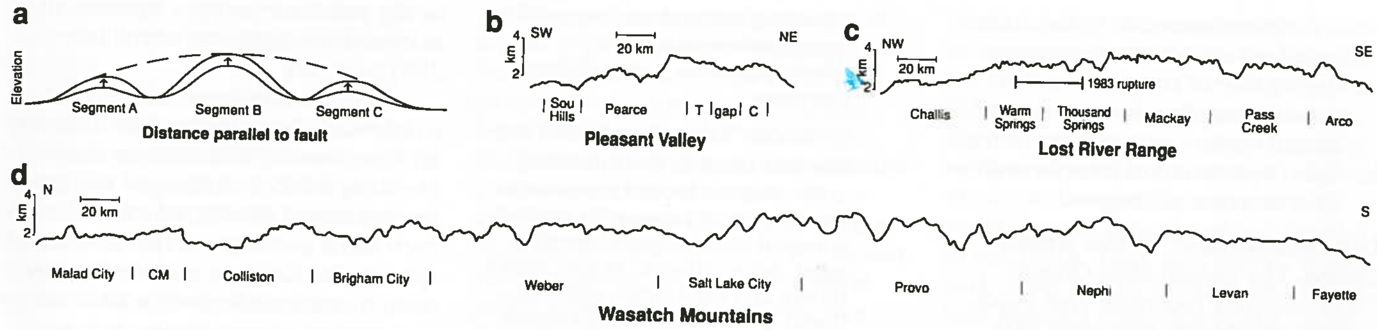

Figure 5. Four normal-fault footwall elevation profiles. a: Hypothetical elevation profiles show a single-humped profile (dashed line) and multi-humped elevation profiles assuming the rupturing is pinned at segment boundaries. b, c, and d: Profiles of the highest elevation across a 5 km swath parallel to their respective faults. Vertical lines are segment boundaries separating named rupture segments (Wallace, 1984; Haller, 1990; Machette et al., 1991). Vertical exaggeration is 5:1.

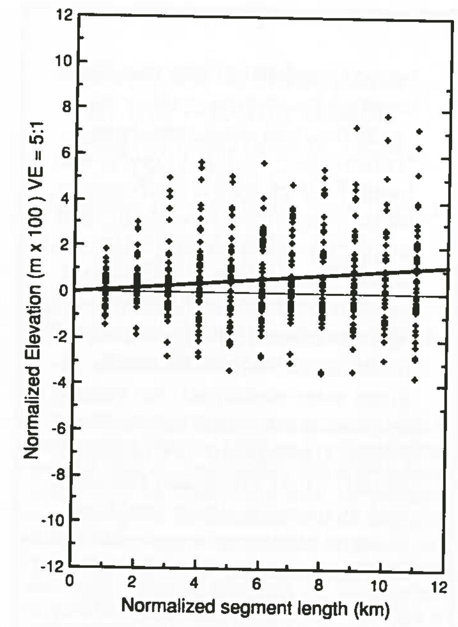

Figure 6. A compilation of normalized elevations between segment ends and midpoints. Slope data to the right of midpoints are inverted so that the sign of respective segments is the same. The regression is fixed at the origin and has a slope of 9.2×10^{-2}.

17 Ma. Within the northeastern Basin and Range province prior to 4 Ma the Teton and Centennial Ranges (Fig. 4) had little or no relief and have since been tilted 10° to 15°, forming a topographic profile as predicted by isostatic-elastic footwall uplift. As insightfully noted by G. K. Gilbert (1884), long-term normal-fault rupture patterns should be reflected by the elevation patterns of the associated range fronts. Using footwall elevation data along the Wasatch Range, Schwartz and Coppersmith (1984) have suggested that rupture segments pinned at end-points over several earthquake cycles will produce multi-humped range-front elevation patterns (Fig. 5a solid lines; exaggerated for emphasis). If, on the other hand, segment boundaries are not pinned, but rather are transitory features, then the overall elevation pattern will reflect a single hump, as first suggested by Vening Meinesz for uplift associated with the east African rift valleys.

Cowie and Scholz (1992) have suggested that fault growth is controlled by the fracture strength of rocks at the leading edges or ends of the fault, causing faults to have a characteristic aspect ratio of length to displacement for a given tectonic environment. Their fault-growth model predicts a single-humped footwall elevation profile caused by outward growth of a fault from a single nucleation point. The ability to construct digital topographic profiles and to average elevation along these profiles permits one to test the single-hump vs. the multi-humped model of footwall growth (see Fig. 5a). Parts b, c, and d in Figure 5 show elevation profiles of several range fronts that bound active normal faults in the Basin and Range province. By qualitative inspection, these segment boundaries (vertical lines in Fig. 5), defined by neotectonic studies, show little or no correlation with expected range-front elevation lows. Using digital topography, we can perform a more quantitative test between multi-humped and single-humped fault-bounded range fronts. The test of multi-humped vs. single-humped elevation profiles assumes a downward slope between segment mid-points and segment ends for multi-humped profiles and assumes that the segment mid-points to end-points slope will most commonly be upward for a single-hump profile. This test was performed on 25 segment boundaries on faults in Utah, Idaho, and Nevada. The results (Fig. 6) show a positive regression slope with 65% of elevation intercepts being positive, which suggests a gross single-humped architecture. Since a positive slope indicates a single-humped profile, segment boundaries are not likely to be fixed features over a long enough geologic time to establish differential range-front uplift. The length of time necessary to cause observable differential uplift is not known well, but at present coseismic rates of offset of active faults in the Basin and Range province (about 1 mm/yr), this could be on the order of 1 to 2 m.y., assuming there is half a kilometre sensitivity in differential elevation. Resolution below 1 m.y. is lost in the significant scatter in the data in Figure 6. The scatter is likely due to erosion and the effects of normalizing short (<10 km) fault segments.

ACKNOWLEDGMENTS

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Note: Full-resolution copies of the maps and profiles in Figures 1, 2, 3, and 4 are available for purchase through the Office of the Director, Lamont-Doherty Geological Observatory, Palisades, NY 10964.

REFERENCES CITED

Anders, M.H., and Geissman, J.W., 1983, Late Cenozoic evolution of Swan Valley, Idaho: Eos (Transactions, American Geophysical Union), v. 64, p. 858.

Anders, M.H., Geissman, J.W., Piety, L.A., and Sullivan, J.T., 1989, Parabolic distribution of circum-eastern Snake River Plain seismicity and latest Quaternary faulting: Migratory pattern and association with the Yellowstone hotspot: Journal of Geophysical Research, v. 94, p. 1589–1621.

Armstrong, R.L., Ekren, E.B., McKee, E.H., and Noble, D.C., 1969, Space-time relations of Cenozoic silicic volcanism in the Great Basin of the western United States: American Journal of Science, v. 267, p. 478–490.

Armstrong, R.L., Leeman, W.P., and Malde, H.E., 1975, K-Ar dating, Quaternary and Neogene volcanic rocks of the Snake River Plain, Idaho: American Journal of Science, v. 275, p. 225–251.

Axen, G.J., 1991, Space-time pattern of the onset of Tertiary extension and magmatism, southern Great Basin: Geological Society of America Abstracts with Programs, v. 23, no. 5, p. A190.

Bacon, C.R., Giovannetti, D.M., Duffield, W.A., Dalrymple, G.B., and Drake, R.E., 1982, Age of the Coso Formation, Inyo County, California: U.S. Geological Survey Bulletin 1527, p. 1–18.

Bond, G.C., and Kominz, M.A., 1984, Construction of tectonic subsidence curves for the early Paleozoic miogeocline, southern Canadian Rocky Mountains: Implications for subsidence mechanisms, age of breakup, and crustal thinning: Geological Society of America Bulletin, v. 95, p. 155–173.

Burchfiel, B.C., and Davis, G.A., 1975, Nature and controls of Cordilleran orogenesis, western United States: Extension of an earlier synthesis: American Journal of Science, v. 275-A, p. 363–396.

Chase, C.G., and Wallace, T.C., 1988, Flexural isostasy and uplift of the Sierra Nevada of California: Journal of Geophysical Research, v. 93, p. 2795–2802.

Christiansen, R.L., and McKee, E.H., 1978, Late Cenozoic volcanic and tectonic evolution of the Great Basin and Columbia Intermontane regions, *in* Smith, R.B., and Eaton, G.P. eds., Cenozoic tectonics and regional geophysics of the western Cordillera: Geological Society of America Memoir 152, p. 283–311.

Cross, T.A., and Pilger, R.H., 1978, Constraints on absolute motion and plate interaction inferred from Cenozoic igneous activity in the western United States: American Journal of Science, v. 278, p. 865–902.

Coney, P.J., Jones, D.L., and Monger, J.W.H., 1980, Cordilleran suspect terranes: Nature, v. 288, p. 329–333.

Cowie, P., and Scholz, C.H., 1992, Physical explanation for displacement-length relationship of faults using a post-yield fracture mechanics model: Journal of Structural Geology (in press).

Davis, R., 1990, Iconic interface processing in a scientific environment: Sun Expert, v. 1, p. 806.

Eaton, G.P., 1982, The Basin and Range province: Origin and tectonic significance: Annual Reviews of Earth and Planetary Sciences, v. 10, p. 409–440.

Eaton, G.P., Wahl, R.R., Prostka, H.J., Mabey, D.R., and Klienkopf, M.D., 1978, Regional gravity and tectonic patterns: Their relation to late Cenozoic epeirogeny and lateral spreading in the western Cordillera, *in* Smith, R.B., and Eaton, G.P., eds., Cenozoic tectonics and regional geophysics of the western Cordillera: Geological Society of America Memoir 152, p. 51–91.

Engdahl, E.R., and Rinehart W.A., 1989, Seismicity map of North America project, *in* Slemmons, D.B., et al., eds., Neotectonics of North America: Boulder, Colorado, Geological Society of America, Decade of North American Geology Map Volume, p. 21–27.

Gilbert, G.K., 1884, A theory of the earthquakes of the Great Basin, with a practical application: American Journal of Science, v. 27, p. 49–54.

Hait, M.H., 1984, Detachment tectonics north of the Snake River Plain, east-central Idaho and southwest Montana: Geological Society of America Abstracts with Programs, v. 16, p. 527.

Haller, K.M., 1990, Late Quaternary movement on range-front normal faults north of the Snake River Plain, east-central Idaho, *in* Roberts, S., ed., Geologic field tours of western Wyoming and parts of adjacent Idaho, Montana and Utah: Geological Survey of Wyoming Public Information Circular no. 29, p. 41–54.

Humphreys, E.R., 1987, Mantle dynamics of the southern Great Basin–Sierra Nevada region: Eos (Transactions, American Geophysical Union), v. 68, p. 1450.

Janecke, S.U., 1991, Eocene ninety degree flip of extension directions, east-central Idaho: A response to slowing oceanic convergence (?): Geological Society of America Abstracts with Programs, v. 23, no. 5, p. A188.

Jones, C.H., 1987, Is extension in Death Valley accommodated by thinning of the mantle lithosphere beneath the Sierra Nevada, California?: Tectonics, v. 6, p. 449–473.

Levy, M., and Christie-Blick, N., 1989, Pre-Mesozoic palinspastic reconstructions of the eastern Great Basin (western United States): Science, v. 245, p. 1454–1462.

Levy, M., and Christie-Blick, N., 1991, Tectonic subsidence of the early Paleozoic passive continental margin in eastern California and southern Nevada: Geological Society of America Bulletin, v. 103, p. 1590–1606.

Machette, M.N., Personius, S.F., Nelson, A.R., Schwartz, D.P., and Lund, W.R., 1991, The Wasatch fault zone, Utah—Segmentation and history of Holocene earthquakes: Journal of Structural Geology, v. 13, p. 137–149.

Morgan, W.J., 1972, Deep mantle convection plume and plate motions: American Association of Petroleum Geologists Bulletin, v. 56, p. 203–312.

Myers, W.B., and Hamilton, W., 1964, Deformation accompanying the Hebgen Lake earthquake of August 17, 1959: U.S. Geological Survey Bulletin 435-I, p. 55–98.

Oldow, J.S., Bally, A.W., Ave Lallemant, H.G., and Leeman, W.P., 1989, Phanerozoic evolution of the North American Cordillera; United States and Canada, *in* Bally, A.W., and Palmer, A.R., eds., The geology of North America—An overview: Boulder, Colorado, Geological Society of America, Geology of North America, v. A, p. 139–232.

Parsons, T., and Thompson, G.A., 1991, The role of magma overpressuring in suppressing earthquake and topography: Worldwide examples: Science, v. 253, p. 1399–1402.

Pike, R.J., 1991, Surface features of central North America: A synoptic view from computer graphics: GSA Today, v. 1, p. 241, 251.

Pike, R.J., and Thelin, G.P., 1989, Shaded relief map of U.S. topography from digital elevations: Eos (Transactions, American Geophysical Union), v. 70, p. 843–853.

Schwartz, D.P., and Coppersmith, K.J., 1984, Fault behavior and characteristic earthquakes—Examples from the Wasatch and San Andreas fault zones: Journal of Geophysical Research, v. 89, p. 5681–5698.

Scott, W.E., Pierce, K.L., and Hait, M.H., Jr., 1985, Quaternary tectonic setting of the 1983 Borah Peak earthquake, central Idaho, *in* Stein, R.S., and Bucknam, R.C., eds., Proceedings of workshop XXVIII on the Borah Peak, Idaho, earthquake: U.S. Geological Survey Open-File Report 85-290, p. 1–16.

Smith, R.B., Richins, W.D., and Doser, D.I., 1985, The 1983 Borah Peak, Idaho, earthquake: Regional seismicity, kinematics of faulting, and tectonic mechanism, *in* Stein, R.S., and Bucknam, R.C., eds., Proceedings of workshop XXVIII on the Borah Peak, Idaho, earthquake: U.S. Geological Survey Open-File Report 85-290, p. 236–263.

Smith, R.B., and Sbar, M.L., 1974, Contemporary tectonics and seismicity of the western United States with emphasis on the Intermountain seismic belt: Geological Society of America Bulletin, v. 85, p. 1205–1218.

Stewart, J.H., 1972, Initial deposits in the Cordilleran geosyncline: Evidence of a late Precambrian (<850 m.y.) continental separation: Geological Society of America Bulletin, v. 83, p. 1345–1360.

Suppe, J., Powell, C., and Berry, R., 1975, Regional topography, seismicity, Quaternary volcanism, and the present-day tectonics of the western United States: American Journal of Science, v. 275-A, p. 397–436.

Thelin, G.P., and Pike, R.J., 1991, Landforms of the conterminous United States—A digital shaded-relief portrayal: U.S. Geological Survey Miscellaneous Investigations Map 2206, scale 1:3,500,000.

Unruh, J.R., 1991, The uplift of the Sierra Nevada and implication for late Cenozoic epeirogeny in the western Cordillera: Geological Society of America Bulletin, v. 103, p. 1395–1404.

Wallace, R.E., 1984, Faulting related to the 1915 earthquake in Pleasant Valley, Nevada; Fault scarp formed during the earthquakes of October 2, 1915, in Pleasant Valley, Nevada, and some tectonic implications: U.S. Geological Survey Professional Paper 1274-A, p. A1–A33.

Wernicke, B., 1992, Cenozoic extensional tectonics of the U.S. Cordillera, *in* Burchfiel, B.C., and Zoback, M.L., eds., The Cordilleran orogen: Conterminous U.S.: Boulder, Colorado, Geological Society of America, Geology of North America, v. G3 (in press).

Wessel, P., and Smith, W.H.F., 1991. Free software helps map and display data: Eos (Transactions, American Geophysical Union), v. 72, p. 441–446.

Wust, S.L., 1986, Extension deformation with northwest vergence, Pioneer core complex, central Idaho: Geology, v. 14, p. 712–714.

Vening Meinesz, F.A., 1950, Les "grabens" africains, resultat de compression ou de tension dans la croute terrestre?: Royal Colonial Institute of Belgium, Bulletin, v. 21, p. 539–552.

Zandt, G., and Owens, T.J., 1980, Crustal flexure associated with normal faulting and implications for seismicity along the Wasatch Front, Utah: Seismological Society of America Bulletin, v. 70, p. 1501–1520. ■

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Forum *continued from p. 119*

noted, "restrained" by the *Aloha* crew and scientific staff.

The individual who was "restrained," Richard Leney, was treated for bruises and abrasions (which were clearly visible), and a suspected concussion at the Gold Beach Hospital after his arrest. I have heard several different explanations from *Aloha* crew and scientific staff as to how Richard's injuries were sustained. According to a statement to the Oregon State Police, the captain of the *Aloha* stated, " [he] ran down the deck and as he went down the deck, he stumbled over some coiled hose and chain laying on the deck and fell...." Clifton believes he was "tackled." Whatever the cause of his injuries, his intentions were simply to chain himself to the A-frame.

The possibility of physical danger either from accident or at the hands of others is always present during Greenpeace nonviolent civil disobedience. It is, along with arrest and imprisonment, a risk we commit ourselves to taking. It is patently absurd to think of Richard Leney, or any crew member of the *Rainbow Warrior*, spitting on anyone, for any reason. Again, I can only assume that Clifton was misinformed.

- Although Clifton did not directly attribute "threatening" phone calls to Greenpeace, it was implied that we were responsible. Greenpeace does not make anonymous calls, nor do we engage in threats. Similarly, the implication that the *Rainbow Warrior* jammed the radio signals of a vessel at sea is insulting at the least and slanderous at worst. All Greenpeace vessels and personnel are scrupulously careful with radio communications for obvious reasons: safe communication at sea is of paramount importance. Penalties for interfering with radio communication are APPROPRIATELY severe. I would caution Clifton against any further such conjecture.
- Clifton commented that upon pursuit of Greenpeace inflatables by the Coast Guard, the "focus of the protestors' confrontation [was shifted] from us to the Coast Guard." On the contrary, Greenpeace has a high regard for the work of the Coast Guard and, although they are occasionally required to arrest participants in civil disobedience, the men and women of the Coast Guard are never a focus of Greenpeace protests.

Often, in fact, we find our concern for the health of the oceans is shared by most individuals in the Coast Guard. I believe you will find a mutual regard between us, although our jobs are very different.

Our focus was always the activities of the *Aloha* throughout the entire three days of the protest. I believe that was clear.

- The mention of a Greenpeace representative "threatening legal action" at a Gold Beach Task Force meeting is presumably a reference to myself, since I was the only Greenpeace person present. I made no such threat. My words, verbatim, were "[the task force] describes the *Aloha* cruise as scientific research, whereas we [those of us in the audience] call it exploration. We obviously need a third opinion."

Greenpeace did, in fact, later retain an attorney to investigate the legality of the cruise within the existing regulatory structure and to outline our position to the U.S. Department of Interior and the Governor of Oregon.

The "Semantics" of the *Aloha* Cruise. The Federal-State Oregon Placer Minerals Technical Task Force is not the first body to suggest that public opposition to specific agency projects is a problem of public "perception," or a matter of "semantics." The Minerals Management Service (MMS) has for years characterized public opposition to its Outer Continental Shelf (OCS) Oil and Gas Leasing Program as a problem with "public perception." It has been the public perception that offshore oil and gas leasing is environmentally destructive, economically ill-advised, and incapable of providing significant contributions to the nation's long-term energy security. This perception is shared either in part or wholly by the National Academy of Science (see "The Adequacy of Environmental Information for OCS Oil and Gas Decisions," NAS, 1989), the General Accounting Office (see "Early Assessment of Interior's Area-Wide Program for Leasing Offshore lands," GAO, 1985), numerous congressional members (particularly in the House Interior Committee and the House and Senate subcommittees on appropriations), and a host of state regulatory agencies. Until MMS is willing to acknowledge that they have a problem with reality, not perception, their credibility is unlikely to improve.

We mention the OCS oil and gas leasing program for good reason. Because of this widespread "perception problem" and concomitant reactions, the OCS oil and gas leasing process has been essentially shut down in most coastal regions (with the exception of Alaska and the Gulf of Mexico). Therefore, MMS is increasingly looking for expansion of its agency mandate by attempting to interest industry and coastal states in marine mineral lease sales. Pacific Northwest residents had already had more than a mouthful of MMS as a result of its attempt to offer the entire Pacific Northwest OCS for an oil and gas lease sale in 1992.

The Oregon Placer Task Force was one of six similar task forces in place in coastal regions around the United States, all chaired and largely funded by MMS. The stated purpose of all six task forces was to define deposits of sand, gravel, and hard minerals, determine the economic feasibility of their extraction, and offer lease sales with the same process as defined for oil and gas sales in the Outer Continental Shelf Lands Act as amended.

This is no particular secret, and there is no semantic confusion—it is the straightforward mandate of the involved agencies. It seems as though this should be enough said, but I will offer some examples of federal and state agency documentation, and why the public is concerned and frustrated by what seems to be an obdurate denial of purpose.

- "Special Information: Office of Strategic and International Minerals," a fact sheet produced by MMS and distributed to Oregon coastal residents, outlines the goals of the program as follows:
  - Developing the potential of the OCS as a domestic supply source for hard minerals.
  - Encouraging development of a viable ocean mining industry compatible with other uses of the sea.
  - Ensuring safe and environmentally acceptable development.
  - Providing a new source of federal revenue.

  Under "Objectives" from the same fact sheet is the following:

  > ... the program focuses its resources on minerals and areas with greatest potential for commercial development. Areas offshore Oregon, Alaska, Hawaii and the Atlantic and Gulf Coasts are currently being assessed as a result of State and industry interests.

- from "National Coastal Geology Program," by the USGS and the Department of Interior, May 1990, is a description of how the agencies will proceed with the "regional characterization of coastal hard mineral resources." Of particular concern to Oregonians:

  > At present, USGS is conducting a cooperative assessment of hard mineral resources with MMS, BOM, and the State of Oregon. This work would be used to guide subsequent investigations. Our first step would be to complete the Southern Oregon work and to set regional priorities.

- from the "Recommended Cruise Plan, September–October 1990," presented by the Oregon Placer Task Force Cruise Steering Committee:

  > The long term objective of the cooperative task force investigation of black sand deposits offshore Oregon is to conduct a definitive characterization of the mineral resources and an appraisal of the economic, strategic, and environmental aspects of their development.

There are many such examples. These are descriptions of a PROCESS that culminates in resource extraction. These are not descriptions of scientific research. Residents of the southern Oregon coast, officials from city and county coastal governments, fishermen, the League of Women Voters, and a host of others, including Greenpeace, repeatedly expressed concerns about the process orientation toward development, both at public meetings and in formal written comments to the Placer Task Force. We were told that we were all simply confused about the purpose of the task force. This recalcitrance and/or condescension exacerbated people's frustration.

Assurances of Environmental Protection Were Unconvincing. We were advised at a task force meeting in Gold Beach that the MMS commitment to environmental protection should answer our concerns about this process orientation; if MMS determined that mining offshore placer deposits would harm the marine environment, then it wouldn't be done, they told us.

We reminded them that the history of the MMS OCS oil and gas leasing process did not reassure us. According to the National Research Council, MMS has never refused an OCS lease sale or turned down a permit for exploration and production for environmental reasons. MMS went so far as to auction off the incomparably rich, productive Bristol Bay, over a chorus of academic, grassroots, State, and Congressional objections.

An MMS–State of Alaska Task Force for a Nome offshore gold-mining lease sale plodded through three years of tedious, expensive bureaucratic process. MMS doggedly pursued this process in the face of documentation of extensive sediment contamination in the lease sale area with methylmercury, arsenic, lead, and copper. In a conclusion that would have been comic had it not been for the wasted time, money, and human resources of the task force process, industry did not submit a single bid at the July 1991 lease sale.

During a task force meeting in Gold Beach, just after an Environmental Assessment (EA) had been completed by MMS, I challenged the gross inadequacy of the EA, which had not even listed endangered and threatened species. The EA drew chemical oceanography parameters from a 1977 study (on physical oceanography, but described by MMS as a chemical oceanography study) when others as recent as 1989 were available; it attempted to extrapolate information from an offshore Washington study to characterize southern Oregon offshore benthic communities; it neglected to even mention the collapse of salmon and dungeness crab fisheries in the region—and so forth.

MMS later rewrote the EA to address our critique, but in an extremely cursory manner and at the last moment. In an evident attempt to mitigate public opposition, MMS finally agreed to allow biological assessment to be a part of the *Aloha* cruise. Initially, MMS officials strenuously objected to anything other than geological/geophysical activity. (We were, incidentally, pleased that even though less than 10% of the funding was finally earmarked for biological assessment, the biologists were actually able to collect a great deal of valuable data. Cruise geologists reported that—for whatever reasons—they were able to collect only 4% of the core samples they had planned.)

The public dialogue should certainly have alerted Clifton and others to the fact that they had more than a semantics problem on their hands. The cities of Brookings, Gold Beach, and Port Orford all passed resolutions condemning the cruise, as did the League of Women Voters, the Pacific States Marine Fisheries Commission, Audubon, numerous fishing groups, Greenpeace, Friends of the Earth, and many others. It is surprising to now hear Clifton state that the participants in the *Aloha* cruise were "perplexed at the intensity of the local reaction."

Drawing the Line. We are not without sympathy for Clifton's consternation. As he said, he was doing his job. And Greenpeace recognizes the worth of much of USGS's work. Unlike MMS, the USGS does valuable, legitimate mapping and research into geological processes and hazards, which we respect.

However, when MMS—whose clear mandate is to lease mineral resources on federally managed offshore lands—drops nearly a quarter of a million dollars in a project to define economically recoverable minerals off the coast of Oregon, people will surely object, including Greenpeace.

Traditional fishing industries in the Northwest are besieged; some are simply gone, others are in precipitous decline. The Placer Task Force ignored, or did not understand, the depth of resistance to yet another threat to these waters, to the people who depend on them—to a whole way of life. As human populations expand, as anthropogenic toxic contamination and habitat destruction push both terrestrial and marine systems past their capacity to absorb more insult, so does human opposition to these activities expand. It is a dilemma.

We can no longer extract resources with the cavalier abandon of the past. Even in the relatively pristine waters of the North Pacific, we must begin to consider the consequences of, for example, mining activities that will resuspend sediments laden with methyl mercury off Nome, Alaska, and what that means for migrating whales, seabirds, and humans far removed from the site.

Greenpeace supports genuine, responsible scientific research. Many of us have been trained in various scientific disciplines ourselves. We have high regard for the impetus to gain a better understanding of our world. However, as we expressed in our final comments to the Oregon Placer Task Force,

> Greenpeace will always be available to scrutinize and publicly reveal any attempts by agencies, industry or academia to cloak a search for 'recoverable' non-renewable marine resources in the guise of science. We feel it necessary to remind you that 'Science' is not an entity, but merely a tool that can be used for good or ill, depending on the particular task at hand.

We would finally like to point out that an admirable scientific task would be to shift focus and explore every possible means to recycle minerals already in the waste stream, and to investigate how to make do with less of them, before we attempt to extract more.

The southern coast of Oregon was indeed a place to draw the line. In the final analysis, I believe it was as much about ethics in science as it was about ocean protection and the rights of local people.

PERSPECTIVE 2: The Problem Will Get Worse

Howard Wilshire and Jane Nielson, geologists, Mountain View, California

> People of Earth, your attention, please. As you will no doubt be aware, the plans for development of the outlying regions of the Galaxy require the building of a hyperspatial express route through your star system, and regrettably your planet is one of those scheduled for demolition.
>
> There's no point in acting all surprised about it. All the planning charts and demolition orders have been on display in your local planning department in Alpha Centauri for fifty of your Earth Years, so you've had plenty of time to lodge any formal complaint and it's far too late to start making a fuss about it now.
>
> —*The Hitchhiker's Guide to the Galaxy*, by Douglas Adams

GSA Today, v. 1, no. 12, carried two perspectives under the issue Confrontational Geology, one by Ed Clifton describing an encounter at sea, and another by Bill Dickinson, who fears restriction of access to public lands. We would like to add a third perspective. We agree with them on one score—the problem is going to get worse. We disagree, however, that either identifies the root of the problem or appropriate responses.

Certainly physical violence, threats of violence, and property damage are not acceptable means of protest. But when a community feels that its way of life and the quality of its environment are in jeopardy, what do we scientists expect them to do?

When a substantial part of the community of owners of public lands feel those lands are being trashed, what should we expect them to do?

How many of us would believe the Clifton task force's repeated, unsuccessful, efforts to convince the community that merely characterizing the heavy-mineral resource potential (research) is not the prelude to mining the resource? Why should the public believe scientists—especially government scientists—who say they are only doing their job, when the decisions based on their supposedly objective research is the responsibility of others with some very non-objective agendas?

The reasons for public distrust of science are spread across the pages of the media daily, and they have been growing for a long time. The public hears about widespread misconduct and fraud on the part of the individual scientists, and about misuse, censorship, and suppression of good science by those who administer it. We should not be surprised to find a distrustful public at any stage of a process that may affect their lives. In addition, public participation in the process of land-use decisions has been continuously marginalized since the implementation of the National Environmental Policy Act (NEPA) by administrators and bureaucrats who ignore public fears and concerns about damage to the environment and livelihoods that depend on it. "Victories" in this pseudo-democratic process are at best delaying actions. The highly publicized egregious damages done to the land by weapons research and development and oil tanker and pipeline spills do not foster public trust.

Let us examine how the agencies and institutions of science operate within the "system" of fact-finding and "democratic" decision-making.

- The University of Arizona hired a public relations firm in an attempt to circumvent NEPA and subvert the Endangered Species Act, to get on with erecting a "world-class" observatory on Mt. Graham. In essence, the Arizona astronomers and collaborators functioned as a self-interested political pressure group.
- In a Congressional Oversight Hearing, gory details were revealed about the suppression of people who had identified scientific misconduct in medical research; this report prompted a Baltimore *Sun* article entitled "The Growing Problem of Sleaze in Science." Another Oversight Hearing report is due out soon on the subject of manipulation of science by bureaucrats in matters of offshore drilling for oil.
- Numerous case histories are surfacing through the efforts of the Association of Forest Service Employees for Environmental Ethics, (AFSEEE), of political interference with implementation of scientific findings in decisions about forestry practices on public lands.

Nor is the U.S. Geological Survey (USGS) a paragon of objectivity, despite its (deserved) reputation for relatively objective scientific research.

- Testimony requested for public hearings, on potential problems with offshore drilling in the Pacific Northwest was suppressed by the Survey.
- USGS is about to be in court over its undocumented computerized methodology that may grossly overestimate undiscovered mineral resources in recommended Wilderness and other areas.
- The Yucca Mountain debacle resulted in withdrawal of the Geological Division of USGS from an appropriate role in assessing this disposal site.
- Recently, a Congressional representative accused the Department of Interior of attempting to intimidate a Survey scientist to prevent presentation of his expert testimony on a geothermal development near Yellowstone National Park.

Again, this pattern has been established over a period of time: USGS published gross overestimates of U.S. petroleum reserves before 1975, and was a party to suppression of research on the distribution of toxic wastes from the Oak Ridge weapons facility in Tennessee in the early 1980s. Under political pressure, the director of USGS publicly disavowed the efforts of one of the Survey's foremost seismologists to assist in developing detection methods of clandestine nuclear tests, which could have facilitated test ban treaties in the 1980s. Thus, this agency shares with other federal research and regulatory agencies a growing public image of being in bed with industry.

Any of us might be as "perplexed" as Clifton and associates, "at the intensity of the local reaction [in opposition of their research]. After reflecting on it," Clifton continued, "I realize that they misperceived the problem; it was not between us and them, but rather between them and their decision-makers." But the foregoing account illustrates that Clifton has misperceived the role of the scientists; the record illustrates vividly that the responsibility of scientists does not end with production of "objective" research results.

Congressman George E. Brown gave an eloquent address (poorly attended) at the 1991 GSA Annual Meeting in San Diego, which identified the crux of this problem. In part, he said, "Science cannot and does not exist in a moral vacuum. If scientists are unwilling to address the moral implications of their work, then they allow their work to be held hostage by ideology and political opportunism."

We believe the root problem is that we scientists have allowed ourselves to become pawns in a political game of opportunism by acting as though our responsibility ends when we have dispassionately gathered the "facts." No one who has examined the record could reach a scientifically viable conclusion that their "facts" (and interconnected assumptions and interpretations) will be properly used by decision-makers, who may not understand them and who may desire to torque them toward a particular end. If we hope to correct this problem and restore public confidence in the objectivity of science, we must organize a concerted effort to promote the use of our science for the public benefit.

As Congressman Brown observed, "We must begin to think of science and technology in different terms—not as mechanisms to increase our wealth and comfort through exploitation of material resources, but as the source of innovation that can drive us to less consumption, less pollution, less depletion of resources, and lower rates of population growth. The scientific community seems very reluctant to embrace the basic terms of this debate. Comfortable with data, but uncomfortable with the ethical and cultural implications of their inquiry, they debate what they perceive to be the substance, and leave the value judgments to the politicians."

If we do not address these issues, no amount of PR can be purchased that will "convince the public that informed decision-making is better than the alternative" in the words of Clifton. The public will be only more convinced that the scientists are in league with politicians. Trying to differentiate "benign" research from "exploitative" research so as to separate the good guys from the bad and thereby defuse confrontation, as suggested by Dickinson, is similarly futile because there is no such distinction. Research on mineral deposits is needed as much as that which has no immediate ties to exploitation. But that isn't the core of the problem, as so clearly perceived by George Brown. ■

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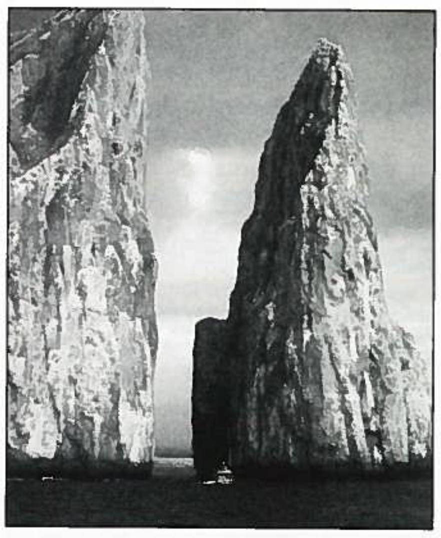

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The nonmember $100 additional fee will be waived for guests who have previously traveled on a GSA GeoTrip.
Full payment is due now.

The fee includes double-occupancy lodging in Quito and aboard the *Isabela II*; transfers and ground transportation; meals as indicated, including three meals per day aboard the *Isabela II*; entrance fees; baggage handling; leadership; and reading materials. Of course, the fee also gives you the opportunity to be close to some of the most unusual flora and fauna on this planet and to travel in the footsteps of Charles Darwin.

GSA GEOHOSTEL

Geology of the Southwestern San Juan Mountains

Fort Lewis College, Durango, Colorado
Five Days and Six Nights: June 27–July 2, 1992

Scientific Leadership

Kenneth E. Kolm and Gregory S. Holden, Colorado School of Mines

The Durango townsite was the terminus to the ice age Animas River glacier, largest to drain the San Juan icefield. Fort Lewis College sits 300 feet above the town on the remnant of an outwash terrace. Views of the mountain peaks and down the valley are impressive. Rocks of the area record a geologic history from Precambrian crystalline basement, through deposition of a Paleozoic and Mesozoic sedimentary sequence, to culmination in Tertiary volcanism, caldera formation and mineralization, all deeply eroded and exposed during Neogene uplift.

A combination of classroom lectures and daily field trips will emphasize the geology of the area from Precambrian to present with discussions of hazards and resource issues. We will visit Mesa Verde National Park, ride the Durango and Silverton Narrow Gauge Railroad, and visit the high peaks. Local activities available outside of class include golfing, hiking in spectacular scenery, touring ghost towns, and rafting.

Program Schedule

June 27, Saturday .... Welcoming get-together
June 28–July 1, Sunday through Wednesday....... Morning classes and field trips
July 2, Thursday .... Full-day field excursion and farewell party

Fee and Deposit

Cost: $325 for GSA Members. Nonmembers $25 more.
Total balance due now.
Minimum age: 21 years. Limit: 30 persons.

Fee includes classroom programs and materials, train ride to Silverton, Colorado, on the Narrow Gauge Railroad, lodging (double occupancy, dormitory suites), breakfast, and welcoming and farewell events. **Not included** are transportation to and from Colorado; transportation during non-class hours; meals, or other expenses not specifically included.

CALL FOR GEOHOSTEL PROPOSALS

Have you thought about leading a GSA GeoHostel? GSA invites those interested in proposing a GSA GeoHostel to contact GSA headquarters for proposal guidelines.

GSA's GeoHostel is a five-day summer program that combines morning classroom lectures and field trips in an area rich in local geology and vacation appeal at an inexpensive fee. Hostelers are usually housed in dormitory-style facilities at a local university or college. Afternoons are open for sightseeing.

Proposals for 1993 are due July 1, 1992.

For proposal guidelines or information, please contact Edna A. Collis, GeoHostel Coordinator, GSA headquarters, (303) 447-2020.

GSA GEOHOSTEL

Geology and Natural History of Eastern California

White Mountain Research Station, Bishop, California
Five Days and Six Nights: July 25–July 30, 1992

Scientific Leadership

Clemens A. Nelson, University of California, Los Angeles (Emeritus)
Bruce A. Blackerby, California State University, Fresno

Contributing Leaders

W. Gary Ernst, Stanford University
Steven R. Lipshie, Los Angeles County Department of Public Works

The town of Bishop lies between the eastern scarp of the Sierra Nevada and the equally impressive White-Inyo Range, which is often referred to as "God's Country." The White Mountain Research Station, used by the University of California campuses for their field camps, is located four miles from Bishop at the base of the White Mountains. The geologic diversity includes complexly folded and faulted Precambrian and Paleozoic rocks, plutonic and metamorphic rocks of the Sierra, the young volcanic rocks of Long Valley and the Inyo and Mono Craters, abundant evidence of glaciations—*and* recent earthquake activity. The natural history of this scenic region also encompasses petroglyphs, the ancient bristlecone pines, and the tufa towers of saline Mono Lake.

Local activities available outside of class include the Bishop Creek Recreation Area offering excellent trout fishing, boat rentals, and horseback riding. Bishop's City Park has lighted tennis courts, a swimming pool, and summer concerts in the gazebo. Numerous nearby restaurants offer excellent fine dining. History and railroad buffs won't want to miss a visit to Laws Railroad Museum, while others may enjoy a round of golf on the 18-hole championship course, complete with a panoramic view of both the High Sierra and White Mountain ranges.

Program Schedule

July 25, Saturday .... Welcoming get-together
July 26–29, Sunday through Wednesday....... Morning classes and field trips
July 30, Thursday.......... Full-day field excursion and farewell party

Fee and Deposit

Cost: $325 for GSA Members. Nonmembers $25 more.
Total balance due now.
Minimum age: 21 years. Limit: 30 persons.

Fee includes classroom programs and materials, field excursions; lodging in barrack-style dormitories; breakfast and lunch each day; welcoming and farewell events. **Not included** are transportation to and from California (Reno makes a good airport destination with travel by car to Bishop); transportation during non-class hours; meals or other expenses not specifically included.

1991

Annual Report

GSA Foundation

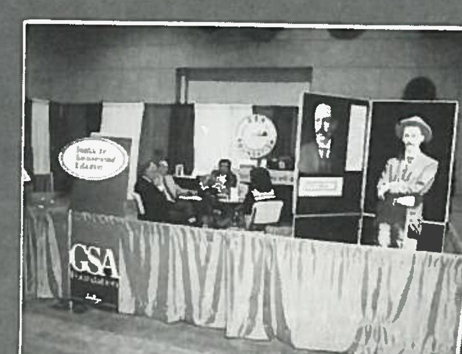
Beach Leighton, Donna Russell, Charles Mankin and Philip LaMoreaux

Peter Flawn and Larry Sloss

Fred Donath and Ray Price

Hubert Gabrielse and Mrs. Gabrielse

Bill Benson, Jim Hays and Mrs. Hays

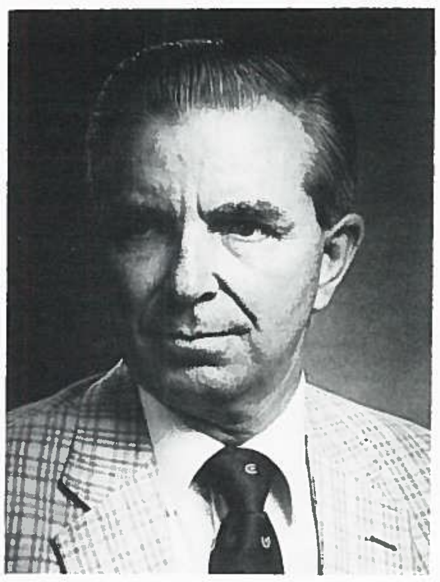


GSA Foundation Booth

San Diego

GSA 1991

CHAIRMAN'S MESSAGE



The Geological Society of America Foundation completed another successful year in support of GSA programs. The Decade of North American Geology (DNAG), is nearing completion, but its impact will be long lived. This far reaching program is an unqualified success by any measure. During the past two years, I have had the opportunity to visit numerous colleges and universities where chapters of Sigma Gamma Epsilon are located. In visiting with students and faculty at those institutions, it is clear that this collection of geological information and ideas concerning the North American Plate is having a substantial, positive effect on geological education. Kudos to all who contributed intellectually and financially to the success of this venture.

Unfortunately, some academic programs do not have access to DNAG. If you are searching for a worthwhile donation to your alma mater, please consider a gift of the DNAG series. Based upon my unscientific survey of geology departments, you will be making a lasting contribution to the improved education of current and future generations of geologists.

While DNAG commanded most of the Foundation's attention for the past several years, other important programs now are moving to center stage. Among these, SAGE, IEE, and headquarters expansion are major items on the Foundation's agenda. Few issues are more challenging and important than improving the understanding of science at all ages and levels of society. SAGE, Science Awareness through Geoscience Education, is a very ambitious program. To be successful, it will require the undivided attention of many and the support of all. A major challenge for the Foundation will be to assist in raising the financial support needed to give those who have picked up the gauntlet a reasonable chance for success.

The two issues that are certain to receive top billing in any public opinion poll or dominate the conversation during many coffee breaks are concerns about the environment and the economy. The two "Es" may even become important topics of debate during this election year, if the media finally tire of "bouncing checks, palace perks, clandestine affairs, and home-baked cookies."

The societal goal of maintaining a habitable environment while preserving a healthy economy is a substantial challenge. IEE, the Institute for Environmental Education, offers a significant way for the Society to contribute to this important goal. It also provides us with the opportunity to apply good science to some crucial concerns in the real world. Again, the challenge for the Foundation will be to assist in developing the needed financial resources to ensure the success of this innovative idea.

These new programs together with the myriad of other new and expanding ventures being fostered by the Society are placing severe pressure on headquarters space. The Foundation is working closely with the GSA Executive Committee to develop a funding strategy to expand headquarters space.

While DNAG has occupied much of the Foundation's attention for the past few years and these major new initiatives will do likewise in the future, we still are concerned with a broad array of on-going ventures. Six new funds, described elsewhere in this report, were added during the past year. Donations were received from more than 1,200 supporters totalling almost $190,000. The average donation exceeded $150.

While the total contributions for last year did not equal those of 1990, absent the large International Geological Congress Fund donation, 1991 was a banner year.

The GSA Foundation Pooled Income Fund has now become a reality with the establishment in early 1992 of the Carol G. and John T. McGill Fund. This gift will provide future funding for engineering geology and geomorphology scholarships and research. Most importantly, it represents a commitment to the future — an example that others would do well to emulate.

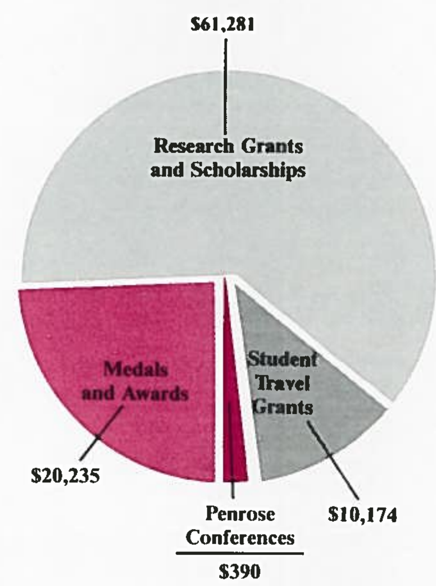
The GSA Foundation Pooled Income Fund functions similar to a mutual fund. The contributor receives income from the fund during his or her lifetime, following which the donor's share of the fund is transferred directly to the Foundation to be used according to their wishes as determined at the time of the donation. At the time of the gift, the donor receives a charitable deduction for income tax purposes, the amount of which is determined by the donor's life expectancy and the expected income from the fund.

The mission of the GSA Foundation is to serve geoscience through developing and maintaining a corpus of funds to aid in supporting the important work of the Society. The Board of Trustees are well versed in the affairs of the GSA. They include two former presidents, a former treasurer, and several former Councillors. Your trustees are fully dedicated to fulfilling their charter responsibilities, and are supported by a small, but equally dedicated staff. I want to pay special recognition to Donna Russell for her exemplary work on every facet of the Foundation's business, and also for being a very special person. Bob Fuchs, who serves as President of the Foundation, is the heart and soul of the organization. If we didn't have him as our president, he would have to be invented. Finally, Mike Wahl, who serves in the dual capacity of Executive Director of the Society and Vice President of the Foundation, is to the Society what Bob Fuchs is to the Foundation. With that kind of support, the Trustees will find it difficult to fail.

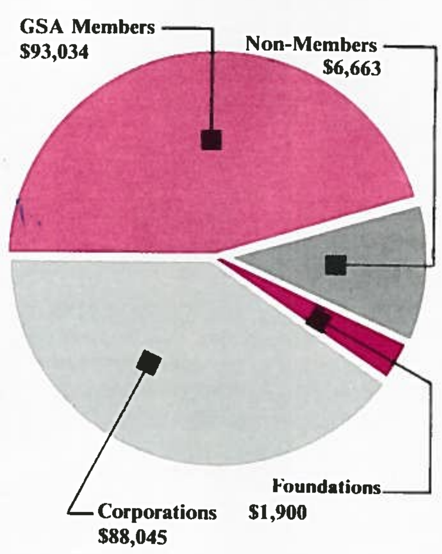
I am honored to serve on the GSA Foundation with this distinguished group of members, and look forward to working with others in GSA to achieve our identified goals.

Charles J. Mankin
Chairman

FUND DISBURSEMENTS
1991
Total $92,080



CONTRIBUTIONS 1992
(not including industry donors)
Total $189,642



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* Second Century Club (Gifts of $100 or more)

Foundation Mission Statement

The GSA Foundation operates under the following mission statement:

The GSA Foundation exists to fund those research, student support, public education, and other programs of the Geological Society of America that the Society deems necessary to accomplish its purpose of the advancement of the science of geology, the scientific growth and development of its members, and the application of geology to the wise use of the Earth.

To accomplish this mission, the Foundation's long-term policy is to raise money from members, individuals, companies, and institutions. Funds received are invested for income, preservation of capital, and growth of principal. GSA program funding requirements are met out of income and such principal as is necessary. The Foundation's financial goal is to build a fund balance in the $5-10 million range.

FOUNDATION OFFICERS

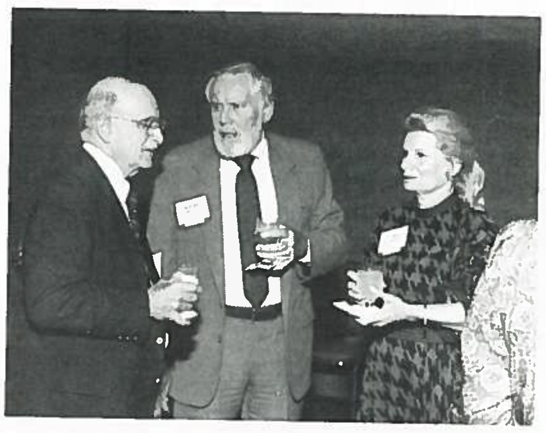
President:
Robert L. Fuchs

Vice President:
F. Michael Wahl

Secretary/Treasurer:
Donna L. Russell

SENIOR FELLOWS RECEPTION

This popular GSA annual meeting event was well-attended in San Diego. Each year the Foundation hosts a party that immediately follows the Board of Trustees meeting, for GSA's Senior Fellows, the Foundation's major contributors, GSA Council, and other special people. The affair provides a unique opportunity for GSA's longest-standing members to remember the past, discuss the present, and look forward to the Society's future.



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1991 Annual Report

PRESIDENT'S MESSAGE

In 1991 the Foundation's fund balance increased over the prior year, closing on December 31 at $1,464,276. Investments increased 10.7% to $1,447,471 at year end. The carrying value of the DNAG publications inventory dropped 23.5%, in keeping with GSA's conservative valuation policy for publications inventory. On December 31 the carrying value of the DNAG series inventory was $618,418. However, liabilities other than fund balances declined 23.5% to $684,925, so the net result of these balance sheet changes in 1991 was an 8% increase in the Foundation's net worth.

Total revenue in 1991 declined 23.6%, to $838,898. On the positive side, DNAG program revenue and interest-dividends increased 13.8% and 33.7%, respectively. The DNAG increase resulted from higher sales of DNAG products, while the interest and dividends reflect the return from a larger endowment base. Contributions declined 66%, because of the absence of a large gift similar to the $328,000 received from the 28th International Geological Congress the previous year. The number of contributors for the year — 1,206 — was the same as in 1990.

In keeping with its role as an increasingly important provider of funds for GSA's programs, grants from the Foundation increased 42% during the year, to just over $100,000. Money was disbursed for research grants, student travel grants, scholarships, awards, Penrose Conferences, and various aspects of SAGE and the Institute for Environmental Education. As the endowment base of the Foundation continues to grow, the amount of annual disbursements to GSA's programs will expand accordingly.

The GSA Foundation was the recipient of deferred gifts in 1991. In addition to receiving notification of some bequests (one of which was disbursed after the end of the year), the Foundation was advised of several planned or life income gifts. In July, the Foundation was designated as a beneficiary of a Charitable Remainder Annuity Trust established by a GSA member and his wife. At the end of the year, Carol McGill established the Carol G. & John T. McGill Fund and in January became the first contributor to the GSA Foundation Pooled Income Fund. Planned gifts of this type, in which the Foundation has the remainder interest, are not reflected currently on either the Foundation's income statement or balance sheet. Nevertheless, the assets represented by these gifts will ultimately become part of the Foundation's endowment.

While the gross numbers for the year are something of a mixed bag — improved assets, DNAG sales, and investment income; lower contributions and reduced inventory valuation — the existence of a strong, supportive contributor base of GSA members and the receipt of gifts for the future augur well for the continued financial well-being of the Foundation and, in turn, the Society as a whole. GSA has undertaken major new programs that require financial support. A large part of this money will come from the Foundation, either in the form of income earned by endowment or as direct, pass-through program funds. There is a major challenge for the GSA Foundation that will occupy us for the next three or four years. That challenge is to find and furnish the funds for SAGE, IEE, research grants, and other programs, as well as to pay for the facilities needed to do this work.

Robert L. Fuchs
President

TRUSTEES MEETING

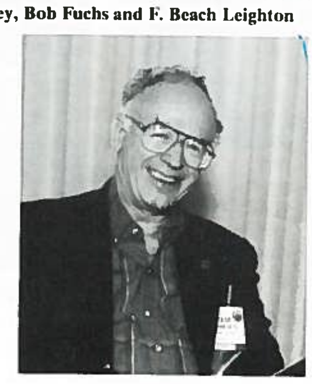
At GSA's annual meeting each year, the Foundation Trustees meet to elect officers, appoint new Trustees, review the progress of the Foundation, and plan for the future. Foundation officers and some GSA staff also attend the meeting, thereby providing a forum for the coordination of GSA programs and Foundation financing activities.

Board of Trustees

Donna Russell, E-an Zen and Brian Skinner

Leonard Cumley, Bob Fuchs and F. Beach Leighton

Bob Fuchs



Phil LaMoreaux

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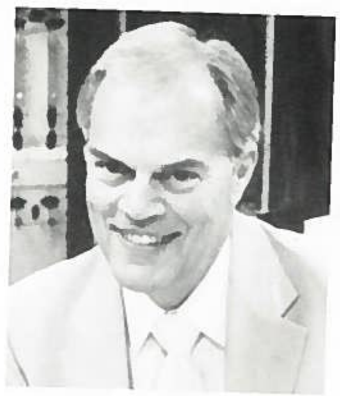
Paul A. Bailly is President of Fulcrum Management, a Company managing two venture capital partnerships focused on precious metals mines at the development stage. He received a Geological Engineering Degree from Nancy University, France and his Ph.D. in Economic Geology from Stanford University. A Fellow of GSA, he was President in 1983. He was President of the Society of Economic Geologists in 1981, and received the Jackling Award of the Society of Mining Engineers in 1979. He is a Director of the Mineral Information Institute, and of six mining Companies.

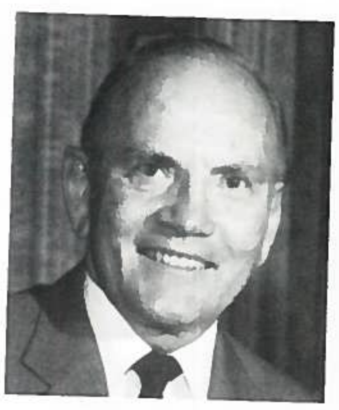


Fred A. Donath is a consultant located in San Clemente, California. He had been Corporate Vice President for R&D in the Earth Technology Corporation. Donath was also Head of Geology at the University of Illinois and, before that, Professor of Geology at Columbia University where he became well-known for his contributions to experimental rock deformation and structural geology. He is a Fellow of the Geological Society of America and served as Acting Editor for the Society during 1964. Donath was recently appointed as the Executive Director for GSA's Institute for Environmental Education.

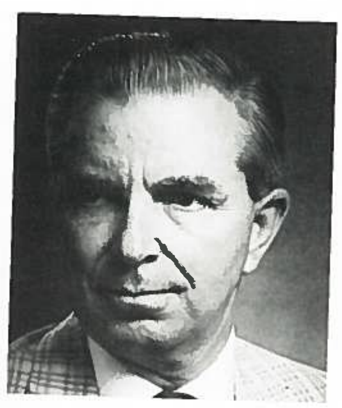
Peter Flawn received a B.A. Degree from Oberlin College and a M.S. and Ph.D. from Yale University. Flawn was Director of the Bureau of Economic Geology, a faculty member and president of the University of Texas. He is a member of the National Academy of Engineering, an honorary member of AASG and AAPG, and past-president of AGI. He received the Wilbur Lucius Cross Medal from Yale University and the Ben H. Parker Medal from AGI. A Fellow of the Geological Society of America, Flawn was Councilor from 1972-74 and President in 1978.

William B. Heroy earned a geology degree from Dartmouth and his Ph.D. from Princeton. His professional career included serving as a geologist at Texaco, as geologist, vice president and president of Geotech, and as a group executive of Teledyne. He was vice treasurer and professor at Southern Methodist University. He belongs to AAPG, SEG, SExG, AIPG, and AGI where he has served as treasurer, vice president and president. A Fellow of GSA, he has been a councilor, treasurer, and has served on numerous committees.

Philip E. LaMoreaux is Chairman of the Board of P. E. LaMoreaux & Associates, Inc. He is a past president of the American Geological Institute, the American Association of State Geologists, and the International Association of Hydrogeologists. He received his B.A. from Denison University and his M.A. from the University of Alabama, both in geology. He also served as Director of the Environmental Institute for Waste Management Studies, University of Alabama through January, 1989. A Fellow and former councilor of GSA, he is the author of many professional publications.



F. Beach Leighton is currently Chairman Emeritus of Leighton & Associates, an engineering geology consulting firm located in southern California. Before retirement in 1988, Dr. Leighton was the chairman of the board and chief executive officer and devoted his attention to the rapidly expanding application of geology to urban environment. He has published extensively on urban geology, earthquakes, and landslides. He received his B.S. from the University of Virginia and his Ph.D. from Caltech.



Charles J. Mankin, director of the Oklahoma Geological Survey, received his B.S., M.A., and Ph.D. in geology from the University of Texas. He served as President of the American Institute of Professional Geologists, the American Geological Institute, the Association of American State Geologists and the Mid-Continent Section of the Society of Economic Paleontologists and Mineralogists. A Fellow of GSA, he has served on the GSA Council and Executive Committee.

Philip Oxley is Exploration Advisor to the Board for Graham Resources, Inc., located in Covington, Louisiana. He received his B.A. from Denison and his M.A. and Ph.D. from Columbia University. Oxley worked for several U.S. oil companies until 1971 when he joined Tenneco Oil Exploration and Production in Houston, Texas. Following his retirement from Tenneco in 1989 he joined the faculty at the University of Colorado in Boulder, Colorado. He is a Fellow of GSA, a Certified Petroleum Geologist, and belongs to AAPG and Sigma Xi. Oxley has been a frequent speaker on geology, exploration, and energy in the U.S. and Europe.

Brian J. Skinner has a Ph.D. from Harvard and is now a professor at Yale University where he works on the geochemistry of mineral deposits. He is editor of Economic Geology, chairman of the Board of Overseers of the American Journal of Science, chairman of the U.S. National Committee on Geology, and was formerly chairman of the Board on Earth Sciences and Resources (NAS/NRC). A Fellow of the Society, he was President in 1985 and chairman of the Committee on the Path to 2000.

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FINANCIAL REPORT

STRAIT · KUSHINSKY AND COMPANY

INDEPENDENT AUDITORS' REPORT

The Board of Trustees
The Geological Society of America Foundation
Boulder, Colorado

We have audited the accompanying balance sheet of The Geological Society of America Foundation as of December 31, 1991, and the related statements of operations and fund balances and cash flows for the year then ended. These financial statements are the responsibility of the Foundation's management. Our responsibility is to express an opinion on these financial statements based on our audit.

We conducted our audit in accordance with generally accepted auditing standards. Those standards require that we plan and perform the audit to obtain reasonable assurance about whether the financial statements are free of material misstatement. An audit includes examining, on a test basis, evidence supporting the amounts and disclosures in the financial statements. An audit also includes assessing the accounting principles used and significant estimates made by management, as well as evaluating the overall financial statement presentation. We believe that our audit provides a reasonable basis for our opinion.

In our opinion, the financial statements referred to above present fairly, in all material respects, the financial position of The Geological Society of America Foundation as of December 31, 1991 and the results of its operations and its cash flows for the year then ended in conformity with generally accepted accounting principles.

Strait · Kushinsky and Company

Colorado Springs, Colorado
March 13, 1992

A PROFESSIONAL CORPORATION OF CERTIFIED PUBLIC ACCOUNTANTS AND CONSULTANTS
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THE GEOLOGICAL SOCIETY OF AMERICA FOUNDATION
Balance Sheet
December 31, 1991
(With Comparative Totals for 1990)

				Totals December 31,	
	Operating	Unrestricted	Restricted	1991	1990
ASSETS					
Cash and cash equivalents	$ 2,567	$ 4,163	$ 42,136	$ 48,866	$ 115,926
Contributions receivable (Note 1)	—	416	500	916	5,653
Accounts receivable (Note 1)	—	—	1,876	1,876	—
Due from Geological Society of America (Note 3)	45	4,123	12,663	16,831	—
Accrued interest receivable and other assets	10	502	5,256	5,768	636
Due from other funds	3,621	—	—	3,621	1,081
Investments, at market (Note 2)	950	127,516	1,319,005	1,447,471	1,307,576
DNAG publications inventory (Note 3)	—	—	618,418	618,418	807,900
Furniture and equipment, net of accumulated depreciation of $34,284 (Note 1)	5,434	—	—	5,434	9,057
TOTAL ASSETS	$12,627	$136,720	$1,999,854	$2,149,201	$2,247,829
LIABILITIES					
Accounts payable	$ 3,898	$ —	$ 3,866	$ 7,764	$ 139,659
Due to Geological Society of America (Note 4)	503	—	673,037	673,540	754,889
Due to other funds	—	422	3,199	3,621	1,081
	4,401	422	680,102	684,925	895,629
FUND BALANCES (Note 1)					
Unrestricted	8,226	136,298	—	144,524	209,402
Restricted	—	—	1,297,670	1,297,670	1,123,066
Held in trust for others	—	—	22,082	22,082	19,732
	8,226	136,298	1,319,752	1,464,276	1,352,200
TOTAL LIABILITIES	$12,627	$136,720	$1,999,854	$2,149,201	$2,247,829

See accompanying notes to financial statements.

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THE GEOLOGICAL SOCIETY OF AMERICA FOUNDATION
Statement of Operations and Fund Balances
December 31, 1991
(With Comparative Totals for 1990)

	Operating	Unrestricted	Restricted	Totals December 31, 1991	Totals December 31, 1990
REVENUES					
Contributions	$ 1,155	$ 28,987	$ 157,875	$ 188,017	$ 549,391
DNAG Program	—	—	437,770	437,770	384,831
Interest and dividends	800	10,527	85,560	96,887	72,474
Other (Note 4)	116,224	—	—	116,224	90,806
	118,179	39,514	681,205	838,898	1,097,502
EXPENDITURES					
Operating expenses	142,825	1,037	4,868	148,730	148,912
DNAG Program	—	—	726,581	726,581	889,268
Grants - Geological Society of America programs	—	14,316	85,913	100,229	70,587
	142,825	15,353	817,362	975,540	1,108,767
EXCESS (DEFICIENCY) OF REVENUES OVER EXPENDITURES	(24,646)	24,161	(136,157)	(136,642)	(11,265)
INVESTMENT ACTIVITY					
Realized gain (loss) on investments	(3)	431	(743)	(315)	(151)
Unrealized gain (loss) on investments	22	9,649	96,311	105,982	(3,424)
FUND TRANSFERS	20,652	(95,144)	74,492	—	—
EXCESS (DEFICIENCY) OF REVENUES OVER EXPENDITURES, INCLUDING INVESTMENT ACTIVITY	(3,975)	(60,903)	33,903	(30,975)	(14,840)
CAPITAL ADDITIONS	—	—	143,051	143,051	—
EXCESS (DEFICIENCY) OF REVENUES OVER EXPENDITURES, INCLUDING INVESTMENT ACTIVITY AND CAPITAL ADDITIONS	(3,975)	(60,903)	176,954	112,076	(14,840)
FUND BALANCE, BEGINNING OF YEAR	12,201	197,201	1,142,798	1,352,200	1,367,040
FUND BALANCE, END OF YEAR	$ 8,226	$ 136,298	$1,319,752	$1,464,276	$1,352,200

See accompanying notes to financial statements.

THE GEOLOGICAL SOCIETY OF AMERICA FOUNDATION
Statement of Cash Flows
For the Year Ended December 31, 1991
(With Comparative Totals for 1990)

	1991	1990
CASH FLOWS FROM OPERATING ACTIVITIES		
Excess (deficiency) of revenues over expenditures, including investment activity and capital additions	$ 112,076	$(14,840)
Adjustments to reconcile excess (deficiency) of revenues over expenditures to net cash provided by operating activities:		
Depreciation	4,651	4,646
Realized loss on investments	315	151
Unrealized (gain) loss on investments	(105,982)	3,424
(Increase) Decrease in assets:		
Contributions receivable	4,737	23,361
Accounts receivable	(1,876)	—
Due from other funds	(2,540)	(888)
Due from Geological Society of America	(16,831)	—
Accrued interest receivable and other assets	(5,132)	(636)
DNAG publications inventory	189,482	70,452
Decrease (Increase) in liabilities:		
Accounts payable	(131,895)	102,895
Due to other funds	2,540	888
Due to Geological Society of America	(81,349)	113,991
Net cash provided (used) by operating activities	(31,804)	303,444
CASH FLOWS FROM INVESTING ACTIVITIES		
Additions to furniture and equipment	(1,028)	(1,214)
Net change in investment cash	183,738	—
Purchase of investments	(1,056,626)	(720,418)
Proceeds from maturities and sale of investments	838,660	232,556
Net cash used by investing activities	(35,256)	(489,076)
CASH FLOWS FROM FINANCING ACTIVITIES		
Cancellation of Geological Society of America advance	—	200,000
NET CHANGE IN CASH	(67,060)	14,368
CASH AND CASH EQUIVALENTS, BEGINNING OF YEAR	115,926	101,558
CASH AND CASH EQUIVALENTS, END OF YEAR	$ 48,866	$ 115,926

See accompanying notes to financial statements.

THE GEOLOGICAL SOCIETY OF AMERICA FOUNDATION
Notes to Financial Statements
December 31, 1991

Note 1: Summary of Significant Accounting Policies

Foundation Operations

The Geological Society of America Foundation (the Foundation) was founded in 1980 to promote the science of geology. A primary objective of the Foundation is to provide funds for the Decade of North American Geology Program (the DNAG Program), which was established to publish a series of geological references in celebration of the 100-year anniversary of the Geological Society of America (the Society) in 1988.

Fund Accounting

To ensure observance of any limitations or restrictions placed on the use of resources, the accounts of the Foundation are maintained in accordance with the principles of fund accounting. The resources are classified for accounting and reporting purposes into funds established according to their nature and purpose. Interfund borrowings are in the combined totals presented in the financial statements.

Operating fund — The operating fund contains those net resources used in the current operations of the Foundation. Operating revenue is available to meet any Foundation expenditures.

Unrestricted fund — The Foundation board has full authority to use donated unrestricted funds for operational purposes.

Restricted fund — Restricted funds represent funds restricted by the donor, grantor or other outside party for particular purposes.

Assets held in trust — The Foundation has an agreement with the Symposium of the Geology of Rocky Mountain Coal (the Symposium) whereby the Foundation will manage the assets of the Symposium. The Foundation receives a management fee equal to 1% per year of the market value of the funds. The agreement can be terminated by either party upon 90-day written notice.

Investments in Marketable Securities

Investments in marketable securities are carried at fair market value. The difference between cost and fair market value is reflected in the statement of operations and fund balances as unrealized appreciation or depreciation on investments.

Tax Exempt Status

The Foundation qualifies as an exempt organization under Section 501(c)(3) of the Internal Revenue Code. Accordingly, no taxes are paid on the Foundation's revenue.

Note 1: Summary of Significant Accounting Policies (Continued)

Fixed Assets

Fixed assets are depreciated over their estimated useful lives using the straight-line method as follows:

	Amount	Estimated Useful Lives
Computers	$17,175	5 years
Equipment	22,543	5 years
	39,718	
Less accumulated depreciation	34,284	
	$ 5,434	

The Foundation recognized $4,651 of depreciation expense for the year ended December 31, 1991 which is recorded in the operating expenses of the operating fund.

Allowance for Bad Debts

It is management's estimate that all material pledges and accounts receivable are collectible; therefore, no allowance has been established in the financial statements.

In-Kind Donations

In-kind donations are recorded at fair value at the date of gift.

Statement of Cash Flows

For purposes of reporting cash flows, cash and cash equivalents include cash on hand and due from banks.

Note 2: Investments

Investments held at December 31, 1991 are summarized as follows:

	Cost	Market Value
Operating fund	$ 950	$ 950
Unrestricted fund	118,866	127,516
Restricted fund	1,229,524	1,319,005
	$1,349,340	$1,447,471

	Cost	Market Value
U.S. Government bonds	$ 340,046	$ 352,064
U.S. Agency bonds	33,779	36,646
Corporate bonds	132,461	137,161
Mutual funds	801,194	879,740
Cash, held for investment purposes	40,910	40,910
Other	950	950
	$1,349,340	$1,447,471

Note 3: DNAG Publications Inventory

The publications inventory of the DNAG Program is recorded at the lower of cost first-in, first-out (FIFO) method or market and consists of the following at December 31, 1991:

	Amount
Finished publications	$ 594,438
Costs incurred for unfinished publications	276,684
	871,122
Estimated adjustment to market	(252,704)
	$ 618,418

Note 4: Related Party Transactions With Geological Society of America

The amount due from the Society of $16,831 is for various contributions and other items received by the Society for the benefit of the Foundation.

The amount due to the Society of $673,540 represents expenditures incurred by the Society for the DNAG Program in excess of designated contributions received from the Foundation. Net proceeds the Foundation receives from the sale of DNAG publications are applied to this amount due.

Included in other revenue is $116,000 received from the Society to subsidize operating expenses of the Foundation.

The Foundation leases its office space from the Society under a month-to-month agreement. Total rent expense paid in 1991 was $3,600.

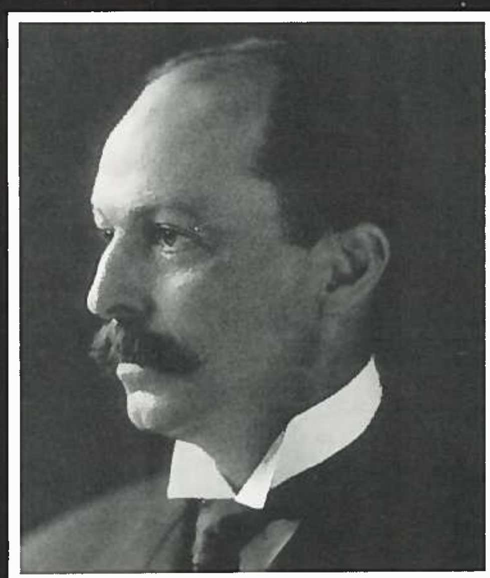
Note 5: Pension Plan

Employees of the Foundation participate in a discretionary pension plan covering substantially all employees. Contributions to the plan are made at the discretion of the Foundation's Board of Directors. The total amount contributed for December 31, 1991 was $2,278.

1991

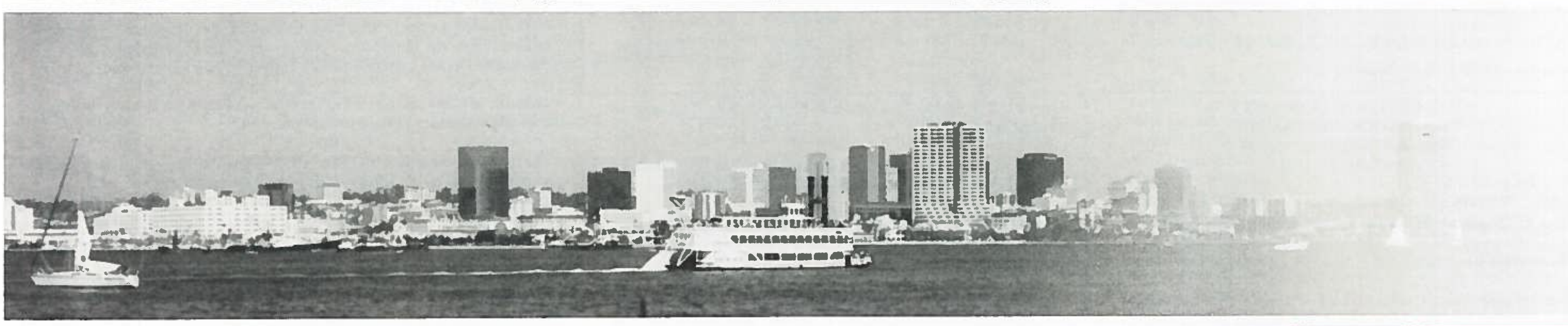
Annual Report

GSA Foundation



We present Richard Penrose as he was, neither a popular hero nor a plundering villain, but an earnest, intelligent, hard-working, ambitious, and self-reliant man who made his millions honestly out of the abundance of the Earth itself, as the fruit of his scientific and technical knowledge and skill, and whose life story is a part of the history of a stage in our country's growth the like of which we shall not see again.

Charles P. Berkey



San Diego

GSA 1991

GSA 1992 ANNUAL MEETING • CINCINNATI, OHIO

THE VOYAGE CONTINUES
From Columbus to Magellan

Theme Sessions and Symposia

ABSTRACTS DEADLINE FOR INVITED AND VOLUNTEERED PAPERS WEDNESDAY, JULY 8, 1992

Technical sessions consist of both invited and volunteered papers organized in one of three presentation formats: symposia, theme sessions, and discipline sessions. All abstracts are due for review by *July 8.* Abstracts must be submitted on the 1992 Abstract Form, available from the Abstracts Coordinator at GSA headquarters.

1992 Technical Program Chairmen

Nicholas Rast
Dept. of Geological Sciences
University of Kentucky
Lexington, KY 40506-0059
(606) 257-3758 (dept.)

Roy Kepferle
Dept. of Geology
Eastern Kentucky University
Richmond, KY 40475-0953
(606) 622-1273 (dept.)

Volunteered Papers

This format includes all abstracts that are not specifically invited for a symposium. Two types of sessions are available:

1. *Discipline Sessions.* Papers are submitted to one scientific category (discipline). The Joint Technical Program Committee (JTPC) representatives select and schedule the papers in sessions focused on this one discipline, e.g., hydrogeology, geochemistry.

2. *Theme Sessions.* Papers are submitted to a specific pre-announced title and to ONE scientific category. Theme sessions are interdisciplinary; each theme may have as many as three categories from which authors may choose ONE. After each theme description below, the categories are identified by name and number as they appear on the 1992 Abstract Form. The full theme descriptions appear in the April 1992 issue of *GSA Today* and were distributed with the 1992 abstract forms in March. Schedules for theme sessions will be available immediately after the JTPC meeting in August and will appear in the September issue of *GSA Today.*

> Papers for theme sessions are to be submitted in oral mode only. The exception is Theme Session #24, which is to be submitted in poster mode only. If the abstract is submitted in the incorrect mode, the abstract will NOT be considered for the theme session, but will automatically be considered for a discipline session instead.

T1. **Tectonic Settings and Paleoenvironments of the Paleo-Pacific Margin—Antarctic and Related Gondwana Sequences.** Paleoceanography/Paleoclimatology (19), Paleontology/Paleobotany (20), Tectonics (33).

T2. **New Discoveries in Neoproterozoic Earth History.** Paleontology (20), Sedimentology (30), Tectonics (33).

T3. **Intraplate Neotectonics.** Geophysics/Tectonophysics (11), Quaternary Geology (28), Structural Geology (32).

T4. **Hydrogeochemistry and Isotope Hydrology of Regional Aquifer Systems.** Geochemistry, Aqueous (7), Hydrogeology (15), Paleoclimatology (19).

T5. **Hydrogeology, Hydrogeochemistry, and Ground-Water Contamination in the Midwest Basin and Arches Region.** Hydrogeology (15), Sedimentology (30), Structural Geology (32).

T6. **Environmental Geology: The Voice of Warning.** Engineering Geology (5), Environmental Geology (6), Hydrogeology (15).

T7. **Environmental Geology: The Voice of Reason.** Engineering Geology (5), Environmental Geology (6), Hydrogeology (15).

T8. **Gulf Coast Cretaceous Project: Biostratigraphy and Correlation; Sea-level Change and Paleogeography; Depositional Environments and Diagenesis.** Paleontology/Paleobotany (2), Sedimentology (30), Stratigraphy (31).

T9. **Discovery in Hydrogeology—Heritage, Wisdom, and Vision.** Engineering Geology (5), History of Geology (14), Hydrogeology (15).

T10. **Transmission Electron Microscopy in Mineralogy and Petrology.** Geochemistry, Other (8), Mineralogy (18), Petrology (22).

T11. **Paleozoic Depositional Sequences; Contrasts in Environments and Fossil Diversity.** Micropaleontology (17), Paleontology (20), Stratigraphy (31).

T12. **Origin and Nature of Meltwater Release from the Laurentide Ice Sheet and Its Impact on Late Glacial Oceans.** Global Change (13), Paleoceanography/Paleoclimatology (19), Quaternary Geology (28).

T13. **Environmental Issues in Urban Settings.** Engineering Geology (5), Environmental Geology (6), Geomorphology (10).

T14. **Consultants/Industries Innovative Applications in Environmental Investigations.** Engineering Geology (5), Environmental Geology (6), Hydrogeology (15).

T15. **Magellan, Galileo, and Planetary Frontiers: The Discovery of New Worlds Continues.** Geophysics/Tectonophysics (11), Planetary Geology (26), Remote Sensing (29).

T16. **Paleosols: Their Geologic Applications.** Paleoceanography/Paleoclimatology (16), Sedimentology (30), Stratigraphy (31).

T17. **Thrust Fault Sesquicentennial.** History of Geology (14), Structural Geology (32), Tectonics (33).

T18. **Quantitative Chemical Hydrogeology: Calculation of Solute Transport and Water-Rock Interaction in Geochemical Processes.** Computers (3), Geochemistry, Aqueous (7), Hydrogeology (15).

T19. **Ordovician K-Bentonites.** Geochemistry, Other (8), Stratigraphy (31), Tectonics (33).

T20. **Biotic Responses to Allocyclic Processes in Carboniferous Coal-Bearing Strata.** Paleontology (20), Sedimentology (30), Stratigraphy (31).

T21. **Time and Place of Compressional Events in the Appalachian Orogen.** Stratigraphy (31), Structural Geology (32), Tectonics (33).

T22. **Formation of Fault Systems.** Geophysics (11), Structural Geology (32), Tectonics (33).

T23. **Advances in Investigation, Characterization, and Monitoring of the Geologic Environment for Waste Disposal.** Environmental Geology (6), Engineering Geology (5), Hydrogeology (15).

T24. **Metamorphism in North and Central America: Regional Studies and Digital Compilation Techniques (Poster Mode only).** Computers (3), Metamorphic Petrology (24), Tectonics (33).

T25. **Late Proterozoic Rifting of the North American Craton.** Precambrian Geology (27), Structural Geology (32), Tectonics (33).

T26. **New Cretaceous-Tertiary Boundary Discoveries—Caribbean and High Latitudes.** Geochemistry, Other (8), Sedimentology (30), Stratigraphy (31).

Invited Papers (Symposia)

This format includes only abstracts that have been invited by the convener of a symposium. Abstracts are sent directly to the convener by *July 8.*

S1. **From Columbus to Magellan—Discovery.** *1992 Technical Program Committee.* Nicholas Rast, University of Kentucky.

S2. **History of Late Glacial Runoff from the Southern Laurentide Ice Sheet.** *Quaternary Geology and Geomorphology Division.* James T. Teller, University of Manitoba, Winnipeg, Canada.

S3. **The History of the Use of Art and Photography in Geological Literature.** *History of Geology Division.* Donald M. Hoskins, Pennsylvania Geological Survey, Harrisburg.

S4. **Preserving Geoscience Imagery.** *Geoscience Information Society.* Louise S. Zipp, University of Iowa.

S5. **Frontiers of Chemical Mass Transport in Contaminant Systems.** *Hydrogeology Division, Institute for Environmental Education.* Yu-Ping Chin and Frank W. Schwartz, Ohio State University.

S6. **Reform in Science Education.** *National Association of Geology Teachers.* Charles Q. Brown, East Carolina University, North Carolina.

S7. **Mineralization Related to Continental Rifts (full day).** *Society of Economic Geologists.* Richard E. Beane, Oro Valley, Arizona.

S8. **Black Shales and Related Ore Deposits.** *Society of Economic Geologists.* Richard I. Grauch, U.S. Geological Survey, Denver; Holly Huyck, Denver, Colorado.

S9. **Ground Truth: Geology of the Earth and Planets from Rocks and Analogs.** *Planetary Geology Division.* Harry Y. McSween, University of Tennessee, Knoxville.

S10. **Applications of Stable Isotope Geochemistry to Problems in High-Temperature Petrogenesis.** *Geochemical Society.* Theodore C. Labotka, University of Tennessee, Knoxville.

S11. **Geologic Aspects of Development Projects in Latin America and the Caribbean Basin.** *International Division, Engineering Geology Division.* Jerome V. DeGraff, USDA Forest Service, Clovis, California; John S. Oldow, Rice University.

S12. **Instability on Clay and Shale Hillslopes.** *Engineering Geology Division.* William C. Haneberg, New Mexico Bureau of Mines, Socorro; Robert W. Fleming, U.S. Geological Survey, Denver.

S13. **Physical and Chemical Responses to Allocyclic Processes in Carboniferous Coal-Bearing Strata.** *Coal Geology Division.* Cortland F. Eble, Kentucky Geological Survey, Lexington; C. Blaine Cecil, U.S. Geological Survey, Reston.

S14. **Controls on Carbon Preservation (full day).** *Organic Chemistry Division* of the *Geochemical Society.* Cindy Lee, State University of New York at Stony Brook.

S15. **The Role of Fluids in Crustal Deformation.** *Structural Geology and Tectonics Division.* Jan A. Tullis, Brown University; Terry Engelder, Pennsylvania State University, University Park.

S16. **Synergism: Archaeological and Geological Sciences.** *Archaeological Geology Division.* Bonnie A. Blackwell, Purdue University.

S17. **Paleosols: Their Geologic Applications.** *Sedimentary Geology Division.* Mary J. Kraus, University of Colorado; David E. Fastovsky, University of Rhode Island.

Field Trips

Cincinnati, Ohio, is central to classical Paleozoic successions of the Midcontinent and Appalachian Basin. The city is also a focal point for exceptional Pleistocene glacial and periglacial features that have been debated for decades. A wide variety of field trips for the 1992 GSA Annual Meeting in Cincinnati will give participants exceptional opportunities to see classical sites as well as new ones that have been crucial to the interpretation of North American geology. We hope you will choose to participate in one or more of these excursions.

All trips begin and end in Cincinnati unless otherwise indicated. Costs are preliminary estimates. Further details will be given when registration begins in August.

For further information, contact the 1992 Field Trips Chairman, Thomas M. Berg, Ohio Dept. of Natural Resources Division of Geological Survey, 4383 Fountain Square Drive, Columbus, OH 43224-1362, (614) 265-6576, or the individual trip leaders.

Premeeting

Sampling the Layer Cake That Isn't: The Stratigraphy and Paleontology of the "Type-Cincinnatian." October 23–24. Richard Arnold Davis, Cincinnati Museum of Natural History, 1720 Gilbert Ave., Cincinnati, OH 45202, (513) 621-3890; Roger J. Cuffey. Cost: $85. Limit: 40.

For over a century and a half, the rocks of the Cincinnati region have been the reference "section" for the Upper Ordovician of North America. Participants will have the rare opportunity to observe the Cincinnatian in its type-area and to collect the rocks and fossils that characterize these classic units. The intention is to visit as many of the formations and members of the type-Cincinnatian as time will allow—from Edenian through Richmondian.

Paleoclimate Controls on Carboniferous Sedimentation and Cyclic Stratigraphy in the Appalachian Basin. October 22–25. Sponsored by the *Coal Geology Division.* C. Blaine Cecil, U.S. Geological Survey, 956 National Center, Reston, VA 22092, (703) 648-6415; Cortland F. Ebel. Cost: $240. Limit: 40. Trip begins in Morgantown, West Virginia.

Participants on this trip will examine evidence for a variety of paleoclimatic controls on sediment flux and cyclic stratigraphy in Carboniferous strata, including major economic coal beds, in the Appalachian basin. Changes in paleoclimate, such as (1) long-term climate change as eastern North America moved from southern hemisphere dry latitudes through the tropical rainy belt of the paleoequator into northern hemisphere dry latitudes, (2) intermediate-term climate change that may be related to 100-ka and 400-ka cycles of orbital eccentricity, and (3) short-term climate cycles that may be the result of cycles in axial tilt and precession, appear to have been a primary control on the physical and chemical characteristics and the biostratigraphy of Carboniferous strata. Evidence for eustatic controls on transgressive-regressive cycles will also be examined.

The Geology Of Columbus' Landfall. October 22–25. Mark R. Boardman, Dept. of Geology, Miami University, 114 Shideler Hall, Oxford, OH 45056, (513) 529-3216; Cindy Carney; Don Gerace. Cost: $750. Limit: 20.Trip begins and ends in Ft. Lauderdale, Florida. Trip travels to San Salvador, Bahamas. Cost includes an overflight. (Optional day trip to Joulters, additional $225.) Limit: 12.

This trip will begin at Ft. Lauderdale, Florida, where on day 1, participants will have a guided aerial tour of the Bahamas including Bimini, Great Bahama Bank lagoon, Joulters Cays ooid shoal, Schooner Cays ooid shoal, Eleuthera Island, Cat Island, and San Salvador. In the afternoon, participants can observe the variability of fauna and flora within lagoonal depositional environments by snorkeling, and Holocene transgressive dunes will be examined. On the second day, participants will see geology from the ocean aboard a large dive boat and will study modern patch reefs—complete with crinoids. The third day will be devoted to the investigation of tidal creeks, stressed lagoons and interior ponds, tidal deltas, Holocene strand plains and beaches, and beachrock. Day 4 will bring participants directly back to Ft. Lauderdale in time to make their way to Cincinnati by mid-afternoon on Sunday. An optional field trip to Joulters Cays ooid shoal will be available on day 4, with participants returning to Ft. Lauderdale in the early evening in time to make a late-night flight to Cincinnati.

Regional Aspects of Pottsville and Allegheny Stratigraphy and Depositional Environments, Ohio and Kentucky. October 24–25. Charles L. Rice, U.S. Geological Survey, 926 National Center, Reston, VA 22092, (703) 648-6938; Ronald L. Martino; Ernie R. Slucher. Cost: $81. Limit: 40.

This field trip will examine basal Pennsylvanian strata of southern Ohio for comparison with those of northeastern Kentucky showing local variations of the Mississippian-Pennsylvanian unconformity, the character of some intra-Pennsylvanian diastems, and regional correlations of Middle Pennsylvanian stratigraphic units. Lithology and stratigraphy of the Pottsville Formation will be contrasted with that of the Allegheny Formation, emphasizing marine shales and limestones and commercial clay deposits in the coal and clay mining district of southern Ohio. Facies architecture of marine units will be discussed in terms of deposystem dynamics and relative sea-level fluctuations. The sedimentology and paleoichnology of selected marginal marine facies will be examined, including heterolithic tidal rhythmites that show a hierarchy of thickening and thinning cycles, bipolar paleocurrents, and abundant trace fossils.

The Sangamonian-Wisconsinan Transition in Southwestern Ohio and Southeastern Indiana. October 25. C. Scott Brockman, Ohio Dept. of Natural Resources Division of Geological Survey, 4383 Fountain Square Drive, Columbus, OH 43224-1362, (614) 265-6473; Robert D. Hall; Thomas V. Lowell; Barry B. Miller. Cost: $35. Limit: 22. Trip will be repeated after the meeting, on October 30.

Nonglacial sediments and paleosols form important markers above and below glacial sediments, bracketing the transition between major glacial events. We will view this set of deposits at five well-known sites near Eaton and New Paris, Ohio, and Richmond and Connersville, Indiana. New analyses of paleosols, carbon-14 dates, amino acid ratios, and till facies relations refine and challenge stratigraphic interpretations and Pleistocene history, centered on the Sangamonian-Wisconsinan transition, that have stood for 30 years in this area. Some sections have moderately difficult access and require waterproof boots.

Geology of Key Archaeological Sites in Northern Kentucky and Southern Ohio. October 24–25. Sponsored by the *Archaeological Geology Division.* Timothy S. Dalbey, Dept. of Anthropology, Southern Methodist University, Dallas, TX 75275, (214) 692-2763. Cost: $130. Limit: 42.

The first day of this trip includes the sites of Big Bone Lick (Kentucky), Shawnee Lookout, Miamisburg Mound, SunWatch, Ohio Historical Center, Newark Earthworks, Flint Ridge, and Dillon State Park. The second day will cover Hocking Hills Gorge, Mound City, Adena, Seip Mound, Serpent Mound, and Fort Hill, and we will travel through the Wisconsinan Cuba end moraine to Fort Ancient.

Karst and Cave Systems in the Stones River Group, Central Tennessee. October 23–24. Ray C. Gilbert, Tennessee Division of Geology, Room B30, 701 Broadway, Nashville, TN 37243-0445, (615) 742-6703; Nicholas Crawford; Patricia Thompson. Cost: $100. Limit: 40. Trip begins and ends in Nashville, Tennessee.

Participants on this trip will examine features associated with the Snail Shell cave system, an extensively studied and well-known karst hydrologic system that covers several square miles of the central basin of Tennessee near Murfreesboro in Rutherford County. This karst system is located near the crest of the Nashville dome and is developed in the Middle Ordovician carbonate rocks of the Stones River Group. We will discuss the hydrologic, structural, and stratigraphic relations of the karst system and the diverse subsurface drainage features evident in the area.

Ordovician, Silurian, and Middle Devonian Stratigraphy in Northwestern Kentucky and Southern Indiana—Some Reinterpretations. October 24–25. James E. Conkin, Dept. of Geology, University of Louisville, Louisville, KY 40292, (502) 588-6821; Barbara M. Conkin; John Kubacko, Jr. Cost: $100. Limit: 40.

On this trip we will focus partly on reinterpretations of the Middle-Late Ordovician boundary and the Middle Silurian Laurel-Waldron and Waldron-Louisville boundaries. It will include treatment of the lithostratigraphy of the Louisville Limestone and Silurian-Devonian type paraconformity. The trip will also cover the detailed stratigraphy of Middle Devonian formations, including biozones, paracontinuities, bone beds, and metabentonites (Kawkawlin, Onondaga, Indian Nation, Lake Chelan, and Tioga). There will be opportunities and time to collect macrofossils (including attached crinoid bases) and microfossils (including forams, charophytes, and conodonts). Bone beds and metabentonites may be sampled as well.

Cincinnati's Geologic Environment: A Trip For Secondary School Science Teachers. October 25. Sponsored by the *Engineering Geology Division.* William Haneberg, New Mexico Bureau of Mines and Mineral Resources, Socorro, NM 87801, (505) 835-5808; Mary Riestenberg; Richard Pohana. Cost: $35. Limit: 50. (Registration for secondary school teachers only.)

Secondary school science teachers are invited to participate in a one-day overview of Cincinnati's geologic environment and its impact on human activities. Topics will include bedrock geology and Paleozoic history; surficial deposits and Quaternary geological history; modern-day hillside processes along the Ohio River valley; the economic consequences of landslides; ground-water resources; and geological considerations in landfill siting. There will be ample opportunities for fossil collecting and photography. No previous geological training is required, but sturdy walking shoes or boots are recommended.

Half-Day Mini Trips (held during the meeting)

Geologic Glimpses from Around the World: The Geology of Monuments in Woodland Cemetery and Arboretum, Dayton, Ohio. October 26. Sponsored by the *History of Geology Division.* Michael R. Sandy, Dept. of Geology, University of Dayton, Dayton, OH 45469-2364, (513) 229-2952. Cost: $17. Limit: 40.

This half-day trip will examine some of the igneous, sedimentary, and metamorphic rocks used in the monuments and buildings of Woodland Cemetery and Arboretum, which was established in 1841. The polished surfaces of many monuments provide excellent opportunities to examine their composition and textures, and consider their geologic histories. The graves of some preeminent Daytonians, including the Wright Brothers, Paul Lawrence Dunbar, and the paleontologist August Foerste, will also be visited.

Excursion to Caesar Creek State Park in Warren County, Ohio: A Classic Upper Ordovician Fossil-Collecting Locality. October 28. Douglas L. Shrake, Ohio Dept. of Natural Resources Division of Geological Survey, 4383 Fountain Square Drive, Columbus, OH 43224-1362, (614) 265-6473. Cost: $25. Limit: 135.

This half-day trip will take participants to Caesar Creek State Park in Warren County, Ohio. This site is a classic locality that is noted for abundant and well-preserved Upper Ordovician (Richmondian) fossils. More than 30 species of macro- and ichno-fossils have been found here, including three species of trilobites. Appropriate field attire is recommended. Physical exertion level is very low. If possible, participants should bring their own sample containers. Trip will be suitable for spouses and children.

Postmeeting

Mississippian Paleosols, Paleokarst, and Eolian Carbonates in Indiana. October 30–31. Donald E. Hattin and J. Robert Dodd, Dept. of Geological Sciences, Indiana University, 1005 E. Tenth St., Bloomington, IN 47405, (812) 855-8232. Cost: $120. Limit: 44.

Participants in this trip will examine evidence for sea-level fluctuation and sequence stratigraphy in the St. Louis and Ste. Genevieve Limestones of southern Indiana. On the first day the field party will observe limestone units consisting of marine-derived carbonate sand grains reworked by eolian processes, paleosols, and exposure features in the Ste. Genevieve Limestone near Corydon, Indiana. Also in the Ste. Genevieve we will view an oolitic sand shoal underlain and capped by exposure surfaces. On the second day we will observe exposure features including calcrete, mud cracks, brecciation, and rhizocretions in the upper Ste. Genevieve and lower St. Louis Limestone. At the last stop of the trip we will see a spectacular buried paleokarst system and other subaerial exposure features displayed along the wall of a deep canyon cut into the St. Louis Limestone. Collection of samples and use of hammers will not be permitted at stop 6, which is in a state park.

Fort Payne Carbonate Facies of South-Central Kentucky. October 30–31. David L. Meyer, Dept. of Geology, University of Cincinnati, Cincinnati, OH 45221, (513) 556-4530; William I. Ausich. Cost: $185. Limit: 35.

Paleoecology, taphonomy, and depositional environments of the Lower Mississippian Fort Payne Formation are the focus of this trip, where the spectacular exposures along Lake Cumberland will be studied by boat. In south-central

Kentucky, the Fort Payne is lithologically heterogeneous and richly fossiliferous. Of special interest are the carbonate buildups, which include crinoid packstone buildups and wackestone buildups interpreted to be examples of the Waulsortian facies.

Changing Interpretations of Kentucky Geology: Layer-Cake, Facies, Flexure, and Eustasy. October 29–31. Frank R. Ettensohn, Dept. of Geological Sciences, University of Kentucky, Bowman Hall, Lexington, KY 40506-0059, (606) 257-3758; Donald R. Chesnut; Steve Barnett. Cost: $215. Limit: 40.

This is the University of Kentucky Department of Geological Sciences Centennial Field Trip. The rather staid "layer-cake" interpretation of Kentucky and mid-continental geology is continually being challenged. This three-day trip will examine some of Kentucky's more typical and atypical Ordovician-through-Pennsylvanian units in light of these challenges. Emphasis will be on models suggesting that many of the units reflect local and regional facies variations resulting from the interaction of basement structures with flexural movements of the lithosphere and with eustasy. We will suggest that such flexural movements can be related to both local examples of synsedimentary tectonism and to the regional far-field-tectonic effects of coeval orogenies.

Building Stone in Three Ohio Cities: Cincinnati, Columbus, and Cleveland. October 29–31. Joseph T. Hannibal, Cleveland Museum of Natural History, 1 Wade Oval Drive, Cleveland, OH 44106-1767, (216) 231-4600; Richard Arnold Davis; Ruth Melvin; Garry D. McKenzie; Mark T. Schmidt. Cost: $100. Limit: 40. Trip ends in Cleveland, Ohio.

Many types of dimension stone, including Berea sandstone, Columbus limestone, and Massillon sandstone, have been used for buildings and monuments constructed in Ohio during the past 150 years. Stone from other North American localities and Europe have also been used in Ohio structures. We will examine a great variety of these stones, used in classic buildings as well as modern skyscrapers, in the downtown areas of Cincinnati, Columbus, and Cleveland. A visit to an active dimension-stone quarry is also planned.

The Sangamonian-Wisconsinan Transition in Southwestern Ohio and Southeastern Indiana. October 30. C. Scott Brockman, Ohio Dept. of Natural Resources Division of Geological Survey, 4383 Fountain Square Drive, Columbus, OH 43224-1362, (614) 265-6473; Robert D. Hall; Thomas V. Lowell; Barry B. Miller. Cost: $35. Limit: 25. Trip will also be run before the meeting, October 25.

Nonglacial sediments and paleosols form important markers above and below glacial sediments, bracketing the transition between major glacial events. We will view this set of deposits at five well-known sites near Eaton and New Paris, Ohio, and Richmond and Connersville, Indiana. New analyses of paleosols, carbon-14 dates, amino acid ratios, and till facies relations refine and challenge stratigraphic interpretations and Pleistocene history, centered on the Sangamonian-Wisconsinan transition, that have stood for 30 years in this area. Some sections have moderately difficult access and require waterproof boots.

Structure and Tectonics of the Rough Creek Graben, Western Kentucky and Southeastern Illinois. October 29–31. Donald K. Lumm, Illinois State Geological Survey, Natural Resources Building, 615 E. Peabody Dr., Champaign, IL 61820-6964, (217) 244-2428; W. John Nelson. Cost: $150. Limit: 44.

Structures of tensional and compressional origin as well as tectonically influenced sedimentary features will be examined in several roadcuts and quarries. The structures are formed in Carboniferous strata and exhibit evidence for two or more episodes of movement. The features are related to the late Paleozoic reactivation of the Reelfoot Rift aulacogen and its eastward extension—the Rough Creek Graben. The trip will conclude at either Cincinnati/Northern Kentucky International Airport or Cincinnati.

Other Field Trips

Keweenaw Copper Deposits of Western Upper Michigan. October 20–23. Sponsored by the *Society of Economic Geologists.* Theodore J. Bornhorst, Dept. of Geological Engineering, Geology, and Geophysics, Michigan Technological University, Houghton, MI 49431, (906) 487-2721; William Cannon; Jeffrey Mauk. Cost: $350 (members and students), and $375 (nonmembers). Trip begins and ends in Houghton, Michigan. Limit: 30.

Participants on this field trip will focus on the Midcontinent Rift System as the geologic setting for the native copper deposits of the Keweenaw Peninsula and the White Pine copper deposit (copper shale mineralization and structurally controlled mineralization). Planned stops include underground tours of the Caledonia and White Pine mines, drill core displays, and surface stops to view rift characteristics. Lectures about the rift geology and world-class White Pine Mine will be presented in the evenings.

Zinc Deposits In East Tennessee. October 29–November 1. Sponsored by the *Society of Economic Geologists.* Kula Misra, Dept. of Geological Sciences, University of Tennessee, Knoxville, TN 37796-1410, (615) 974-2366; Robert E. Fulweiler. Cost: $325 (members and students), and $350 (nonmembers).

On this trip we will focus on the stratigraphic setting and nature of mineralization of Mississippi Valley–type zinc deposits hosted in the Upper Knox (Lower Ordovician) carbonates. Planned stops include, Young Mine, the largest in the Mascot–Jefferson City zinc district, and its mill; the Mossy Creek open cut, the first zinc mine in the district; surface tour of the inactive Idol Zinc Mine (Copper Ridge zinc district); and (time permitting) the Ballard open pit (Sweetwater barite-fluorite district). Distinct mineralization will be seen in the New Prospect Mine (Powell River district), where lead occurs in faults and shear zones in the lowermost Knox (Copper Ridge Dolomite, Cambrian) and the underlying Maynardville Limestone. The Thornhill section, comprising well-exposed rocks from the Lower Cambrian Rome Formation to the Lower Mississippian Grainger Formation, will provide an excellent overview of the regional stratigraphy.

Cyclic Sedimentation and Sequence Stratigraphy of a Storm-Dominated Carbonate Ramp: Kope and Fairview Formations of the Cincinnati Region. October 25. Sponsored by the *Keck Geology Consortium.* Thomas J. Algeo, Fisk Laboratory of Sedimentology, Dept. of Geology, University of Cincinnati, Cincinnati, OH 45221-0013, (513) 556-4195; Ben Datillo; Sharon Diekmeyer. For information: Henry H. Woodard, Keck Consortium Coordinator, Dept. of Geology, Beloit College, Beloit, WI 53511, (608) 363-2222. Participation limited to faculty and students of the Consortium.

The trip will examine lithologic and faunal cyclicity within the Upper Ordovician Kope and Fairview Formations in light of recent interpretations of the sequence as a record of storm-dominated carbonate-ramp sedimentation. The interplay of eustatic and climatic factors in the development of multiple orders of cyclicity will be considered. Recent work indicating that meter-scale cyclicity within the formations formed through orbital forcing of the climate system at Milankovitch periodicities will be reviewed.

CINCINNATI

GSA Penrose Conferences

September 1992

Applications of Strain: From Microstructures to Mountain Belts, September 9–13, 1992, Liscomb Mills, Nova Scotia, Canada. Information: Mark Brandon, Dept. of Geology and Geophysics, Yale University, P.O. Box 6666, New Haven, CT 06511-8130, (203) 432-3135; Scott R. Paterson, Dept. of Geological Sciences, University of Southern California, Los Angeles, CA 90089-0740, (213) 740-6130.

Origin and Emplacement of Low-K Silicic Magmas in Subduction Settings, September 25–30, 1992, Chelan, Washington. Information: James S. Beard, Virginia Museum of Natural History, Martinsville, VA 24112, (703) 666-8611, fax 703-632-6487; George W. Bergantz, Dept. of Geological Sciences, University of Washington, Seattle, WA 98195, (206) 545-4972; Marc J. Defant, Dept. of Geology, University of South Florida, Tampa, FL 33620, (813) 974-2238, fax 813-974-2668; Mark S. Drummond, Dept. of Geology, University of Alabama, Birmingham, AL 35294, (205) 934-8130.

October 1992

Fluid-Volcano Interactions, October 4–9, 1992, Warm Springs, Oregon. Information: Steve Ingebritsen, U.S. Geological Survey, MS 439, 345 Middlefield Road, Menlo Park, CA 94025, (415) 329-4422, fax 415-329-4463; Bruce Christenson, Geothermal Research Centre, Private Bag 2000, Taupo, New Zealand; Craig Forster, Dept. of Geology and Geophysics, University of Utah, 719 W.C. Browning Building, Salt Lake City, UT 84112; Grant Heiken, Los Alamos National Laboratory, MS-D462, Los Alamos, NM 87545; Craig Manning, Dept. of Earth and Space Sciences, University of California, 405 Hilgard Avenue, Los Angeles, CA 90024.

Late Precambrian Tectonics and the Dawn of the Phanerozoic, October 18–23, 1992, Death Valley, California. Information: Ian W.D. Dalziel, Institute for Geophysics, University of Texas, Austin, TX 78759-8345, (512) 471-6156, fax 512-471-8844; Andrew H. Knoll, The Botanical Museum, Harvard University, Cambridge, MA 02138, (617) 495-9306 (on sabbatical in Cambridge, UK); Eldridge M. Moores, Dept. of Geology, University of California, Davis, CA 95616, (916) 752-0352 or 752-0350, fax 916-752-6363.

1992 Meetings

June

33rd U.S. Symposium on Rock Mechanics, June 8–10, 1992, Santa Fe, New Mexico. Information: Wolfgang R. Wawersik, Geomechanics Division 6232, Sandia National Laboratories, Albuquerque, NM 87185, (505) 844-4342, fax 505-844-7354.

6th Symposium on the Geology of the Bahamas, June 11–15, 1992, Bahamian Field Station, San Salvador, Bahamas. Information: Donald T. Gerace, Executive Director, Bahamian Field Station, Ltd., P.O. Box 2488, Port Charlotte, FL 33949.

First Thematic Conference on Remote Sensing for Marine and Coastal Environments, June 15–17, 1992, New Orleans, Louisiana. Information: Nancy J. Wallman, ERIM/Marine Environment Conference, P.O. Box 134001, Ann Arbor, MI 48113-4001, (313) 994-1200, x3234, fax 313-994-5123, telex 4940991 ERIMARB.

Neotectonics—Recent Advances, June 16–17, 1992, London. Information: C. Vita-Finzi, Dept. of Geology, University College, Gower Street, London WC1E 6BT, England, fax 071-388-7614.

Geology of the Taconic Orogen: A Sesquicentennial Field Conference, June 20–21, 1992, Shoreham, Vermont. Information: Paul A. Washington, P.O. Box 242, Shoreham, VT 05770, (919) 733-1330.

■ **3rd Spanish Geological Congress and 8th Latin American Congress of Geology,** June 21–26, 1992, Salamanca, Spain. Information: ODECO, Avenida de Alemania 41, 37007 Salamanca, Spain.

American Association of Petroleum Geologists Annual Meeting, June 21–24, 1992, Calgary, Alberta, Canada. Information: George Eynon, General Chairman, Bow Valley Industries, Ltd., P.O. Box 6610, Postal Station D, Calgary, Alberta T2P 3R7, Canada, (403) 261-6100; AAPG Convention Dept., P.O. Box 979, Tulsa, OK 74101, (918) 584-2555.

Interpraevent 1992—Protection of Habitat against Floods, Debris Flows and Avalanches, June 29–July 3, 1992, Berne, Switzerland. Information: Interpraevent 1992, c/o Bundesamt für Wasserwirtschaft, Postfach 2743, CH-3001 Berne, Switzerland

Western Society of Malacologists 25th Annual Meeting, June 30–July 3, 1992, Asilomar, California. Information: Henry Chaney, Museum of Natural History, 2559 Puesta del Sol Road, Santa Barbara, CA 93105, (805) 682-4711, ext. 334.

July

7th International Symposium on Water-Rock Interaction, July 13–22, 1992, Park City, Utah. Information: Yousif Kharaka, Secretary-General, U.S. Geological Survey, MS 427, 345 Middlefield Road, Menlo Park, CA 94025, (415) 329-4535, fax 415-329-5110.

Society for Industrial and Applied Mathematics Annual Meeting, July 19–24, 1992, Los Angeles, California. Information: SIAM Conference Dept., 3600 University City Science Center, Philadelphia, PA 19104-2688, (215) 382-9800, fax 215-386-7999, E-mail: siamconfs@wharton.upenn.edu.

International Committee for Coal Petrology 44th Meeting, July 20–24, 1992, University Park, Pennsylvania. Information: Alan Davis, Penn State University, 205 Research Bldg. E, University Park, PA 16802, (814) 865-6544, fax 814-865-3573.

Society for Organic Petrology, 9th Annual Meeting, July 23–24, 1992, University Park, Pennsylvania. Information: Jim Hower, Center for Applied Energy Research, 3572 Iron Works Pike, Lexington, KY 40511, (606) 257-0261, fax 606-257-0302.

Northeastern Science Foundation–History of Earth Sciences Society Meeting on the History of Geology, July 29–August 1, 1992, Troy, New York. Information: Gerald M. Friedman, Northeastern Science Foundation, P.O. Box 746, Troy, NY 12181-0746, (518) 273-3247, fax 518-273-3249.

August

XVII Congress of International Society for Photogrammetry and Remote Sensing, August 2–14, 1992, Washington, D.C. Information: XVII ISPRS. Congress Secretariat, P.O. Box 7147, Reston, VA 22091-7147, (703) 648-5110.

10th International Conference on Basement Tectonics, August 3–7, 1992, Duluth, Minnesota. Information: Richard Ojakangas, Dept. of Geology, University of Minnesota, Duluth, MN 55812, (218) 726-7238, fax 218-726-6360.

International Geographical Union 27th Congress, August 9–14, 1992, Washington, D.C. Information: IGU Congress Secretariat, 17th and M Streets, NW, Washington, DC 20036, (202) 828-6688.

13th Caribbean Geological Conference, August 10–14, 1992, Pinar del Rio, Cuba. Information: Grenville Draper, Florida International University, Geology Dept., University Park, Miami, FL 33199, (305) 348-3572, fax 305-348-3877, Bitnet: DRAPER@SERVAX.

Phanerozoic Basins of Southwestern Gondwana: Tectonics, Stratigraphy, and Seismic Expression, August 12–16, 1992, Santa Cruz, Bolivia. Information: Ramiro Suarez Soruco, Casilla 727, Santa Cruz, Bolivia, fax 591-3-34-6472; A. J. Tankard, Petro-Canada, P.O. Box 2844, Calgary, Alberta, T2P 3E3, Canada, (403) 296-5808, fax 403-296-5875.

Second International Conference on Asian Marine Geology, August 19–22, 1992, Tokyo, Japan. Information: Shin'ichi Kuramoto, Ocean Research Institute, University of Tokyo, 1-15-1, Minamidai, Nakano-ku, Tokyo, 164 Japan, phone 03-3376-1251, fax 03-3375-6716, telex 25607/ORIUT, E-mail: kuramoto@tansei.-cc.u-tokyo.ac.jp *or* kuramoto@jpnoriut.-bitnet.

29th International Geological Congress, August 24–September 3, 1992, Kyoto, Japan. Information: Secretary General, IGC-92 Office, P.O. Box 65, Tsukuba, Ibaraki 305, Japan, phone 81-298-54-3627, fax 81-298-54-3629, telex 3652511 GSJ J.

GeoTech '92—Geocomputing Conference, August 29–September 1, 1992, Denver, Colorado. Information: Mark Cramer, GeoTech, Contract Station 19, P.O. Box 207, Denver, CO 80231-4952, (303) 752-4951, fax 303-752-4979.

IAS/SEPM Research Conference on Carbonate Stratigraphic Sequences: Sequence Boundaries and Associated Facies (Emphasis on Outcrop and Processes Studies), August 30–September 3, 1992, La Seu, Spain. Information: Toni Simo, Dept. Geology and Geophysics, University of Wisconsin, 1215 W. Dayton St., Madison, WI 53706, (608) 262-5987, fax 608-262-0693, E-mail: simo@geology.wisc.edu; Mark Harris, Dept. Geosciences, University of Wisconsin, P.O. Box 413, Milwaukee, WI 53201, (414) 229-5452; Evan Franseen, Kansas Geological Survey, 1930 Constant Ave., Lawrence, KS 66047, (913) 864-5317.

International Conference on Large Meteorite Impacts and Planetary Evolution, August 31–September 2, 1992, Sudbury, Ontario, Canada. Information: B. O. Dressler, Ontario Geological Survey, 77 Grenville St., 9th Floor, Toronto, Ontario M7A 1W4, Canada, (416) 965-7046, fax 416-324-4933.

September

International Conference on Arctic Margins, September 2–4, 1992, Anchorage, Alaska. Information: David Steffy or Dennis Thurston, U.S. Minerals Management Service, 949 E. 36th Ave., Anchorage, AK 99508, (907) 271-6553, fax 907-271-6805.

5th International Symposium on Seismic Reflection Profiling of the Continental Lithosphere, September 6–12, 1992, Banff, Alberta, Canada. Information: R. M. Clowes, Lithoprobe Secretariat, 6339 Stores Road, University of British Columbia, Vancouver, BC V6T 1Z4, Canada, (604) 822-4202, fax 604-822-6958; A. G. Green, Geolgical Survey of Canada, 1 Observatory Crescent, Ottawa, Ontario K1A 0Y3, Canada, fax 613-992-8836.

International Symposium on the Geology of the Black Sea Region, September 7–11, 1992, Ankara, Turkey. Information: ISGB Sekreterliği, MTA Genel Müdürlüğü, 06520 Ankara, Türkiye, phone (90)-(4)-223 69 27, fax 90-(4)-222 82 78.

The Transition from Basalt to Metabasalt: Environments, Processes, and Petrogenesis, September 9–15, 1992, Davis, California. Information: Peter Schiffman, Dept. of Geology, University of California, Davis, CA 95616, (916) 752-3669, E-mail: PSchiffman@UCDavis.edu.

Association for Women Geoscientists, 2nd National Convention, September 11–13, 1992, Denver, Colorado. Information: Pam Goode, 6103 Alkire Ct., Arvada, CO 80004, (303) 424-2045.

3rd International Conference on Plasma Source Mass Spectrometry, September 13–18, 1992, Durham, England. Information: Grenville Holland, Dept. of Geological Sciences, The University Science Laboratories, South Road, Durham DH1 3LE, England, phone 091-374-2526.

Federation of Analytical Chemistry and Spectroscopy Societies Annual Meeting, September 20–25, 1992, Philadelphia, Pennsylvania. Infomation: FACSS, P.O. Box 278, Manhattan, KS 66502, (301) 846-4797.

4th International Conference on Paleoceanography, September 21–25, 1992, Kiel, Germany. Information: ICP IV Organizing Committee c/o GEOMAR, Wischhofstrasse 1-3/Bldg. 4, D-2300 Kiel 14, Germany.

23rd Annual Binghamton Geomorphology Symposium: Geomorphic Systems, September 25–27, 1992, Oxford, Ohio. Information: Bill Renwick, Dept. of Geography, Miami University, Oxford, OH 45056, (513) 529-1362, E-mail: BRENWICK@MIAMIU.BITNET; Jonathan Phillips, Dept. of Geography, East Carolina University, Greenville, NC 27858, (919) 757-6082, E-mail: GEPHILLI@ECUVM1.BITNET.

Underwater Mining Institute, Washington, D.C., September 27–30, 1992. Information: Charles Morgan, University of Hawaii, Look Laboratory, 811 Olomehani St., Honolulu, HI 96813-5513, (808) 522-5611, fax 808-522-5618.

American Institute of Professional Geologists Annual Meeting, September 27–October 1, 1992, Lake Tahoe, Nevada. Information: Jon Price, AIPG, P.O. Box 665, Carson City, NV 89702, (702) 784-6691.

October

Association of Engineering Geologists, Annual Meeting, October 2–9, 1992, Long Beach, California. Information: John W. Byer, 444 "A" East Broadway, Glendale, CA 91205, (818) 549-9959, fax 818-242-2442.

SEPM Midcontinent Section Annual Meeting: Paleosols, Paleoweathering Surfaces and Sequence Boundaries, October 9–11, 1992, Knoxville, Tennessee. Information: Steven G. Driese, Dept. of Geological Sciences, University of Tennessee, Knoxville, TN 37996-1410, (615) 974-2366, fax 616-974-2368.

2nd International Congress on Energy, Environment and Technological Innovation, October 12–16, 1992, Rome, Italy. Information: Secretaria CPA: Comisión de Promoción Académica, Facultad de Ingeniería, Universidad Central de Venezuela, Edif. Decanato, Caracas 1050, Venezuela, phone 58-2-6627538/7612, fax 58-2-6627327.

Seismological Society of America, Eastern Section Annual Meeting, October 14–16, 1992, Richmond, Virginia. Information: John Filson or Henry Spall, U.S. Geological Survey, 904 National Center, Reston, VA 22092, (703) 648-6078. (*Abstract deadline: September 11, 1992.*)

American Institute of Hydrology Conference: Interdisciplinary Approaches in Hydrology and Hydrogeology, October 17–22, 1992, Portland, Oregon. Information: AIH, 3416 University Ave. SE, Minneapolis, MN 55414-3328, (612) 379-1030.

Gulf Coast Association of Geological Societies and Gulf Coast Section of SEPM, Joint Annual Convention, October 21–23, 1992, Jackson, Mississippi. Information: Cragin Knox, GCAGS Convention 1992, P.O. Box 2474, Jackson, Mississippi 39225-2474.

Geological Society of America Annual Meeting, October 26–29, 1992, Cincinnati, Ohio. Information: GSA, Meetings Dept., P.O. Box 9140, Boulder, CO 80301, (303) 447-2020, fax 303-447-1133. (*Abstract deadline: July 8, 1992.*)

Geological Association of New Jersey 9th Annual Meeting and Field Trip, October 30–31, 1992, New Brunswick, New Jersey. Information: Howard Parish, Jersey City State College, 2039 Kennedy Blvd., Jersey City, NJ 07305, (201) 200-3164, fax 201-200-2298.

November

28th Annual Conference and Symposia: Managing Water Resources During Global Change, November 1–5, 1992, Reno, Nevada. Information: Raymond Herrmann, NPS, WR-CPSU, WRD, Colorado State University, Ft. Collins, CO 80523, (303) 491-7825.

Joint Meeting of the Clay Minerals Society and the Soil Science Society of America, November 1–6, 1992, Minneapolis, Minnesota. Information: Jerry Bigham, Dept. of Agronomy, Ohio State University, Columbus, OH 43210, (614) 292-2001.

14th New Zealand Geothermal Workshop, November 4–6, 1992, Auckland, New Zealand. Information: 4th New Zealand Geothermal Workshop, The University of Auckland, Private Bag 92019, Auckland, New Zealand, fax 64-9-373-7419. (*Abstract deadline: July 3, 1992.*)

Eastern Oil Shale Symposium, November 18–20, 1992, Lexington, Kentucky. Information: Geaunita H. Caylor, Coordinator, University of Kentucky/OISTL, 643 Maxwelton Court, Lexington, KY 40506-0350, (606) 257-2820, fax 606-258-1049.

Geological Society of New Zealand and New Zealand Geophysical Society Joint Annual Conference, November 23–27, 1992, Christchurch, New Zealand. Information: David Shelley, Dept. of Geology, University of Canterbury, Christchurch 1, New Zealand, phone 64-3-667-001, fax 64-3-642-769.

December

■ **IGCP Project 274 Annual Meeting—Coastal Evolution in the Quaternary**, December 7–15, 1992, Wellington, New Zealand. Information: Alan Hull, DSIR Geology & Geophysics, P.O. Box 30-368, Lower Hutt, New Zealand, +64(4) 569-9059, fax +64(4) 566-6168, E-mail: srlnagh@lhn.geo.dsir.govt.NZ. (*Abstract deadline: October 1, 1992.*)

1993 Meetings

February

Ninth Thematic Conference, Geologic Remote Sensing—Exploration, Environment, and Engineering, February 8–11, 1993, Pasadena, California. Information: ERIM/Thematic Conferences, Nancy J. Wallman, P.O. Box 134001, Ann Arbor, MI 48113-4001, (313) 994-1200, ext. 3234, fax 313-994-5123. (*Abstract deadline: June 8, 1992.*)

March

■ **GSA South-Central Section Meeting**, March 15–16, 1993, Fort Worth, Texas. Information: John Breyer, Dept. of Geology, Texas Christian University, Fort Worth, TX 76129, (817) 921-7270.

■ **GSA Northeastern Section Meeting**, March 22–24, 1993, Burlington, Vermont. Information: Vanessa George, P.O. Box 9140, Boulder, CO 80301, (303) 447-2020.

Fluvial-Dominated Deltaic Reservoirs in the Southern Midcontinent, March 23–24, 1993, Norman, Oklahoma. Information: Kenneth S. Johnson, Oklahoma Geological Survey, University of Oklahoma, 100 East Boyd, Rm. N-131, Norman, OK 73019, (405) 325-3031.

■ **GSA North-Central Section Meeting**, March 29–30, 1993, Rolla, Missouri. Information: Richard Hagni, Dept. of Geology and Geophysics, University of Missouri, Rolla, MO 65401, (314) 341-4616.

April

■ **GSA Southeastern Section Meeting**, April 1–2, 1993, Tallahassee, Florida. Information: James Tull, Dept. of Geology, Florida State University, Tallahassee, FL 32306, (904) 644-1448.

■ **25th International Symposium on Remote Sensing and Global Environmental Change**, April 4–8, 1993, Graz, Austria. Information: Dorothy M. Humphrey, ERIM, P.O. Box 134001, Ann Arbor, MI 48113-4001, (313) 994-1200, ext. 2290, fax 313-994-5123.

Integrated Methods in Exploration and Discovery, April 17–20, 1993, Denver, Colorado. Information: SEG Conference '93, P.O. Box 571, Golden, CO 80402.

Canadian Quaternary Association (CANQUA), April 17–21, 1993, Victoria, British Columbia, Canada. Information: Environmental Geology Section, BC Geological Survey Branch, 553 Superior Street, Victoria, British Columbia, V8V 1X4, Canada, (604) 387-6249, fax 604-356-8153.

International Conference on Geoscience Education and Training, April 21–25, 1993, Southampton, England. Information: Dorrik A.V. Stow or Esther Johnson, Dept. of Geology, University of Southampton, Southampton, SO9 5NH, England, phone 0703-593049, fax 0703-593052, telex: 47662 SOTONU G.

May

■ **GSA Cordilleran/Rocky Mountain Section Meeting**, May 19–21, 1993, Reno, Nevada. Information: Vanessa George, P.O. Box 9140, Boulder, CO 80301, (303) 447-2020.

International Basin Tectonics and Hydrocarbon Accumulation Conference, May 25–June 15, 1993, Nanjing, People's Republic of China. Information: David Howell, U.S. Geological Survey, 345 Middlefield Road, MS 902, Menlo Park, CA 94025, (415) 354-5430, fax 415-354-3224.

■ **Field Conference and GIS Workshop, INQUA Commission on Formation and Properties of Glacial Deposits: Work Groups on Glacial Tectonics and Mapping Glacial Deposits**, mid-May, 1993, Regina, Saskatchewan, Canada. Information: D. J. Sauchyn, Dept. of Geography, University of Regina, Regina, Saskatchewan, S4S 0A2 Canada, (306) 585-4030, fax 306-585-4815; or J. S. Aber, Earth Science, Emporia State University, Emporia, KS 66801, (316) 341-5981, fax 316-341-5997. (*Manuscript deadline: June 1, 1992; abstract deadline: February 1, 1993.*)

June

34th U.S. Symposium on Rock Mechanics, June 27–30, 1993, Madison, Wisconsin. Information: Bezalel C. Haimson, Dept. of Materials Science and Engineering, 1509 University Avenue, Madison, WI 53706, (608) 262-2563, fax 608-262-8353, E-Mail: haimson-@macc.wisc.edu.

July

5th International Conference on Fluvial Sedimentology, July 5–9, 1993, Brisbane, Australia. Information: Continuing Professional Education, The University of Queensland, Queensland 4072, Australia, phone +61-7-365 7100, fax +61-7-365 7099, telex UNIVQLD AA40315.

Send notices of meetings of general interest, in format above, to Editor, *GSA Today*, P.O. Box 9140, Boulder, CO 80301.

GSA Southeastern Section Offers Education-oriented Mini Grants

In response to a request from the Education Committee, the Southeastern Section GSA Management Board has allocated $1000 per year for two years as seed money for educational projects in the southeastern states featuring GSA involvement. Projects may target either grades K–12 or college-level students and/or teachers. The maximum allocation per project is $250. A request for a mini grant is judged on how well the project meets the SAGE (Science Awareness through Geoscience Education) objectives adopted by the Geological Society of America. Preference will be given to projects that involve teachers and/or students in hands-on activities and include some follow-up partnerships. A workshop format is more likely to receive funding than a field trip format, although combination projects will receive full consideration. Funds will not be awarded for travel expenses or stipends.

Only members of the Southeastern Section of the Geological Society of America are eligible for competition. Proposals for projects through spring 1993, must be received by *August 1, 1992.* Proposals for projects through spring 1994, must be received by *March 1, 1993.*

For further information and a list of proposal guidelines, please write to John R. Wagner, Chair, SE GSA Education Committee, Dept. of Earth Sciences, Clemson University, Clemson, SC 29634-1908.

GSA ANNUAL MEETINGS

CINCINNATI
THE VOYAGE CONTINUES
From Columbus to Magellan

■ 1992

GSA Annual Meeting, Cincinnati, Ohio
Cincinnati Convention Center, October 26–29

General co-chairmen: Raphael Unrug and J. Barry Maynard

Field trip chairmen: Thomas Berg and John Rupp

Technical Program chairmen: Nicholas Rast and Roy Kepferle

For information call the GSA Meetings Department, (303) 447-2020

■ 1993

GSA Annual Meeting, Boston, Massachusetts
Hynes Convention Center, October 25–28

Chairman: James W. Skehan, S. J., Boston College

Call for Field Trip Proposals: Please contact the field trip chairmen listed below.

John T. Cheney	J. Christopher Hepburn
Dept. of Geology	Dept. of Geology and Geophysics
Amherst College	Boston College
Amherst, MA 01002	Chestnut Hill, MA 02193
(413) 542-2233 (Dept.)	(617) 552-3640 (Dept.)

For information call the GSA Meetings Department, (303) 447-2020.

■ FUTURE

Boston .... October 25–28 1993
Seattle .... October 24–27 1994
New Orleans ..... November 6–9 1995
Denver .... October 28–31 1996

For general information on technical program participation (1992 or beyond) contact: Sue Beggs, Meetings Manager, GSA headquarters.

GSA SECTION MEETINGS

■ 1993

South-Central	March 15–16	Texas Christian University, Fort Worth, Texas
Northeastern	March 22–24	Sheraton Inn Conference Center, Burlington, Vermont
North-Central	March 29–30	University of Missouri, Rolla, Missouri
Southeastern	April 1–2	Florida State Conference Center, Tallahassee, Florida
Cordilleran/Rocky Mountain	May 19–21	University of Nevada, Reno, Nevada

June *BULLETIN* and *GEOLOGY* Contents

The Geological Society of America
BULLETIN
Volume 104, Number 6, June 1992

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NO. 6
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JUNE 1992

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Geology Department UPNG, has vacancies for Lecturer/Snr Lecturer in (a) Clastic Sedimentology and Stratigraphy and (b) Geophysics. 6 wks ann. leave. Return airfares to point of recruitment after 18 mo. Salary Lec K26000-29000; Snr Lec K29000-37000 plus gratuity = 25% of all earnings upon completion of contract. PNGK = 1.04USD. Housing provided on campus. Contact Hugh Davies for info by 31 Jul 92: fax 675-267187, ph 675-260268, mail Geology UPNG, University NCD, PNG.

THE UNIVERSITY OF NORTH TEXAS

The Department of Geography is seeking an Earth Scientist/Physical Geographer for a tenure-track Assistant Professor position (Ph.D. preferred at time of appointment). Individual must be qualified to teach introductory physical and historical geology and earth science courses in addition to upper division courses in specialty areas. Interests in environmental geology, hydrologic processes, and GIS/remote sensing applications highly desirable. Successful applicant must have proven teaching and research experience, strong potential to secure external funding, and willingness to participate in interdisciplinary research projects. Salary competitive. Send letter of interest, vitae, transcripts and names of three referees by June 15, 1992. The University of North Texas is a rapidly emerging, nationally recognized research institution. UNT is an AA/EEO employer; minorities and women encouraged to apply.

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Opportunities for Students

Master of Geology, University of Sonora at Hermosillo, Sonora, Mexico. The Department of Geology at the University of Sonora invites applications from students holding a Bachelor degree to its Master in Science program with main emphasis on: ore deposits of Northwestern Mexico, cartography and structural analysis, regional tectonic studies.

This is a good opportunity of get familiar with the exploration of ore deposits in the region and to learn Spanish. The Department has working connections with several countries and an international teaching corpus. Applicants should submit a curriculum vitae. Accepted students who are not fluent in Spanish are advised to plan a two month period in Hermosillo prior to classes. More information: Department of Geology, University of Sonora, P.O. Box 7386, Nogales, AZ 85628.

Abstract Forms Available Now

THE VOYAGE CONTINUES

From Columbus to Magellan

GSA
ANNUAL MEETING
OCTOBER 26–29, 1992
CINCINNATI, OHIO

Abstracts Deadline:
July 8

Abstracts must be typed on 1992 Abstract Forms, available from the Abstracts Coordinator, Geological Society of America, P.O. Box 9140, Boulder, CO 80301, or call (303) 447-8850. Volunteered abstracts must be mailed to the same address in time to arrive on or before July 8, 1992.

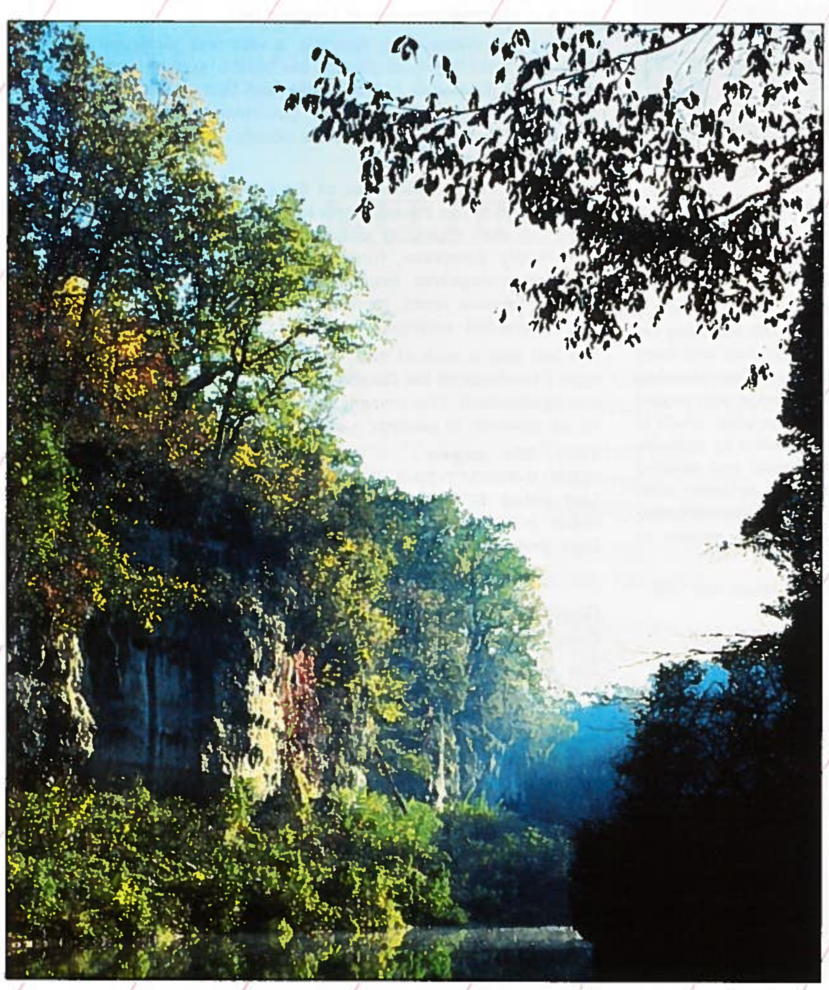

Photo courtesy of Tomi Lou Spyker

CINCINNATI

GSA Officer and Councilor Nominees for 1993

Council announces the following officer and councilor candidates. Voting members will receive biographical information on all candidates with the ballot to be mailed in August.

For Councilor (1993–1994) and President (1993)
Robert D. Hatcher, Jr.; Knoxville, Tennessee

For Councilor and Vice-President (1993)
William R. Dickinson; Tucson, Arizona

For Councilor and Treasurer (1993)
David E. Dunn; Richardson, Texas

For Councilor (1993–1995)—Position 1
Gail M. Ashley; Piscataway, New Jersey
Franklin W. Schwartz; Columbus, Ohio

For Councilor (1993–1995)—Position 2
Anthony J. Naldrett; Toronto, Ontario, Canada
Sigmund Snelson; Houston, Texas

For Councilor (1993–1995)—Position 3
Darrel S. Cowan; Seattle, Washington
Sharon Mosher; Austin, Texas

For Councilor (1993–1995)—Position 4
Kevin Burke; Washington, D.C.
Mark Cloos; Austin, Texas

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