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INSIDE

180 Million Years of Subduction

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ABSTRACT

A compilation of lithosphere consumed globally in the past 180 m.y. reveals that the equivalent of the surface area of Earth has descended into the mantle, producing "lithospheric graveyards." Not evenly distributed, this subducted lithosphere lies concentrated in areas of cold mantle that correspond to gross mantle heterogeneities delineated by seismic tomography and the geoid and inversely related to the global distribution of hotspots. Some convergent margins (e.g., North American continent) show subducted lithosphere distributed over a large region beneath the land mass while others (e.g., eastern Eurasia) show an accumulation of up to 18 subducted lithospheric thicknesses in a narrow region. Differences in graveyard distribution result from displacements of trenches (assumed nearly fixed to the overriding plates) over the mantle: North America, South America, Africa, and southeastern Eurasia each advanced toward and perpendicular to their trenches by approximately 4000, 3000, 2700, and 1000 km, respectively between 150 Ma and the present. In contrast, eastern Eurasia (near Japan) first retreated by approximately 1200 km until 80 Ma and then advanced an equivalent distance to the present.

Net convergence at selected subduction zones also shows variability: in the past 150 m.y., approximately 13 000 km of lithosphere descended into the Japan and western North American trenches, approximately 8000 km under the central Andes and Himalayan regions, and about 1000 km of convergence was accommodated by the western Alps. Such extreme differences in kinematic histories may help explain contrasting orogenic styles. It appears that a large amount of convergence is not a necessary condition for orogeny (western Alps) nor is it sufficient (eastern Eurasia), whereas significant trench advance may be both necessary and sufficient, especially when the plate interaction involves at least one continent.

Previous workers have shown that a decrease in global spreading rates (based on estimating the geometry and spreading history of ridges for the past 80 m.y.) is the primary cause of a volume decrease in mid-ocean ridges and is consistent with a corresponding lowering of eustatic sea level during this time interval. We present an extension of this hypothesis to the past 180 m.y. by using our rates of global lithospheric consumption to estimate total global spreading and calculate the inferred changes in mid-ocean ridge volumes. Changes in global spreading rates do not affect the age distribution within the oceans instantaneously, because it takes a finite amount of time for significant amounts of oceanic crust to be replaced: an approximate 30 m.y. lag time is noted between first-order changes in global spreading rates and eustatic sea level. A simple model that predicts eustatic sea level using global spreading rates is in good agreement with the observed sea-level curve, especially after 120 Ma. A noted misfit in predicted and observed eustatic sea level prior to 120 Ma may indicate a long period of slow global spreading before 120 Ma. This may reflect rising mantle temperatures, consistent with a recently proposed dynamic-convection model.

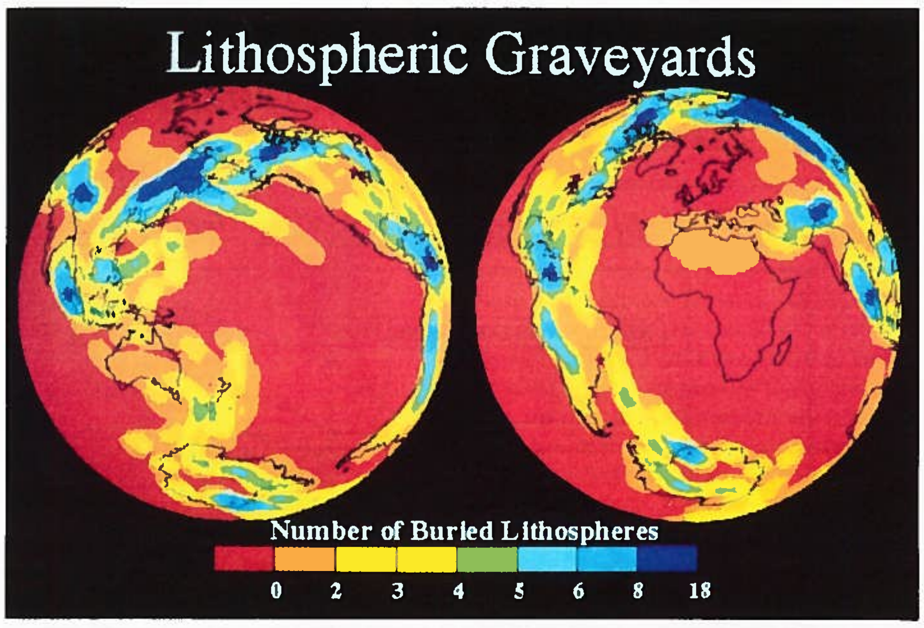

Figure 1. Locations of lithosphere subducted globally for the past 180 m.y. Dark blue areas represent the location of greater than 8, and as much as 18, km^2 of subducted lithosphere per km^2 of Earth surface area. A convenient way to interpret these values would be that *n* oceanic lithospheres were subducted below the colored areas. Red areas are locations where no plate has been subducted within this time interval. (a) Equal-area polar projection centered at lat 0°N and long 180°E; (b) Equal-area polar projection centered at lat 0°N and long 0°E.

TABLE 1. SOURCES FOR THE RECONSTRUCTION

Plate pair*	Time (Ma) From	To	Reference
PA-HS	142	0	Henderson et al. (1984)
AF-HS	180	0	Morgan (1983)
AF-NA	3	0	DeMets et al. (1990)
AF-NA	180	3	Klitgord and Schouten (1986)
EU-NA	3	0	DeMets et al. (1990)
EU-NA	105	3	Srivastava and Tapscott (1986)
AF-SA	3	0	DeMets et al. (1990)
AF-SA	133	3	Cande et al. (1988)
PA-FA	21	0	Wilson (1988)
PA-FA	180	21	Engebretson et al. (1984)
PA-KU	85	43	Engebretson et al. (1984)
PA-IZ	180	85	Engebretson et al. (1984)
PA-PH	180	115	Engebretson et al. (1984)
AN-AF	3	0	DeMets et al. (1990)
AN-AF	142	3	Molnar et al. (1988)
AU-AN	3	0	DeMets et al. (1990)
AU-AN	95	3	Stock and Molnar (1988)
IN-AF	3	0	Stock and Molnar (1988)
IN-AF	142	3	Molnar et al. (1988)
AU-NI	95	0	Weissel and Hayes (1977)
PA-NZ	3	0	DeMets et al. (1990)
PA-NZ	84	3	Pardo-Casas and Molnar (1987)
PA-NZ	180	84	Engebretson et al. (1984)

* PA: Pacific; HS: Hotspots; AF: Africa; NA: North America; EU: Eurasia; KU: Kula; IZ: Izanagi; PH: Phoenix; AN: Antarctica; AU: Australia; IN: India; NI: North Island, New Zealand; NZ: Nazca.

INTRODUCTION

Continued refinement of relative plate motions within the fixed-hotspot reference frame allows global subduction parameters to be estimated. Of prime interest is the area of lithosphere subducted annually (presented in km^2/yr) and the locations of this subducted lithosphere (referred to as lithospheric graveyards; Fig. 1). As proposed by Chase (1979), Chase and Sprowl (1983), and Richards et al. (1988), large regions containing previously subducted lithosphere should correlate with large-scale mantle heterogeneities. The relation between locations of subducted lithosphere and mantle heterogeneity was tested by Richards and Engebretson (1992) and is reviewed here.

Also of interest is the kinematic character of subduction zones in both the hotspot reference frame and in total convergence at plate boundaries. The distribution of lithospheric graveyards is a direct result of the prebreakup configuration of the subduction zones encircling Pangea, the subsequent migration of these convergent boundaries, and the net convergence at these boundaries. We selected five convergence zones and calculated the displacements over the hotspots of the overriding plates perpendicular to their boundaries and linear consumption of lithosphere descending into the mantle.

Given no net Earth expansion or contraction, calculation for the global accretion rate at oceanic ridges provides the opportunity to estimate the capacity of the world's ocean basins to hold sea water. Previous attempts were based on knowing the lengths and spreading histories of ridge systems (e.g., Pitman, 1978; Kominz, 1987) and covered the time period since 80 Ma. Our work is dependent upon knowing the geometry and plate interaction history at subduction zones, and we extend the analysis back to 180 Ma. Both methods share severe uncertainties that increase greatly as the time of interest is expanded. The methods presented here are preferred since the history of subduction is probably more completely recorded in the geologic record than past geometries of largely missing oceanic crust.

GLOBAL SUBDUCTION PARAMETERS

Finite rotations describing relative motions in the various ocean basins and between plates and hotspots given in Table 1, along with their sources, have been calibrated to the time scale of Kent and Gradstein (1986). It is beyond the scope of this paper to critically evaluate all sources of uncertainties in the model. Uncertainties grow with increasing reconstruction time such that results prior to about 150 Ma are highly speculative. Sources for errors include the fixity of hotspots (motions between Pacific and African hotspots), plate-to-hotspot motions (especially

Subduction *continued on p. 94*

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Subduction *continued from p. 93*

prior to 120 Ma), plate-to-plate displacements, plate geometries (with the possibility of missing entire plates, most notably during the early history of the Tethys), and the magnetic time scale. We experimented with end-member reconstructions and found a qualitative estimate for uncertainty in time-integrated motions to be about 20% at 100 Ma and 40% at 180 Ma.

To obtain amounts of subducted lithosphere, subduction zones were assigned to an overriding plate, digitized at their present locations and reconstructed to their former positions in a fixed-hotspot reference frame at 30 m.y. intervals. It was assumed that these convergence zones remained fixed relative to their overriding plates: we acknowledge that back-arc spreading and trench-polarity reversals introduce additional errors into the results. Critical decisions made about the location of the interacting plates were based primarily on the locations of plate boundaries within the oceans and to a lesser extent on known geologic histories. Stage poles of 5 m.y. duration that correspond to the relative motions along the length of convergence were used to calculate the area of subducted lithosphere. This area of lithosphere was then injected into the mantle at 700 km depth at a position inboard of the subduction zone, assuming a 45° dip in the down-going plate. A reasonable physical interpretation of this method would be that lithosphere descends into the mantle at the 45° angle until it reaches 700 km; it then descends vertically into the lower mantle. The process was repeated for each of the 30 m.y. intervals back to 180 Ma and compiled globally by summing the total area of plate residing within 10° circles centered at each 1° latitude and longitude intersection. These total amounts (lying within each of the 10° circles) were divided by the area of the circle to normalize the values to Earth surface area. Figure 1 shows total area of subducted lithosphere (per Earth area) at latitude and longitude intersections and can be interpreted to represent the number of lithospheres buried beneath each location.

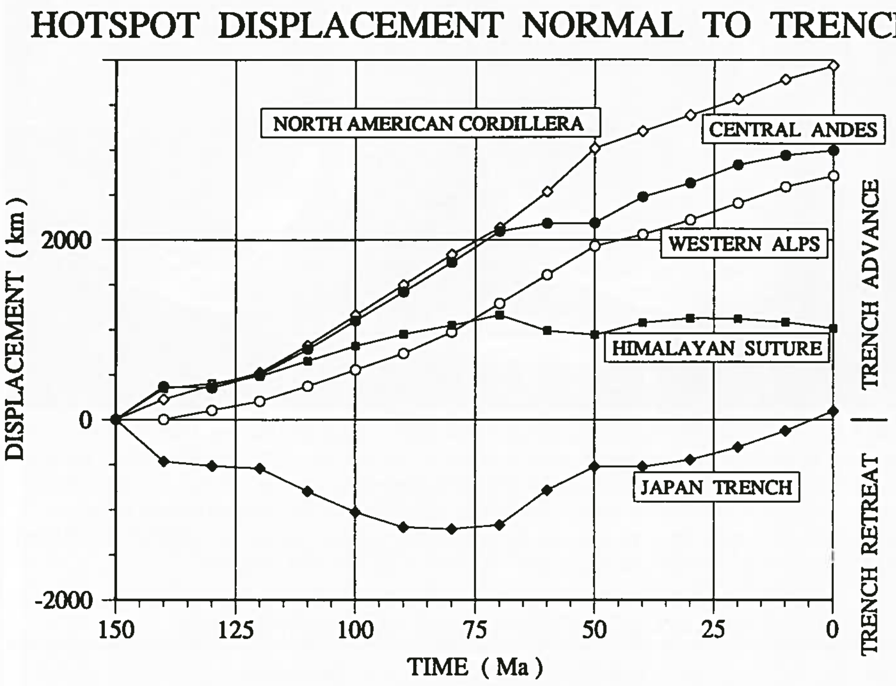

Figure 2. Components of total motion perpendicular to plate boundaries for overriding plates in the hotspot reference frame. Positive values (and slopes) represent advance of plate toward subduction zones; negative values (and slopes) show retreat. Analysis begins at 150 Ma because of the large uncertainties prior to this time. Site latitude, longitude, and trench azimuth are as follows: North American Cordillera—37°N, 236°E, 320°; central Andes—30°S, 289°E, 10°; Himalayan suture—33°N, 83°E, 270°; Japan Trench—35°N, 140°E, 205°; Western Alps—44°N, 10°E, 270°).

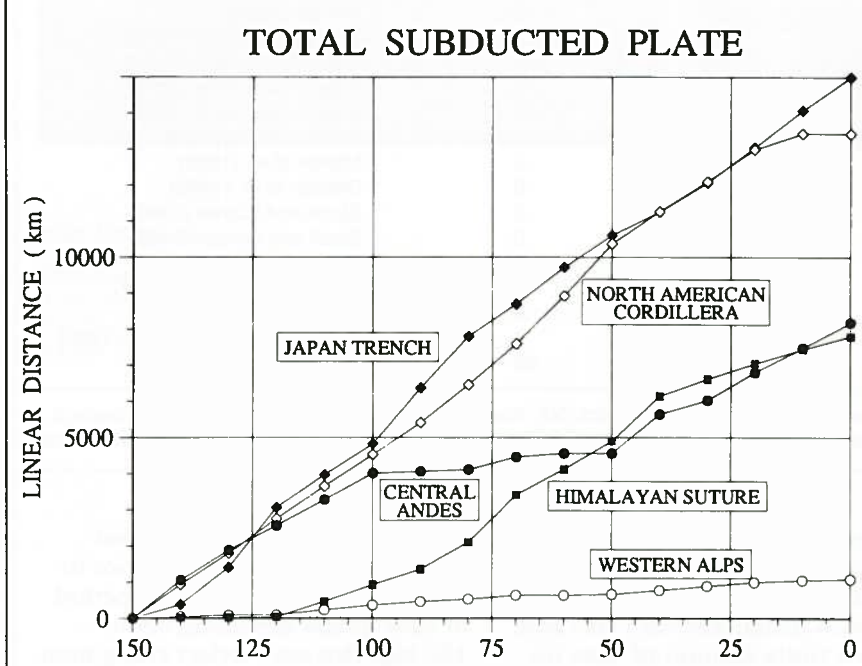

Figure 3. Total convergence perpendicular to trenches at selected sites. Amounts were calculated in a reference frame fixed to the overriding plate. Sites and azimuths are same as in Figure 2. Histories of plate interaction are as follows. North American Cordillera—Farallon 150–84 Ma, Kula 84–68 Ma, Farallon 68–10 Ma, Pacific 10–0 Ma; central Andes—Farallon 150–84 Ma, Nazca 84–0 Ma; Himalayan suture—India 150–0 Ma; Japan Trench—Izanagi 150–84 Ma, Pacific 84–0 Ma; Western Alps—Eurasia 150–0 Ma.

DISTRIBUTION OF LITHOSPHERIC GRAVEYARDS

Differences in graveyard size are the result of the 180 Ma location and subsequent migration of the overriding plate relative to the mantle (hotspots) and the total plate consumed at trenches. To investigate these relations, two kinematic compilations were made at five selected sites: the total component of displacement over the mantle normal to plate boundaries (Fig. 2), and the total amount of plate consumed (Fig. 3). For these analyses, we have restricted the treatment to post–150 Ma because of poorly determined reconstructions for the earlier record. Positive values in Figure 2 represent time-integrated motions of overriding plates advancing in the direction of their boundaries; negative values show retreat. Likewise, positive and negative slopes along the curves in Figure 2 represent rates of advance and retreat, respectively. To arrive at Figure 3, perpendicular components of subduction relative to the overriding plates (North America, South America, Eurasia, and Africa) were calculated by using the plate boundary azimuths given in the caption for Figure 2. Plate interaction histories are summarized in the caption for Figure 3.

Figures 1, 2, and 3 show the following patterns: both North America and South America advanced large distances toward their trenches (Fig. 2), thereby distributing subducted lithosphere beneath their land masses (Fig. 1), North America more so than South America. In contrast, Eurasia first retreated from the Japan Trench (between about 150 and 90 Ma) and then advanced to create the largest graveyard seen globally, a ratio of subducted plate area to Earth surface area of 18 (within the dark blue area near Japan). North America and Eurasia (near Japan) each consumed approximately 13 000 linear km of plate (Fig. 3). Near the Himalayan suture, Eurasia advanced trenchward approximately 1000 km between 150 and 75 Ma and then remained stationary (Fig. 2). In total plate consumed, Eurasia (near the Himalayan suture) and South America are similar (about 8000 km) but differ in their times of major convergence (see the pre—50 Ma curves in Fig. 3). Quite different is the kinematic history of Africa (near the western Alps) where approximately 2200 km of northward trench advance is seen since 150 Ma. Eurasia also moved northward but at a slower rate, resulting in a minimum of convergence for the sites studied (about 1000 km).

MANTLE HETEROGENEITY

Mantle heterogeneities (seen through lower mantle seismic velocities, the geoid, and global hotspot distribution; Fig. 4) have been attributed to long-term (100–200 Ma) global subduction (e.g., Chase, 1979; Chase and Sprowl, 1983; Davies, 1984; Richards et al., 1988; Anderson, 1989; Richards and Engebretson, 1992). Chase (1979) noted a qualitative correlation between a circum-Pacific band of geoid lows and post–125 Ma subduction. Davies (1984) suggested that large-scale mantle structure could lag behind rapidly changing plate boundary configurations and showed with simple convection models that the geoid could plausibly represent a thermal structure developed in the Mesozoic or earlier. Similar thermal effects from subduction encircling Pangea were discussed by Anderson (1989). Richards et al. (1988) showed that the effect of cold subducted slabs from the Cenozoic and Mesozoic was, in principle, sufficient to explain the lower mantle degree-2 seismic velocity structure as well as the geoid. Thus, they hypothesized that the amount and location of lithosphere subducted over the past 100–200 m.y. might explain the observed large-scale structure of convection. This assumes, implicitly, that mid-ocean ridges are passive structures and that mantle heterogeneity is primarily the result of subduction. This hypothesis was supported by Richards and Engebretson (1992), using the relative motion model outlined here.

Figure 4 (from top to bottom) shows the general agreement found between the largest wavelengths (10 000–20 000 km) of the time-integrated flux of subducted slabs since 120 Ma, lower mantle seismic structure, residual geoid, and global hotspot distribution. The main conclusion of Richards and Engebretson (1992) was that there is a dynamically reasonable relation between plate tectonics and large-scale mantle convection—the deep mantle is cold where there has been subduction. Implicit in this work is the assumption that horizontal motions in the deep mantle are much slower than in the upper mantle. This is justified by the fact that hotspots, which presumably result from deep mantle plumes, exhibit relative motions that are much slower than relative plate motions. Therefore, we feel justified in ignoring horizontal motions of subducted slabs after they enter the lower mantle, although they probably continue to descend (nearly vertically).

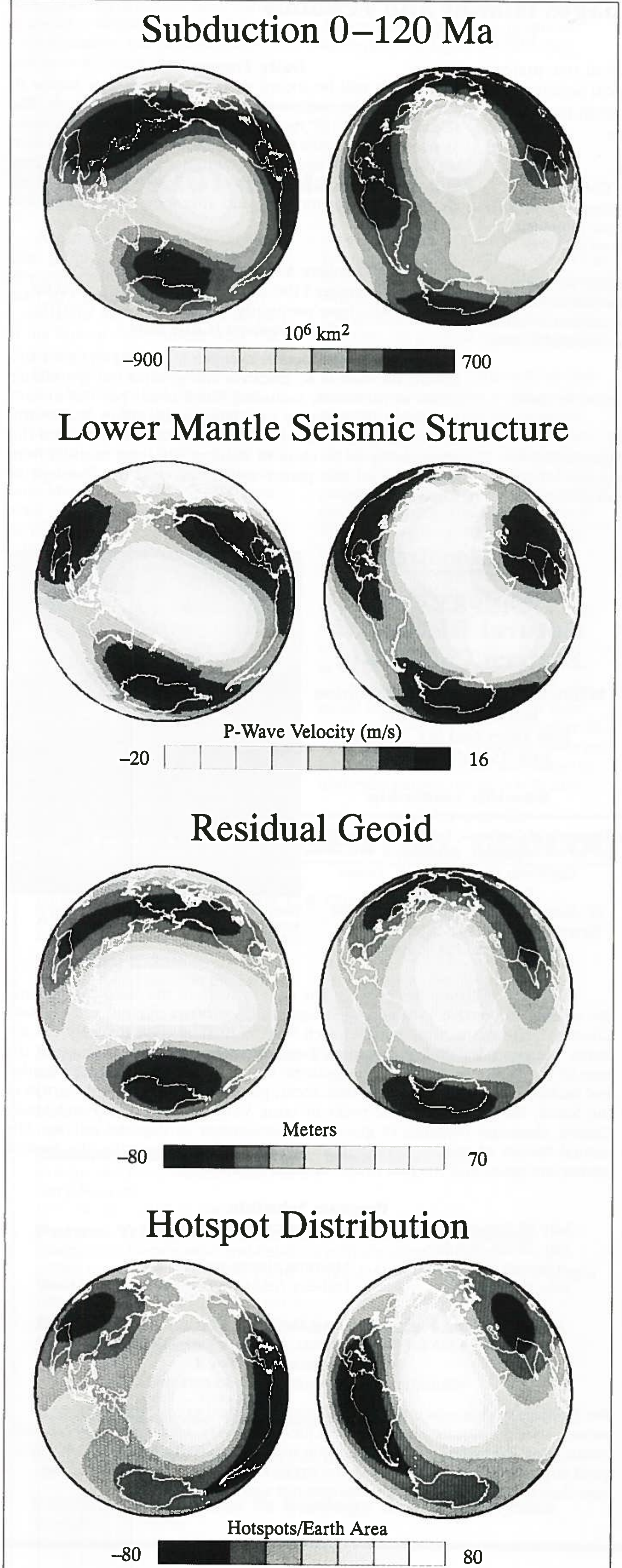

Figure 4. Comparison (from top to bottom) of spherical harmonic components (L = 2,3) of: time-integrated flux of subducted slabs since 120 Ma calculated in the hotspot fixed reference frame (Richards and Engebretson, 1992); lower mantle seismic velocity model of Dziewonski (1984); observed geoid of Lerch et al. (1983) corrected for hydrostatic figure (Nakiboglu, 1982) and upper-mantle slab signal (Hager, 1984); and hotspot distribution (Richards et al., 1988). Projections same as in Figure 1.

ACCRETION RATES AND SEA LEVEL

During periods of rapid seafloor spreading, young (hot) ocean floor displaces older (cold) parts of the seafloor, causing the volume of the world's ocean basins to decrease (Pitman, 1978). Gurnis (1990) has questioned this relation by pointing out that the effect of increased spreading rates is to increase the amount of cold lithosphere injected into the mantle, significantly changing the deep thermal structure under oceans and continents. Increased injection of cold lithosphere reduces the volume of sublithospheric mantle, causing the volume of the ocean basins to increase, most notably when subduction occurs within the ocean basins.

The primary difference between the dynamic-convection model (Gurnis, 1990) and the lithosphere-subsidence model (Pitman, 1978) occurs about 100 m.y. after a significant change in spreading from steady spreading rates (Fig. 2 in Gurnis, 1990). Hager (1980) presented a dynamical model in which sea level could either rise or fall with increased spreading. If lithospheric slabs are primarily injected into mantle beneath the oceans, the overriding plate is pulled down, which increases the volume of the oceans and lowers sea level; if slabs are primarily subducted beneath continents, the local effect is to pull down the continent and locally produce a sea-level rise. Sea level will rise or fall according to increased or decreased spreading only when subcontinental and suboceanic mantles are cooled equally by subducted lithosphere (Hager, 1980). We will return to these discussions after presenting our attempt to model sea level using only the lithospheric-subsidence model.

Previous estimates for the effect of variations in global spreading rates (e.g., Pitman, 1978; Kominz, 1987) have focused on knowing the lengths and spreading rates of all the world's ridge systems. In contrast, the method used here infers spreading rates from global subduction rates. Global spreading rates were derived by summing the total area of subducted lithosphere through 5 m.y. time intervals (Fig. 5). Interestingly, the grand total of subducted lithosphere (area under curve in Fig. 5) is approximately 525×10^6 km², nearly equal to the surface area of Earth. Included in Figure 5 is eustatic sea level (Haq et al., 1987) averaged through a 10 m.y. running window. Note the approximate 30 m.y. lag time between greatest accretion rate and highest sea level (dashed line in Fig. 5).

Pitman (1978) and Kominz (1987) have demonstrated the importance that spreading rates have in regard to changes in sea level by estimating the lengths and spreading rates of ridges, calculating ridge bathymetry from the age-depth relation (Sclater et al., 1971; Parsons and Sclater, 1977), and interpreting corresponding volume changes assuming they knew the shape and size of the ocean basins being filled or drained. General agreement between their work and estimates of eustatic sea level from seismic stratigraphy (e.g., Vail et al., 1977; Haq et al., 1987) support a causal relation. Kominz (1987) presented the most complete analysis of these relations to date, analyzed sources of error, produced several reconstruction stages estimating ridge volumes, and showed that the primary cause of a decrease in ridge volume since the Late Cretaceous was a decrease in spreading rates. Kominz (1987) noted that ridges within the Pacific basin dominate the results; several important discrepancies in ridge geometries exist between Kominz's (1987) work and our own (Engebretson et al., 1984, 1985). Whereas the work of Kominz (1987) was an excellent attempt at a difficult problem, some improvements are possible given that there are new reconstructions available for nearly all plate pairs and improved reconstructions for the hotspot reference frame. Moreover, by reconstruction of the subduction history we were able to extend the analysis back to 180 Ma. Results back to 120 Ma are reasonably successful; poor agreement (Fig. 6) is seen between 180 and 120 Ma, presumably due either to our inability to decipher earlier plate displacements or to processes involved in the dynamic-convection model.

Subduction *continued on p. 100*

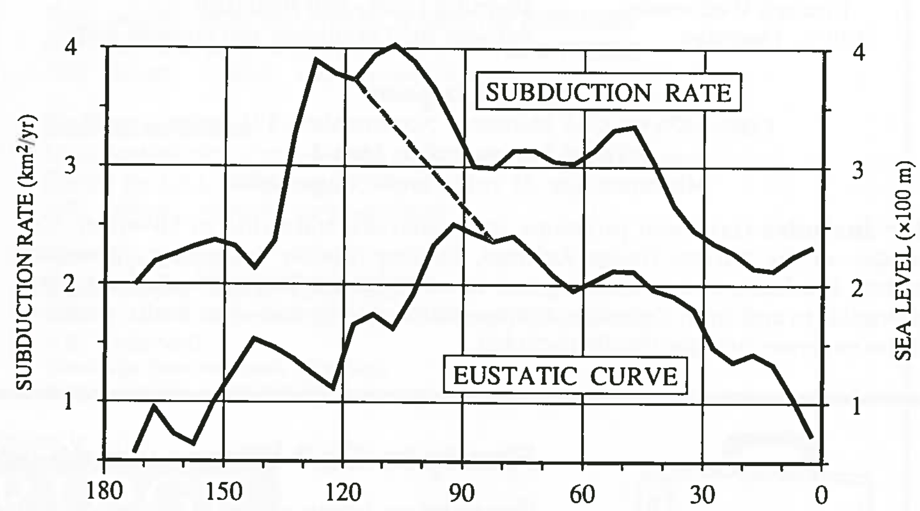

Figure 5. Subduction rate vs. time (upper curve) and the eustatic sea-level curve of Haq et al. (1987). Both curves have been smoothed with a 10 m.y. running window. Dashed curve shows approximate 30 m.y. lag time between maximum spreading rates and highest sea level.

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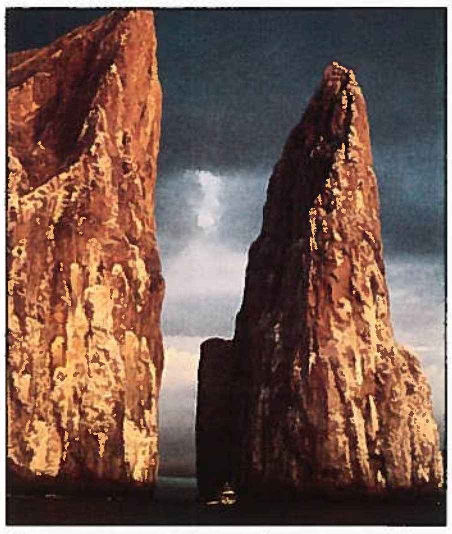

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Program Schedule

July 5 .... Depart Miami, arrive in Quito, Ecuador
July 6 .... Ecuador itinerary
July 7–14 .... Explore the Galápagos Islands
July 15 .... Return to Ecuador and Miami or begin the next adventure

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Exploration will be aboard the *new*, 34-passenger *Isabela II*, one of the most comfortable ships serving these islands. The air-conditioned, 162' motorboat provides comfort and convenience with all cabins facing outside and having twin or double beds (no bunk beds). Each cabin has a private bath. Three full, excellent meals are served daily. A skiff takes small groups ashore for morning and afternoon field exploration on the islands.

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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

Animas River Valley and Narrow Gauge Train, Silverton, Colorado. *Courtesy of Ken Kolm*

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: May 1
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.

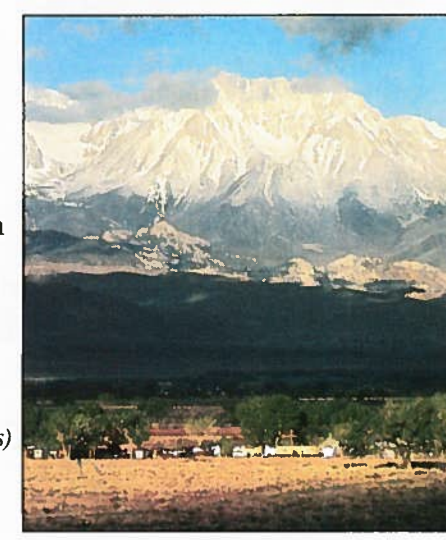
GSA GEOHOSTEL

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 and Steven R. Lipshie, Los Angeles County, Department of Public Works



White Mountains, Bishop, California. *Courtesy of White Mountain Research Station*

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.

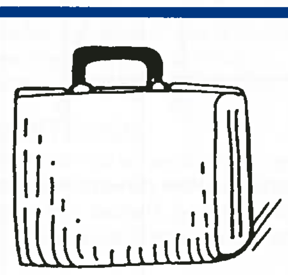
Program Schedule

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: May 1
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.



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WASHINGTON REPORT

Bruce Molnia

Washington Report provides the GSA membership with a regular window on the activities of the federal agencies, Congress and the legislative process, and international interactions that could impact the geoscience community. In future issues, Washington Report will present summaries of agency and interagency programs, track legislation, and present insights into Washington, D.C., geopolitics as they pertain to the geosciences.

5300 or 5301 or Maybe Less

About 5300 earth scientists (geologists, geophysicists, hydrologists, and physical scientists), or slightly less than 10% of the professional earth scientists in the United States are part of the Federal Government work force. Thirty-eight hundred, or about 71.8%, of these earth scientists are employed by the Department of the Interior. Department of the Interior Bureaus employing earth scientists are the U.S. Geological Survey (USGS)—3,100 positions—58.5% of total, the Bureau of Land Management (BLM)—300 positions—5.7% of total, the Bureau of Reclamation (BOR)—150 positions—2.75% of total, the Minerals Management Service (MMS)—150 positions—2.75% of total, the Bureau of Mines (BOM)—100 positions—1.9% of total, and also the Office of Surface Mining (OSM).

In Fiscal Year 1992, the level of full-time-equivalent (FTE) staff positions authorized to the USGS by the President's Office of Management and Budget (OMB) was 9607. Of this number, approximately 3100 positions were for earth scientists. The positions are allocated such that 1700 are in the Water Resources Division (WRD) and 1400 are in the Geologic Division (GD). Included within the 1400 GD earth scientists are 936 geologists, 269 geophysicists, 100 chemists, 32 physical scientists, and 31 earth science librarians.

The remaining 1500 Federal Government earth science positions are distributed among the Department of Agriculture—about 550 positions—10.4%, the Department of Defense—about 500 positions—9.4%, the Department of Commerce—about 200 positions—3.8%, the Environmental Protection Agency—about 220 positions—3.8%, the Department of Energy—about 50 positions—0.9%, and the General Accounting Office (GAO)—1 position—0.0002%. Loren Setlow is the one and only full-time Federal Government earth scientist at GAO. More about him later.

In February, President Bush's proposed federal budget for Fiscal Year 1993 (October 1, 1992—September 30, 1993) was released. Although there are many opportunities for the budget to undergo changes before it is finally adopted, if it were instituted as proposed in February, DOI bureaus would suffer a reduction of 900 FTE positions, from 74,900 to 74,000. How many of these would be earth science positions is unknown. Specifically, USGS would lose 250 positions, BLM would lose 30 positions, BOR would lose 143 positions, MMS would lose 43 positions, and BOM would lose 155 positions. The largest loss, 400 positions, would be from the Bureau of Indian Affairs. OSM's staff size would remain the same.

Focusing on USGS, the FY 1993 budget estimate is $540.327 million, a decrease of $42.459 million from the FY 1992 enacted budget of $582.786 million. The FY 1993 proposed budget is a mixture of both program increases and program reductions. Specifically, the proposed budget contains increases totaling $21.6 million for fixed costs, for oil and gas and coal-energy geological surveys, and for an increase in the implementation of the National Water Quality Assessment (NAWQA) Program. These increases are offset by reductions in existing programs totaling $63.9 million. To quote from "The Interior Budget in Brief—Fiscal Year 1993" (p. 45) the proposed reductions will "maintain adequate but lower levels for many of the Survey's programs such as capital investment in the Advanced Cartographic Systems; earthquake, volcano, global change, and coastal and wetland processes research; and mapping, geologic, and water resources data collection, management and dissemination."

For GD, the proposed FY 1993 budget calls for a reduction of 17 positions and $6.663 million from the Earthquake Hazards Reduction Program, a reduction of five positions and $3.557 million from the Volcano Hazards Program, a reduction of 20 positions and $2.246 million from the National Geologic Mapping Program, a reduction of two positions and $0.462 million from the Deep Continental Studies Program, a reduction of 11 positions and $5.762 million from the Coastal and Wetlands Processes Program, a reduction of six positions and $1.104 million from the Global Change and Climate History Program, a reduction of eight positions and $1.553 million from the Offshore Geologic Framework Program, a reduction of nine positions and $1.559 million from the Strategic and Critical Minerals Program, a reduction of 15 positions and $2.040 million from the Development of Assessment Techniques Program, a reduction of $0.590 million from the Evolution of Sedimentary Basins Program, and a reduction of one position and $0.477 million from the Geothermal Investigations Program.

Staff and budget increases are proposed for three GD programs. These are the National Mineral Resource Assessment Program, staff increase of three and budget increase of $0.750 million; the Coal Investigations Program, staff increase of two and budget increase of $0.600 million; and the Oil and Gas Investigations Program, staff increase of 10 and budget increase of $2.000 million. The result, broken down by organizational unit, is a loss of 79 positions and $22.663 million from GD, a loss of 54 positions and $14.446 million from WRD, a loss of 62 positions and $13.011 million from National Mapping Division, a loss of one position and $0.352 from facilities management, and a loss of 11 positions from general administration. The general administration budget shows a proposed increase of $1.012 million. The USGS budget identifies an additional four positions that would be

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World Geomorphology. *E. M. Bridges. Cambridge University Press, New York, 1990, 260 p., cloth $70, paper $24.95.*

World Geomorphology is an introductory textbook that divides Earth into large physiographic regions and then describes each of them. After a quick introduction to plate and smaller scale tectonics and their landforming implications, Bridges marches around the planet, dividing each continent and adjacent ocean basin. An impressive sequence of obscure place names and simple maps flies by. These are largely regional lithostratigraphic listings with macrophysiographic summaries. The conclusion points out that large-scale geomorphology is useful for landscape description and biogeographical interpretations as well as for predicting locations of tectonic hazards, mineralization, and fossil fuels.

Compressing the world's surface into 260 pages results in a thin, overgeneralized presentation, which is not improved by the largely inadequate cartography. The bibliography is limited, and many key points, as well as map sources, are not cited. Thus, directions to guide an ambitious student to the primary sources are not provided. The worst aspects of a tertiary-level synthesis from secondary materials are, as a consequence, conspicuous.

You may find this book embarrassing if you believe regional geomorphology should be useful and intellectually rewarding. Nonetheless, the message of the book is important. Bridges's intent is an explicit counterpoint to the prevailing instruction in geomorphology, where "process" dominates at the expense of understanding the historical and landscape contexts of landforms. Now that the basics of earth surface processes are well understood, the moment seems appropriate to establish a new style of large-scale geomorphology and teach it. Unlike the broad brush of Bridges, this new physiography would use multimedia remote sensing and digital altimetry while applying the real-time history of plate tectonics and an appreciation of ongoing climatic changes. Landform genesis could be linked to adjacent sedimentary styles and onlapping pedogenic trends. Such a regional geomorphology, a geological tour de force, would be a real asset to the other environmental sciences and their application to human problems. Perhaps the example in *World Geomorphology* will inspire others to take up the cause.

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Impact Cratering—A Geologic Process. *H. J. Melosh. Oxford University Press, New York, 1989, 245 p., $65.*

In the first sentence of his preface and, again, in the first sentence of his introduction to this book, H. J. Melosh writes: "Impact cratering has been recognized as a field of study for only the last few decades." This statement bears repeating, because only within the past 30 to 35 years has impact cratering gained recognition as a field worthy of the interest and research efforts of a large number of scientists. Some of us see it as a process of fundamental importance in modifying Earth's crust. Up until now, however, readers wishing to survey the field or keep abreast of developments have had to search through many journals or to refer to the "blue bible," *Impact and Explosion Craters* (D. J. Roddy et al., 1977, Pergamon Press). Melosh has presented the essentials of impact cratering within the 254 pages of this slim volume. It is the first monograph devoted to impact cratering, and a very welcome book indeed.

Melosh aimed his text primarily at terrestrial geologists—either graduate students or professionals who are interested in learning about impact cratering but possess no expertise on the subject. He introduces the topic with a short historical account and then discusses the nature of the evidence on which prevailing theories have been built, or older ones demolished. Throughout the book he focuses on impact as a process, guiding the reader through the physics of stress waves, compression and excavation mechanics, the character and distribution of ejecta deposits, and applications of scaling laws, with reference to studies of controlled experimental impacts and atomic explosion craters. He predicts that physicists may want to skip some of these sections. Furthermore, he quotes one reader of the manuscript as saying that every expert on impact cratering will find something to disagree with in the book. But the book is not intended for physicists or cratering experts. As noted above, it was written to acquaint geologists with current knowledge—and the gaps in current knowledge—of this complex subject.

Crater morphologies, simple, complex, and aberrant, are described with diagrams and illustrations, and comparisons are made between the consequences of impacts on airless bodies and those enveloped in atmospheres. Melosh includes a chapter on multiringed basins, those spectacular features that he says have been observed only on the Moon, Callisto, and Gany-

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Washington *continued from p. 97*

gained from the Working Capital Fund and 47 positions that will be lost from Transfers and Reimbursables. The net result is a loss of 250 positions in FY 1993.

Returning to Loren Setlow, the only earth scientist in the General Accounting Office (GAO). Imagine being required to examine all the pertinent geologic and engineering data related to particular issues to find out: (1) if the impacts of geologic hazards on the Trans-Alaska Pipeline were being properly overseen by government agencies, (2) the scientific merit of the site selection for low-level radioactive waste disposal in Nebraska, and (3) whether Elk Hills oil field waste brines were impacting the ground water quality of California's San Joaquin Valley. After completing your data analyses, imagine that you had to brief Congressional staffers, write reports to Congress, and, perhaps, prepare testimony on your findings. What you just imagined is what Loren Setlow's job required of him in 1991. Setlow has worked for GAO for nine years, having previously spent 11 years with other state and federal agencies. GAO, one of four legislative agencies in the Federal Government (the others are the Library of Congress and its Congressional Research Service, the Congressional Budget Office, and the Office of Technology Assessment), conducts investigations and audits for Congress of federal programs and expenditures. It then provides its findings through reports, briefings, testimony before Congressional committees, legal opinions, comments on legislation, and informal discussions with Congressional staff.

To explore more about the responsibilities of GAO's only geologist, I interviewed Loren Setlow.

Q: What kind of employees does GAO have?

A: GAO staff come from a variety of professional backgrounds. Most of its people are trained as program "evaluators," rather than accountants, since the agency has changed from its original financial accounting role of many years ago. GAO's more than 5000 employees also include physical and environmental scientists, and engineers. Several other individuals with earth science training work in GAO offices around the country, in the capacity of evaluators.

Q: Why does GAO need a geologist on its staff?

A: Congressional committees, individual Senators, and individual Congressmen ask GAO to conduct investigations of specific technical programs because they lack the personnel to independently evaluate these questions. GAO responds by putting together a team with specific subject knowledge. The requests may require technical background beyond the evaluator staff's training and experience. In those instances, I serve as a geological consultant to specific teams that need help in assessing questions and information pertaining to petroleum and minerals, oceanography, geohazards, hydrology, and environmental and geotechnical engineering issues in order to respond to a Congressional request.

Q: How are GAO investigations performed?

A: Our projects are performed in three parts: (1) a job or project design phase, (2) a data collection and analysis phase, and (3) a report or product preparation phase. Once a Congressional request is received, I work with a team to develop project plans, a schedule, the criteria to evaluate the program under review, and the analyses to be conducted. I then conduct literature searches and evaluate technical documents generated by the program or project being investigated. I also collect geological data in the field, conduct site investigations on field trips, and interview scientists and engineers. When the information gathering effort is complete, I do my own geological analyses and mapping. I then write a geological report with annotated references and distill it down into a nontechnical version for GAO use. Lastly, I provide briefings for Congressional staff, and help prepare a report, letter, or testimony for Congress as needed. Since there are always many requests related to geoscience issues, I usually am working on several questions at a time.

Q: Who reviews your written reports?

A: As a rule, after extensive internal reference source and editorial reviews are completed, GAO submits its draft reports for review to government agencies or nongovernmental entities, such as businesses or universities, affected by the investigation. Any technical comments received by us on a draft are either accepted for revising report text, or refuted in a reply printed in a final report along with a copy of the comments.

Q: How are the briefings and reports you prepare used?

A: Congress uses the briefings and reports as the bases for holding public hearings on important issues, to make changes in federal programs or legislation, or to adjust program budgets. Affected executive branch agencies are obligated to act on our recommendations or explain why they cannot.

Q: Do you personally testify at hearings?

A: Generally, I prepare testimony for agency directors and attend hearings in the capacity of a back-up witness to respond to technical questions. On occasion, I prepare questions for Congressmen or Senators to ask at hearings.

Q: What projects are you now investigating?

A: Presently, I'm working on four Congressional requests. The first is an examination of the bases and accuracy of the Interior Department's revised oil resource estimates for the Arctic National Wildlife Refuge and the Energy Department's estimates of the future economic viability of the Trans-Alaska Pipeline. The second is an investigation to determine if the Army did put a small Maryland water company out of business by withdrawing too much ground water from an aquifer. The third is an effort to verify charges of geologic engineering problems in the building of the Superconducting Super Collider in Texas. The last is in response to a request to review federal drought planning efforts nationwide.

Q: Is it difficult to cover so many aspects of geology?

A: Yes, due to the lack of time and the large amount of travel I have to do; but it's never boring. A long time ago, I decided not to concentrate on just one geological specialty. That decision allowed me to be flexible in picking my job assignments and paid off in letting me work on some of the most interesting headline issues in the country. ■

mede. This is a personal opinion and he skillfully defends it, although it goes against a sizable literature on multi-ringed basins on Earth, Mercury, and Mars. In his final chapter he outlines the probable role of impact cratering in planetary evolution and discusses the currently favored theory of the collisional origin of the Moon. Grounded in his mastery of the field, Melosh's views, always authoritative, are of special interest when he challenges the canons of accepted knowledge.

The effort to condense a sprawling technical literature into a small treatise required that some topics be left out. Geological descriptions of individual craters are omitted except for those used to illustrate a point, and little detail is included on shock metamorphism, geochemistry, or microcratering. The text is not referenced; if it had been, the book might have been one-fourth longer. However, related readings are listed at the end of each chapter. This book provides geologists with a lucidly written entry into this enormously important geologic process.

Melosh may overestimate the degree to which terrestrial geologists have begun to integrate impact processes into their thinking. Originating outside Earth and striking at unpredictable times and places, impact still appears to be largely excluded from mainstream geological thought. Even today, when coesite, stishovite, and shocked quartz grains have been found only in experimental runs or at impact sites, many a geologist still rejects these features as criteria of impact shock in the hope that sometime, somewhere they may be found in a volcano. A single, unambiguous volcanic example could wreak havoc among impact specialists, but such a contingency seems less likely every year. We may hope that this book will engage the interest of terrestrial geologists and help to bridge the gap between them and those scientists who contemplate the impact-cratered surfaces of the Moon and other planetary bodies every day.

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Memorial Preprints

The following memorial preprints are now available, free of charge, by writing to GSA, P.O. Box 9140, Boulder, CO 80301.

Horace R. Blank, Sr.
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John Albion Young, Jr.
Edward Blanton

The H-F Boundary: Who Needs a Bolide?

Umberto Cordani, Digby J. McLaren, Leon T. Silver, Brian J. Skinner, M. Gordon Wolman

This June Brazil will host an extraordinary international conference in Rio de Janeiro. It is something of a gamble—if it is successful, the forces set in motion by the conference will help bring the peoples of the world together to face our common future, if unsuccessful, it will continue to foster the illusion that we do not live in one world sharing a common environment.

Our global population seems to have realized that we inhabit a planet under stress and that the source of the stress is a collective "us." Some realized the problem long ago, but now almost everyone senses the stress. Realization, however, is one thing and defense of turf is another. Over the millennia we have developed and staunchly defended different languages, religions, and cultures. Is it now possible for us to agree to put aside our fiercely defended beliefs and work together in order to blunt the pressures of our profligate ways? On that question hangs the answer to a terrifying question: Are we doomed to live through the catastrophic end of an era that will leave its messy mark in the geological record as the Holocene-Future (H-F) boundary? Or can we all agree on the critical pressure points and take collective actions to ameliorate the pressures so that the future promises a pleasantly habitable globe rather than a planetary disaster?

The conference, which will be convened by the United Nations, is expected to attract delegations (many led by heads of state) from about 100 countries; an additional 30,000 people representing organizations of all kinds, but mainly nongovernmental organizations (NGOs), will also be present in Rio. Commonly called the Earth Summit, the official title of the U.N. gathering is the United Nations Conference on Environment and Development, 1992 (UNCED '92). It will be led by Maurice F. Strong of Canada, Secretary-General of UNCED. Because it is impossible to have so many groups of people conferring in one place, the Brazilian government will convene a parallel conference for NGOs, also in Rio and coinciding with UNCED '92. The NGO conference is called the '92 Global Forum, and the recommendations coming from it will probably play a major role in the actions of UNCED '92.

Conferences such as UNCED '92 and the '92 Global Forum could easily dissolve into north-south shouting matches, become platforms for strident pressure groups, or collapse into a black hole of massive inaction. To try to offset such possibilities and to help focus the attention of both UNCED and '92 Global Forum conferees on the key issues, the International Council of Scientific Unions (ICSU) has developed an Agenda of Science for Environment and Development into the 21st Century (ASCEND-21). The five authors of this letter were among 250 scientists and social scientists who participated in the preparation of that agenda.

Approximately 60 people (including two authors here, Skinner and Wolman) were charged with writing 16 position papers on broad topics that were identified by the ICSU organizing committee as encompassing the key scientific issues. These 16 papers will appear in print in a volume to be published by Cambridge University Press in May 1992, in time to be read (or if not read, at least referred to) by delegates to both UNCED '92 and the '92 Global Forum. Topics of the papers range from energy, health, soil degradation, global cycles, and the climate, to biodiversity, quality of life, capacity building, and policies for technology.

The wrap-up of ASCEND-21 was a week-long conference in Vienna, in November 1991, at which all 250 writers, critics, discussants, and organizers were present. Participants came from 70 countries. From the gathering, there eventually emerged a conference statement that was meant to highlight the conclusions and recommendations of the position papers, but in many respects the statement reflects the likely problems and potential weaknesses of the UNCED '92 process. In trying to satisfy everyone, the statement satisfies few (and certainly not us)—it is too weak, too diffuse, and too diluted by the inclusion of minor issues among the major issues. Everyone, however, recognizes that population size, population growth, and high rates of consumption are the major problems. They also recognize that solutions must include improved education at all levels and in all countries, and that the reduction of poverty is essential, especially in the so-called third world countries. Listed below are the eight key recommendations highlighted in the Executive Summary of ASCEND 21.

1. intensified research into natural and anthropogenic forces and their interrelationships, including the carrying capacity of Earth and ways to slow population growth and reduce over-consumption;
2. strengthened support for international global environmental research and observation of the total Earth system;
3. research and studies at the local and regional scale on: the hydrological cycle, impacts of climate change, coastal zones, loss of biodiversity, vulnerability of fragile ecosystems, impacts of changing land use, of waste, and of human attitudes and behavior;
4. research on transition to a more efficient energy supply and use of materials and natural resources;
5. special efforts in education and in building up of scientific institutions as well as involvement of a wide segment of the population in environment and development problem-solving;
6. regular appraisals of the most urgent problems of environment and development and communication with policy-makers, the media and the public;
7. establishment of a forum to link scientists and development agencies along with a strengthened partnership with organizations charged with addressing problems of environment and development; and
8. a wide review of environmental ethics.

We could hardly disagree with these clearly stated suggestions, all of them adopted after long discussion by a community of scientists that was both interdisciplinary and international. But note that items 1 to 4 are recommendations for research rather than for action. Where the position papers identified the problems and stressed the need for action (most of it immediate), when it came to the preparation of a group statement the conference as a whole foundered on the rocks of equality of guilt. If we cut our population, argued the representatives of developing countries, will you in the developed world immediately decrease your conspicuous consumption to equal levels of consumption? Or, why should we listen to you while you take our third world resources and pollute the globe with the waste of your greed? Such opinions prove that all of us realize what the underlying problems are and that we understand that lost time will only increase the difficulty and cost of taking effective action. Even so, we seemed to be unable to articulate our concerns. We couldn't agree on a direct, unanimous, collective statement saying that action is needed—and needed now! The only way we were able to agree was to say that future activities (unspecified) would take place after further research. There is the paradox. The position papers by so many discipline groups make it painfully clear that information freely available now is more than adequate to establish the need for immediate action. But once we try to blend the concerns and understandings of the different discipline groups, we are unable to say action is needed, not just research. Is it possible that politicians will be able to be more assertive than the ASCEND-21 conferees? We hope so.

ASCEND-21 was a sobering experience. We all sensed that we might have been present on a historic occasion, but we wish the scientific community could learn to speak more directly and more boldly. The concerns and recommendations from ASCEND-21 will be presented in the plenary sessions of UNCED '92 by J.W.M. la Rivière, a distinguished Belgian hydrologist, who is secretary general of ICSU and will occupy the plenary seat assigned to ICSU.

We urge you, the reader of *GSA Today*, to watch the progress of UNCED '92 and know, as you do, that this is one occasion when geologists were not left out. We, and the other earth scientists at ASCEND 21, had a lot to say about geological issues concerning soils, water, resources, geochemical disturbances, biodiversity, and geochemical cycling. Only time will tell whether our efforts will bear any fruit. ■

McKelvey Fund Will Support Scholarship at Syracuse

Syracuse University announces the establishment of the Vincent E. McKelvey Scholarship Fund. McKelvey was an honors graduate of Syracuse in 1937 and recipient of an honorary Doctor of Science degree in 1975. McKelvey was director of the U.S. Geological Survey from 1971 to 1977. The fund will provide scholarships for undergraduate students in geology or fellowships for graduate students. Donations to the fund should be made to: Syracuse University, McKelvey Scholarship Fund, and sent to: M. E. Bickford, Dept. of Geology, 204 Heroy Geology Laboratory, Syracuse University, Syracuse, New York 13244-1070.

Subduction *continued from p. 95*

We analyzed the effect that changes in global spreading rates have on eustatic sea level (lithosphere subsidence model) by modeling the age-area distribution within the oceans at 1 m.y. increments. Predicted changes in sea level were based on the following methods and assumptions.

1. Assume a linear decrease in the age-area distribution for a 180 Ma ocean basin as observed in today's oceans (Parsons, 1982). As noted below, various beginning models can be used. One simply "builds" an ocean basin with a chosen spreading rate and assigns the age distribution according to the relation (from Parsons, 1982): area (age) = rate (1 – age/180), where area = 10^6 km^2 of a given age, age = m.y., and rate = areal spreading rate (10^6 km^2/m.y.).

2. Assume that no plate older than 180 Ma is preserved. Thus, at each 1 m.y. interval, remove all of the plate that is older than 180 Ma.

3. The percentage of plate of a given age (younger than 180 Ma) removed from the model depends upon the percentage of plate that age present. Assume that the total amount subducted equals the amount formed.

4. Calculate the volume of the ocean basin at each step by using the age-depth relation of Parsons and Sclater (1977).

5. Calculate the resulting change in sea level from the relation, provided by Pitman (1978), that assumes a known shape and size of the ocean basin being filled or drained.

The dark curve in Figure 6 is eustatic sea level (from Haq et al., 1987) averaged over a 10 m.y. running window. Lighter curves in Figure 6 result from different initial rates used for the original ocean basin (equation above). Although there is poor agreement prior to 120 Ma (discussed below), good agreement is seen after this time. Major trends in the eustatic sea-level curve and predicted sea-level height are well matched by using an original ocean basin that is formed from an areal spreading rate of approximately 2 × 10^6 km^2/m.y. Note the near agreement in the two highest peaks in sea level (at about 90 and 45 Ma), thus accounting for the lag time seen in Figure 5 (it takes an extended period of time for a significant part of older plate to be replaced by younger plate). In view of the large misfit prior to 120 Ma, we may have underestimated spreading rates between 180 and 120 Ma.

For an alternative explanation of the discrepancies seen between 180 and 120 Ma, we return to the discussion involving the dynamic-convection model of Gurnis (1990). In this model, long-term slow spreading rates would allow the sublithospheric mantle to rise in temperature and increase in volume, the result being a rise in sea level for time intervals on the order of 120–240 m.y. after the initiation of slow spreading (Fig. 2 of Gurnis, 1990). If the slower spreading rates seen in our model prior to 130 Ma are approximately correct, and are applicable to earlier times, the misfit in our model prior to 120 Ma is consistent with the dynamic-convection model. Put more optimistically, the pre–120 Ma increase in eustatic sea level suggests that spreading rates were slow for the time period prior to 130 Ma and possibly as far back as about 250 Ma.

Agreement (at least since 120 Ma) between first-order changes in eustatic sea level and predicted changes using simple assumptions about the overall age distribution of lithosphere entering trenches coupled with global spreading rates is encouraging.

SUMMARY

Since 180 Ma, the area of plate (primarily oceanic) now buried in the mantle is approximately equal to the surface area of Earth. Subducted lithosphere is concentrated in regions (lithospheric graveyards), and these regions correspond to gross mantle heterogeneity—the mantle is cold where plate is buried.

More than 13 000 km of convergence has occurred at the Japan Trench and western North America since 150 Ma. Approximately 8000 km has descended beneath the central Andes and the Himalayas, and only about 1000 km of convergence is seen for the western Alps.

With regard to motions of the overriding plates relative to the hotspots (the component orthogonal to their boundaries), North America and South America show a net advance (primarily westward) of about 3000 km. Eurasia, near the Himalayan suture, has advanced approximately 1000 km (southward) with most of this displacement occurring prior to 75 Ma. Although no net orthogonal motion is observed for the Japan Trench, retreat of this trench about 1500 km (eastward) between 150 and 90 Ma was followed by an equivalent advance (westward). Africa, near the western Alps, shows approximately 2200 km of steady trenchward advance (northward). Thus, each of these regions of convergence displays a unique kinematic history. It appears that a significant amount of advance of the overriding plates toward their convergent boundaries is both a necessary and sufficient condition for large-scale crustal uplift and orogeny.

Finally, the pattern of global spreading rates at oceanic ridges is consistent with a first-order eustatic sea-level curve (120 Ma to the present) when a simple model for the age-area distribution within the world's ocean basins is assumed (lithosphere subsidence model). The amount of plate subducted as a function of its age appears directly related to the percentage present. Effects of the dynamic-convection model of Gurnis (1990) may be recorded in the steady rise of eustatic sea level between 180 and 120 Ma and imply a long history of slow spreading prior to 120 Ma.

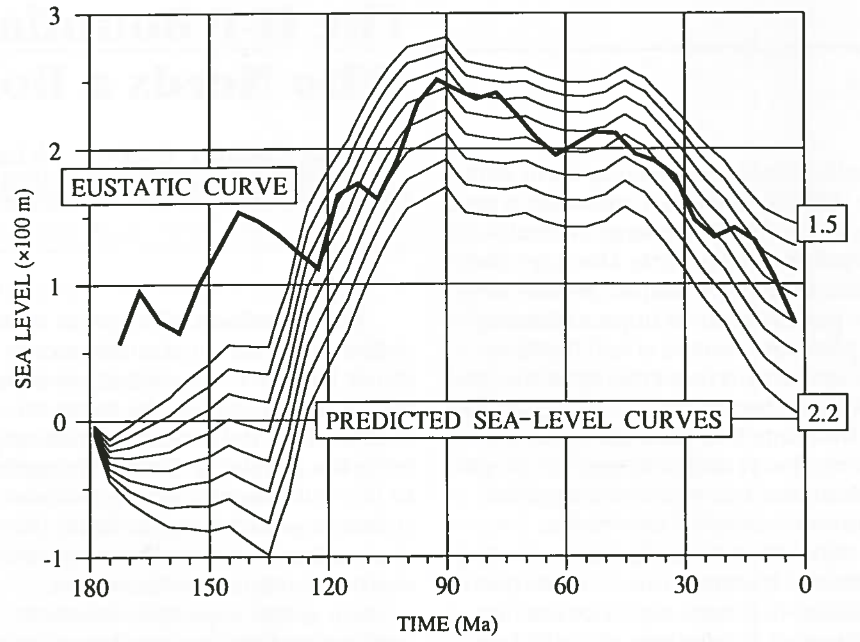

Figure 6. Predicted sea-level curves (light lines) vs. eustatic sea level (heavy curve) of Haq et al. (1987) averaged with a 10 m.y. running window. Numbers on right side of diagram refer to areal rate of spreading (×10^6 km^2/m.y.) used to build the 180 Ma ocean basin.

ACKNOWLEDGMENTS

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GSA Divisions and Sections—1992

DIVISIONS

GSA's twelve specialty divisions provide a focus for members interested in a particular discipline. The divisions hold annual business meetings in conjunction with the Society's annual meeting, and each division publishes a newsletter periodically. Division membership totals are as of December 31, 1991.

Archaeological Geology Members: 500
Officers: E. Arthur Bettis III, chairman; Bonnie A. Blackwell, first vice-chairman; Henry P. Schwarcz, second vice-chairman; C. Reid Ferring, secretary-treasurer; Julie K. Stein, past chairman.
Newsletter editor: Vance T. Holliday.

Coal Geology Members: 335
Officers: Timothy A. Cross, chairman; Robert A. Gastaldo, first vice-chairman; Alan Davis, second vice-chairman; Cortland F. Eble, secretary; Robert B. Finkelman, past chairman.
Newsletter editor: Cortland F. Eble.

Engineering Geology Members: 1108
Officers: Charles W. Welby, chairman; Jerome V. DeGraff, chairman-elect; Rhea Lydia Graham, secretary; Perry H. Rahn, past chairman.
Newsletter editor: John R. Giardino.

Geophysics Members: 539
Officers: Laura F. Serpa, chairman; Richard G. Gordon, first vice-chairman; Lawrence L. Malinconico, Jr., second vice-chairman; G. Randy Keller, secretary-treasurer; Laurie L. Brown, past chairman.
Newsletter editor: Henry Spall.

Geoscience Education Established May 1991
Officers: John R. Carpenter, chairman; Dorothy L. Stout, first vice-chairman; Whitman Cross II, second vice-chairman; Stephen H. Stow, secretary-treasurer; no immediate past chairman.

History of Geology Members: 398
Officers: Donald M. Hoskins, chairman; Samuel T. Pees, first vice-chairman; Joanne Bourgeois, second vice-chairman; Michele L. Aldrich, secretary-treasurer; Alan E. Leviton, past chairman.
Newsletter editor: Michele L. Aldrich.

Hydrogeology Members: 1832
Officers: John A. Cherry, chairman; Franklin W. Schwartz, first vice-chairman; Leonard F. Konikow, second vice-chairman; John F. Harsh, secretary-treasurer; Paul R. Seaber, past chairman.
Newsletter editor: Alan R. Dutton.

International Members: 314
Officers: William R. Greenwood, president; Kevin Burke, first vice-president; Bruce F. Molnia, second vice-president; John S. Oldow, secretary-treasurer; Brian J. Skinner, past president.

Planetary Geology Members: 434
Officers: Baerbel K. Lucchitta, chairman; Harry Y. McSween, Jr., first vice-chairman; George E. McGill, second vice-chairman; Larry S. Crumpler, secretary-treasurer; Theodore A. Maxwell, past chairman.
Newsletter editor: Larry S. Crumpler.

Quaternary Geology and Geomorphology Members: 1413
Officers: David M. Mickelson, chairman; Stephen G. Wells, first vice-chairman; Parker E. Calkin, second vice-chairman; Deborah R. Harden, secretary; Richard F. Madole, past chairman.
Newsletter editor: William E. Scott.

Sedimentary Geology Members: 1048
Officers: Timothy F. Lawton, chairman; Cathy J. Busby-Spera, first vice-chairman; William J. Schweller, second vice-chairman; Mary J. Kraus, secretary-treasurer; Donald R. Lowe, past chairman.
Newsletter editor: Robert Suchecki.

Structural Geology and Tectonics Members: 2020
Officers: Darrel S. Cowan, chairman; Jan A. Tullis, first vice-chairman; Richard H. Groshong, Jr., second vice-chairman; Donald T. Secor, Jr., secretary-treasurer; Mark Cloos, past chairman.
Newsletter editors: Greg A. Davis, Scott R. Paterson.

SECTIONS

GSA has six regional North American sections, generally including GSA members who live within the geographical limits of each section. (Members who live in one section but have a professional interest in another section can become members of the section of interest.) Each section holds annual technical and business meetings. The number of voting members shown for each section is as of December 31, 1991.

Cordilleran Voting members: 3793
Geographic area: Alaska, Arizona south of lat 35°N, California, Hawaii, Nevada, Oregon, Washington, British Columbia, Yukon, Northwest Territories.
Officers: Richard A. Schweickert, chairman; to be elected, vice-chairman; Bruce A. Blackerby, secretary; Patrick L. Abbott, past chairman.

Rocky Mountain Voting members: 1870
Geographic area: Arizona north of lat 35°N, Colorado, Idaho, Montana, New Mexico, North Dakota, South Dakota, Utah, Wyoming, Alberta, Saskatchewan.
Officers: Walter S. Snyder, chairman; Craig M. White, vice-chairman; Kenneth E. Kolm, secretary; Sidney R. Ash, past chairman; E. Fred Pashley, Jr., past vice-chairman.

North-Central Voting members: 1261
Geographic area: Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Nebraska, Ohio, Wisconsin, Manitoba, Ontario west of 89th meridian.
Officers: Richard D. Hagni, chairman; Eva B. Kisvarsanyi, vice-chairman; George R. Hallberg, secretary; Raymond R. Anderson, past chairman; Holmes A. Semken, Jr., past vice-chairman.

South-Central Voting members: 1380
Geographic area: Arkansas, Kansas, Oklahoma, Texas.
Officers: Hans G. Avé Lallemant, chairman; John A. Breyer, vice-chairman; Rena M. Bonem, secretary-treasurer; G. Randy Keller, past chairman.

Northeastern Voting members: 2173
Geographic area: Connecticut, Delaware, District of Columbia, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, New Brunswick, Newfoundland, Nova Scotia, Prince Edward Island, Quebec, Ontario east of 89th meridian.
Officers: James M. McLelland, chairman; Sandra M. Barr, vice-chairman; Kenneth N. Weaver, secretary; Gail M. Ashley, past chairman.

Southeastern Voting members: 1558
Geographic area: Alabama, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, Virginia, West Virginia.
Officers: William A. Thomas, chairman; James F. Tull, vice-chairman; Michael J. Neilson, secretary-treasurer; Timothy M. Chowns, past chairman; Paul D. Fullager, past vice-chairman. ■

Marcus E. Milling Appointed AGI Executive Director

Marcus E. Milling has been appointed executive director of the American Geological Institute. Christopher C. Mathewson, AGI's president, announced the appointment effective February 24, 1992.

Milling, currently associate director of the Texas Bureau of Economic Geology at the University of Texas, Austin, has served in a number of positions at the bureau since joining the university in 1987. He played a leading role in establishing the Geoscience Institute for Oil and Gas Recovery Research and served as the institute's director from 1988–1991.

Before joining the university, Milling served as manager of ARCO's geological staff (1986–1987) and general manager of geological research (1980–1986). Also, from 1968–1980 he worked in a variety of research and line-operation positions with Exxon Company USA.

"Significant opportunities exist for advancing the goals of the geoscience community through improvements in precollege geoscience education, assessment of natural resources, and expansion of geoscience information services," Milling said upon accepting his new position. He also stressed the need for increasing the recognition and the value of geoscientific contributions to the nation's well-being. "AGI can assist the geoscience community to increase that recognition. I look forward to the opportunity to work with the institute to do that," he concluded.

Milling has been professionally active in the American Geological Institute since 1983. He has been vice-chairman of the AGI Foundation Board of Trustees and chairman of the Human Resources Advisory Committee for the last five years.

Milling was born in Galveston, Texas. He received his bachelor of science degree in geology at Lamar University, and his master's and Ph.D. from the University of Iowa.

The American Geological Institute is a nonprofit federation of 19 member organizations that represent geologists, geophysicists, and other earth scientists. ■

About People

GSA Member **I. K. Gilmore** has been promoted to chief geologist at Texasgulf's Phosphate Mining Operations near Aurora, North Carolina.

Fellow **Daniel F. Merriam**, Wichita State University, Kansas, will receive the 1992 William Smith Medal from the Geological Society of London at their annual meeting this June.

Member **Jane H. Wallace**, U.S. Geological Survey, Washington, D.C., has been awarded the Smith College Medal for outstanding career achievements.

Fellow **Robert J. Weimer**, Colorado School of Mines, has been elected a member of the National Academy of Engineering.

In Memoriam

David Clinton
New York

William I. Gardner
Moraga, California

Mackenzie Gordon, Jr.
Washington, D.C.
January 30, 1992

John W. Hosterman
Vienna, Virginia
November 13, 1991

Stanley W. Lohman
Denver, Colorado
January 12, 1992

Robert K. Morse
El Paso, Illinois

Nuria Pequera
Rochester, New York
November 6, 1991

Philip W. Reinhart
Santa Barbara, California
December 16, 1991

R. Dana Russell
Santa Rosa, California
February 17, 1992

Charles W. Stuckey, Jr.
Houston, Texas
November 26, 1991

Vernon E. Swanson
Aurora, Colorado
January 15, 1992

Penrose Conference Report

Development and Evolution of Foreland Basins

Conveners

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A Penrose Conference on the development and evolution of foreland basins brought 78 scientists, including 18 present or recent doctoral students, to Can Boix on the south flank of the Pyrenees in October 1991. The European setting of the conference helped to promote international participation—more than ten countries were represented. More importantly, the southern Pyrenees provided an excellent showcase for examining some of the attributes and complexities of foreland basins through a series of field trips. The conference brought together a cross section of geoscientists utilizing a variety of theoretical, experimental, and field-based approaches to solving problems related to basin development of varied temporal and spatial scales, primarily in Tethyan, Asian, and American foreland basins.

The conference began with a traverse of the eastern Ebro foreland basin starting in the Catalan Coastal Range and ending in the Spanish Pyrenees. The magnificently displayed Montserrat fan-delta along a transpressional foreland margin sparked the first lively discussions on the relative importance of tectonics and sea level in modulating depositional sequences. From salt-cored structures in the center of the Ebro Basin, it was possible to see from the distal transpressional foreland margin to the main Pyrenean thrust front and to appreciate the manner in which well-preserved and well-exposed forelands can provide new insights on the complex linkages between deformation and deposition on various basin margins.

The conference included three days of keynote and "hot topic" presentations, with more than half of the time devoted to discussions led by varying arrays of panelists. Small-group discussions were used effectively as a vehicle to summarize aspects of recent progress and to delineate major problems. A poster session, consisting of more than 60 displays and continuing throughout the entire meeting, provided a focal point for innumerable discussions and arguments that persisted well beyond midnight every day. Interspersed with the formal sessions were several additional field trips. The first was a walking trip from the conference center across the succession of interleaved conglomerates and thrusts that constitute the southeast margin of the South-Central Unit. Although stratigraphic and structural evidence clearly demonstrated coeval hindward- and forward-imbricating thrusting, vigorous discussions focused on the character of syntectonic sedimentation, the steadiness of deformational and depositional processes, and the regional implications of the sequence. A second trip toured the southern margin of the Cadi and Pedraforca thrust sheets and concentrated on the spectacularly displayed "progressive unconformities" of the Alt Cardener region. Oriol Riba, in many respects the guiding figure in modern stratigraphic analysis in Spain, led the trip to this classic area, one he described nearly 20 years ago. The multiple generations of fanning sedimentary packages provided intriguing and complex puzzles for those trying to understand the interaction between thrust geometries and deformation of coeval sedimentary strata. Following the conference, nearly half of the participants went on a six-day field trip that traversed the Tremp-Graus and Ainsa basins and provided a further sampling of the broad range of depositional environments and

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DNAG NEWS

Allison R. (Pete) Palmer

The End Is in Sight

The *Gulf of Mexico Basin* is now available for purchase. All contributors should have received their copies. *The Cordilleran Orogen: U.S.* is awaiting final figures for Chapter 7 which have not yet been received. They are expected momentarily, so this book may be off to the printer by the time you read this. It should be available by early fall. Right behind this volume is *The Precambrian: Conterminous U.S.* The last chapter was delivered on St. Patrick's day, and Jack Reed should be going over the galleys prior to final paging around the end of April. The book is expected to be ready for the GSA Annual Meeting in Cincinnati. The final proofs for the *Geothermal Aspects Map of North America*, which completes the Neotectonic map series that accompanies the recently completed *Neotectonics of North America*, were sent to Dave Blackwell for a last-minute check in mid-March. The map should be available in May. Still out there are the *Geology of Alaska*, wending its way through USGS review in Menlo Park; at least two more transects and the transects volume; and the Geologic Map of North America. We hope to have colored copies of the North American map to display at the GSA meeting in Cincinnati.

Congratulations to the Precambrian Authors

With receipt of the last manuscript for the U.S. Precambrian volume, the very patient contributors can at last be congratulated and are listed below. It's been a long haul, complicated by the need to recreate two of the major chapters when the original editors for these megachapters were replaced after deadlines had long been exceeded without promised texts. The 73 authors listed below bring the total number of DNAG contributors to 2006—with two more GSA and seven more Canadian volumes to come! The contributions from this massive sector of the community of geologists working in North America are greatly appreciated. ■

J. L. Anderson
R. R. Anderson
T. T. Ball
P. W. Bauer
R. L. Bauer
E. E. Bender
M. E. Bickford
S. A. Bowring
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J. McLelland
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S. Mosher
M. G. Mudrey, Jr.
R. W. Ojakangas
N. J. Page
R. C. Pearson
Z. E. Peterman
A. Prave
D. W. Rankin
N. M. Ratcliffe
J. C. Reed, Jr.
M. W. Reynolds
J. M. Robertson
K. J. Schulz
D. T. Secor, Jr.
S. B. Shirey
L. T. Silver
P. K. Sims
E. I. Smith
G. L. Snyder
D. L. Southwick
J. H. Stewart
S. B. Treves
O. Tweto
W. R. Van Schmus
P. W. Weiblen
P. R. Whitney
M. L. Williams
D. Winston
J. L. Wooden
R. G. Worl
L. A. Wright
C. T. Wrucke
M. L. Zientek

Penrose Report *continued from p. 102*

deformational styles that characterize the southern Pyrenean foreland basin.

The formal presentations, posters, and discussions served to highlight both the progress that has been made since the last foreland basin meeting (1985, in Fribourg) and the problems that are still unresolved. Simple, one-dimensional Airy backstripping has given way to two- and three-dimensional forward models on a variety of scales from individual thrusts to entire collisional orogens. The theory of critically tapered wedges, the concept of drainage-basin equilibrium times, diffusion modeling, and the controls exerted by crustal rigidity, collision polarity, surficial processes, and moisture sources have been woven into some of these models. The modelers emphasized that models should be used to define end members and to guide critical thinking about potential interrelations among different variables that might otherwise be overlooked. Field geologists at the conference were concerned about the discrepancies between the rock record they are studying and the model results, and they hoped that improved data bases would help constrain more "realistic" models in the future. Whereas models were presented for the discontinuous migration of forebulges, geologists had difficulty providing unequivocal stratigraphic evidence for their existence, let alone their migration rate! Nearly everyone agreed that the modeling is forcing us to ask new questions and to search for ways to test simple model predictions. It seems that the highly complex models are essentially untestable at present, except in a qualitative fashion.

Structural controls on the geometry of foreland basins were examined at varied scales and with respect to numerous basins. Detailed reconstructions of thrust development, related syntectonic sedimentation, and even rates of processes have been created for a remarkably diverse suite of foreland settings. At a larger scale, it was argued that the width of the foreland was controlled by the tectonic load, crustal rigidity and heterogeneity, the rate of plate convergence, and slab pull and that the transition from overdeepened to overfilled and from "flysch" to "molasse" is a function of the stage of the collision and the degree to which crystalline basement is involved in the deformation. Further calibration of timing of accretion events and of the rates of thrust advance, crustal uplift, and denudation promise improved understanding of the way in which processes within the deforming hinterland affect adjacent foreland. Controls exerted by precollisional structural and basinal geometries and by the distribution of kinematically weak stratigraphic horizons on the location of major thrusts and on the structural partitioning of forelands were clearly illustrated for the Alps, Pyrenees, and Cordillera. For many forelands, it was argued that the hinterland thrust stack controls the tectonic load and that shallow-water sedimentary deposits and thrust sheets involving cover rocks fill the flexurally induced foreland space. In contrast, individual thin-skinned thrust sheets create insignificant loads but exert key controls on depositional patterns.

Given the relatively steady rates of plate convergence, it is intriguing to consider at what spatial and temporal scales tectonic processes within and adjacent to forelands appear to be discontinuous. Structural geometries dictate, for example, that continuous

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GSAF UPDATE

Robert L. Fuchs

ARCO Foundation Grant Supports the Institute for Environmental Education

The GSA Foundation has received a grant of $10,000 from the ARCO Foundation for the Institute for Environmental Education (IEE). The funds are being used as seed money for the development of the Institute's programs. Specifically, this money has enabled the IEE's Internship Program to begin functioning (see *GSA Today*, March 1992, p. 55). Also the groundwork is being laid for other environmental education programs such as the Annual Environmental Forum. The first Forum will be held at the GSA Annual Meeting in Cincinnati on October 25, 1992.

In acknowledging the ARCO grant, President E-an Zen reiterated GSA's commitment to making geology better serve the public and the nation and stated appreciation for ARCO's financial expression of confidence in GSA's programs. Zen pointed out that ARCO has long been a steadfast friend and continuing supporter of GSA activities.

Mortality and Immortality

As human beings, we succumb easily to procrastination: don't paint the bedroom this weekend, it will still be there next weekend; don't go to the trouble of getting the car serviced tomorrow, it's running perfectly fine. As geologists we can be even more susceptible to this foible. After all, the Colorado River has been flowing through the Grand Canyon for a great many centuries. The geomorphological characteristics of the Appalachian Mountains haven't changed appreciably in the time span that humans have populated Earth.

But as we all learned in Geology 101, the only constant is change itself. Changing river levels and flows are decimating sand beaches in the Grand Canyon. Weathering chisels at the Appalachians' Paleozoic outcrops. Appearances of immortality are underlain by the harsh realism of mortality. While our life span may seem endless in the full bloom of early adulthood, our years are in fact only a brief instant on the geologic time scale.

The point of this musing is that we must deal sooner or later in our personal lives with our own mortality. Although it is difficult and unpleasant to contemplate death, the knowledge that a proper estate plan is in place that will effectively and efficiently distribute the deceased's assets can be a source of long-term personal comfort.

A will is essential to accomplishing proper distribution of your estate after death. Without a will, the state will distribute your property according to certain strict and impersonal laws. The result could violate your every wish. Not only is a will critical to the realization of your desires, but also it must be reviewed periodically and revised if necessary. Changes in federal and state laws, a new residence in another state, remarriage, a beneficiary's altered circumstances—any of these events could require a new will.

Estate distribution through a will is accomplished by bequest. Various types of bequests, such as general, specific, residuary, contingent, absolute, and immediate, are available for the testator.

Charitable bequests, such as to the GSA Foundation, provide tax savings to the estate because they are fully deductible for federal estate tax purposes. Thus, a $1,000,000 estate making a $100,000 gift to the GSA Foundation will save $39,000 in estate taxes, resulting in a net cost of the bequest to the estate of $61,000.

Further sophistication in estate distribution and bequests can be achieved through annuity trusts, unitrusts, and life insurance. We have a primer, *Planning Your Bequests*, that will introduce you to this entire field of wills, bequests, and estate planning. Mail in the accompanying coupon or call the Foundation office, (303) 447-2020; we will be happy to send you a free copy.

The financial health of GSA and its ability to support publications and research for the benefit of members and the geoscience community stem significantly from the $3,900,000 bequest to the Society in 1931 by member R.A.F. Penrose, Jr. The financial needs of geoscientists continue to increase, as does the GSA Foundation's role in filling these needs. With the advent of SAGE and IEE additional endowment and program funds are required. The Penrose Endowment Fund cannot shoulder the entire burden. Estate planning by GSA members that includes bequests to the Foundation will provide future funds for education, research, publications, and scientific advancement. ■

Donors to the Foundation, February 1992

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Penrose Report *continued from p. 103*

shortening can produce discontinuities in vertical uplift rates. High-resolution time control of some deformational sequences and nearly complete preservation of syntectonic strata juxtaposed with thrust sheets permit stage-by-stage reconstruction of deformational sequences and provide clear evidence at the local scale for largely continuous deformation and deposition at shortening rates of 1–10 mm/yr across time spans of a few million years. Switching of the locus of deformation within the foreland and out-of-sequence thrusting in the hinterland, both of which represent discontinuities at the local scale, can often be understood in the context of a critically tapered wedge that is advancing and undergoing continuous mass distribution through erosion and uplift.

Although unconformity-bounded sedimentary packets are widely recognized within all foreland basins, the primary controls on unconformity development remain controversial. Forward models and field observations suggest that either redistribution of the tectonic or stratal load and/or physical deformation through thrusting create major unconformities and cause sediment bypassing. Local base-level changes, intraplate stresses, and autocyclic processes were viewed by some as the critical controls, and it was argued that tectonics merely enhance unconformity development driven by other processes.

Sequence stratigraphic concepts, developed for depositional successions on passive margins, have been widely applied to foreland basin strata. For some, volumetric partitioning of alluvial strata is solely controlled by sea-level variations via geographical shifts in newly created accommodation space. For others, the interplay between transverse and longitudinal alluvial systems is modulated by shifts in tectonic deformation and is unrelated to sea-level variations. Autocyclic and geomorphic processes, such as the simple elaboration of drainage basins or the focusing of rivers into structural reentrants, are suggested to control coarsening and fining trends and sequence development in adjacent basins, irrespective of either active tectonics or changing sea level.

It is clear that agreement about the key controls on depositional successions in foreland basins remains elusive. Beyond the perennial debates about the relative importance of eustasy and tectonism, the role of climate in defining the magnitude and character of sediment supply is poorly understood and typically ignored in the analysis of ancient strata. This is clearly a major frontier of the future. Analyses of modern basins that integrate studies of in situ stress, seismic tomography, structural deformation, geomorphic processes, and climatic change may pave the way toward a more holistic view of forelands. Although everyone agrees that foreland basins must be understood in the context of their genetically linked, adjacent thrust systems, more reliable and finer temporal resolution in both the foreland and the adjacent mountains is a prerequisite for more unambiguous correlation, definition of rates, and examination of processes and responses in foreland basins. We need to know more about both rates and the three-dimensional distribution of crustal uplift and exhumation in the mountains, and of subsidence, tectonic advance, and sediment fluxes in the foreland. A unified, accessible database for this and related information on forelands would be likely to produce insights that are at present obscured because of the diverse nature of today's data sets. Although the strata of piggyback basins and of proximal, autochthonous forelands are providing enhanced understanding of the style, sequence, and rate of structural deformation, the links between this record and that of the majority of foreland strata in the medial and distal basin are poorly known. Increased use of seismic data and other methods of improved correlation are needed to delineate these linkages. Whereas process-based models may never, and perhaps shouldn't, be able to mimic faithfully the rock record, their defining parameters must be calibrated against improved data sets, and they need to make testable predictions. Continuum mechanics appear inappropriate for dealing with discontinuous, threshold-type processes, and new approaches may be required to model such phenomena successfully. Finally, recent geopolitical changes are opening up new geographic areas for research. Perhaps there are largely unexplored foreland basins that can help to resolve some of these persistent questions. Let's put on our boots and go find out! ■

Penrose Conference Participants

Antenor Aleman	George Mascle
Phillip Allen	Albert Matter
Pau Arbues	Mike May
Enrique Banda	David McCormick
Christopher Beaumont	Donatella Mellere
Peter Bentham	Jim Meyers
Christian Betzler	Jean-Louis Mugnier
Steven Boyer	Josep Anton Muñoz
Doug Burbank	Gregory Nadon
Louis Cabrera	Gary Nichols
Douglas Cant	Wout Nyman
Valerie Chamberlain	Shaun O'Connell
Bernard Coakley	Tim Peper
Sarah Crampton	Chris Pigram
Timothy Cross	Cai Puigdefàbregas
Poppe de Boer	Robert Raynolds
Peter DeCelles	Oriol Riba
Joachim Deramond	Massimo Rossi
Steve Dorobek	Leigh Royden
Trevor Elliott	Dorothy Satterfield
Daniela Fontana	James Schmitt
Gordon Fraser	Fred Schwab
Lloyd Furer	Pete Schwans
Katherine Giles Goebel	Robert Schwartz
Steve Graham	Michel Seguret
James Granath	Hugh Sinclair
John Grotzinger	Tim Stern
Sanjeev Gupta	Roger Suthren
Adrian Hartley	Lee Suttner
Paul Heller	Peter Talling
Phillip Hogan	Anthonio Teixell
James Holl	William Thomas
Peter Homewood	James Trexler
David Johnson	Jaume Vergés
Neville Jones	Stephen Vincent
Teresa Jordan	Paula Waschbush
Timothy Lawton	Gert Jan Weltje
Matt Lloyd	Manel Zamorano
Mariano Marzo	Reini Zoetemeijer

Committee Service Provides Way to Affect GSA

The GSA Committee on Committees wants your help. The committee is looking for potential candidates to serve on committees of the Society or as GSA representatives to other organizations. You can help by volunteering yourself or suggesting the names of others you think should be considered for any of the openings and submitting your nomination on the form on page 105.

Listed below are the number of vacancies along with a brief summary of what each committee does and what qualifications are desirable. If you volunteer or make recommendations, please give serious consideration to the special qualifications for serving on a particular committee. *Please be sure that your candidates are Members or Fellows of the Society and that they meet fully the requested qualifications.*

Volunteering or Making a Recommendation

All nominations received at headquarters by **July 15, 1992**, on the official one-page form will be forwarded to the Committee on Committees. *Council requires that the form be complete.* Information requested on the form will assist the committee members with their recommendations for the 1993 committee vacancies. Please use one form per candidate (additional forms may be copied). The committee will present at least two nominations for each open position to the Council at its October 28 meeting in Cincinnati, Ohio. Appointees will then be contacted and asked to serve, thus completing the process of bringing new expertise into Society affairs.

Committee on Committees

The 1992 committee consists of the following people: Chairman **Charles J. Mankin**, Oklahoma Geological Survey, 100 East Boyd Street, Room N-131, Norman, OK 73019-0628, (405) 325-3031; **John E. Costa**, U.S. Geological Survey, 5400 MacArthur Boulevard, Vancouver, WA 98661, (206) 696-7811; **Priscilla C. Grew**, Minnesota Geological Survey, 2642 University Avenue, St. Paul, MN 55114, (612) 627-4780; **Fernando Ortega-Gutiérrez**, Instituto de Geologia, UNAM, Ciudad Univ., Deleg Coyoacan, Mexico City, D.F., Mexico 04510, phone 52-5-548-0772; **Paul C. Ragland**, Dept. of Geology, Florida State University, Tallahassee, FL 32306, (904) 644-5860; **Peter Robinson**, Dept. of Geology and Geography, University of Massachusetts, Amherst, MA 01003, (413) 545-2593.

Committees and Qualifications

Day Medal (2 vacancies)
Selects candidates for the Arthur L. Day Medal.

Committee members should have knowledge of those who have made "distinct contributions to geologic knowledge through the application of physics and chemistry to the solution of geologic problems."

Education (1 vacancy)
Stimulates interest in the importance and acquisition of basic knowledge in the earth sciences at all levels of education.

Committee members work with other interested scientific organizations and science teachers' groups to develop precollege earth-science education objectives and initiatives. The committee also promotes the importance of earth science education to the general public.

Geology and Public Policy (2 vacancies)
Translates knowledge of the earth sciences into forms most useful for public discussion and decision making.

Committee members should have an awareness of public policy and decisions involving the science of geology. They should also be able to develop, disseminate, and translate information from the geologic sciences into useful forms for the general public and for the Society membership; they should be familiar with appropriate techniques for the dissemination of information.

Honorary Fellows (2 vacancies)
Selects candidates for Honorary Fellows, usually non–North Americans.

Committee members should have knowledge of geologists throughout the world who have distinguished themselves through their contributions to the science.

Long-Range Planning (1 vacancy)
Assesses the purpose and objectives of the Society in each of its major program areas, and reviews proposals for new policies or program initiatives. Reviews annually the basic mission, the strategic objectives, and goals of the Society with respect to the changes in the science of geology.

Committee members should have a broad understanding of programs and research in the geosciences, and have actively participated in the affairs and programs of other earth science societies.

Membership (2 vacancies)
Screens Member and Fellow applications; evaluates membership benefits and makes recommendations to the Council about them.

Committee members must be GSA Fellows and must be able to attend one meeting a year. Previous experience in recruitment programs and in the evaluation of professional qualifications is desired.

Nominations (5 vacancies; one position for a member from Canada or Mexico)
Recommends to the Council nominees for the positions of GSA officers and councilors.

Committee members should be familiar with a broad range of well-known and highly respected geological scientists.

Penrose Conferences (2 vacancies)
Accepts or rejects Penrose Conference proposals; recommends and implements guidelines for the success of the conferences.

Committee members must either be past conveners or have attended two or more Penrose Conferences.

Penrose Medal (1 vacancy)
Selects candidates for the Penrose Medal.

Committee members should be familiar with outstanding achievements in the geological community that are worthy of consideration for the honor. Emphasis is placed on "eminent research in pure geology which marks a major advance in the science of geology."

Publications **(2 vacancies)**
Makes recommendations to the Council concerning Society publications.

Committee members should be familiar with a wide range of scientific publications and especially GSA publications. Should also have some knowledge of publication processes and costs and should have concern for the quality of content and presentation of GSA publications.

Research Grants **(2 vacancies)**
Evaluates research grant applications and selects grant recipients.

Committee members must be able to attend the spring meeting and should have experience in directing research projects and in evaluating research grant applications.

Short Courses **(2 vacancies)**
Will direct, advise, and develop the Society's short course program, accept or reject proposals, recommend and implement guideline changes, and monitor the scientific quality of courses offered.

Committee members should be familiar with short courses or have short-course teaching experience.

Treatise on Invertebrate Paleontology **(1 vacancy)**
Advises the Treatise editor in all phases of *Treatise* policy including planning of new volumes as well as revisions; also gives advice on special editorial matters such as acceptance or rejection of contributed manuscripts.

Committee members should be familiar with and have a broad understanding of paleontology.

Young Scientist Award (Donath Medal) **(2 vacancies)**
Selects candidates for the Donath Medal.

Committee to have members covering a broad range of disciplines, i.e., geophysics, economic geology, stratigraphy, etc.

Committee members should have knowledge of young scientists with "outstanding achievement(s) in contributing to geologic knowledge through original research which marks a major advance in the earth sciences."

Joint Technical Program Committee GSA Representatives-at-Large **(3 vacancies)**
Supervises the review of abstracts for papers to be presented at the GSA annual meeting.

Representatives-at-large should be specialists in either computers, Precambrian geology, or paleoceanography/paleoclimatology. These subdisciplines are not represented by any of the associated societies or GSA divisions.

GSA Representative to the North American Commission on Stratigraphic Nomenclature **(1 vacancy)**
Must be familiar with and have expertise in stratigraphic nomenclature. ■

GSA COMMITTEE NOMINATION FORM

NOMINATION FOR GSA COMMITTEES FOR 1993

(One form per candidate, please. Additional forms may be copied.)

(Please Print)

Name of candidate ______________________
Address ______________________
____
Phone (   ) ______________________

COMMITTEE(S) BEING ☐ VOLUNTEERED or ☐ NOMINATED FOR (please check):

Committee(s):

Comment on special qualifications:

☐ GSA Fellow   Section affiliation:
☐ GSA Member   Division affiliation(s):

Brief summary of education:

Brief summary of work experience (include scientific discipline, principal employer—e.g., mining industry, academic, USGS, etc.):

If you are VOLUNTEERING to serve GSA, please give the name of two referees/references (please print):
Name: ______________________
Phone: (   ) ______________________
Name: ______________________
Phone: (   ) ______________________

If you are NOMINATING SOMEONE other than yourself to serve GSA, please give your name, address, and phone number (please print):
Name: ______________________
Address: ______________________
____
Phone: (   ) ______________________

DEADLINE: Please return this form to headquarters by July 15, 1992. To be considered, form must be complete in every respect.

AAPG & GSL

Special Reduced Prices to GSA Members for Geological Society of London publications...

Engineering Geology Special Publication:

Quaternary Engineering Geology

An excellent volume that focuses on engineering geology problems specifically related to deposits and processes common to the Quaternary. Features of this volume include:

- Overview of Quaternary deposits, from glacial tills to tropical residual soils
- Detailed case studies dealing with highways, tunnels, reservoirs, waste disposal, and ground water
- International field of researchers

Catalog #266 — SAVE $50 GSA price: $75

European Engineering Geology Directory

An indispensable reference tool for anyone whose business involves engineering geology. This sourcebook provides:

- 1,500 detailed entries of non-commercial organizations in engineering-related fields of the earth sciences
- A source of initial contacts for those wishing to work outside their own country
- An index of organizations; entries by both original name and its English translation

Catalog #269 — SAVE $14 GSA price: $20

Special Publication No. 54

Deformation Mechanisms, Rheology and Tectonics

"This Special Publication provides a large variety of very detailed information on the different mechanisms of rock deformation, ranging from the brittle field to plastic deformation and from theory to practical applications. A really special publication."—*Mitteilungen der Geologie und Bergbaustudenten,* Volume 37.

Catalog #256 — SAVE $57 GSA price: $85

Special Publication No. 58

Modern and Ancient Continental Shelf Anoxia (revised copy included)

A unique volume that addresses the problems of anoxia in the modern shelf and the deposits of ancient shelf sediments. Features:

- An improved understanding of shelf anoxia, owing to a unique combination of geological and biological approaches
- Assesses paleo-oxygenation in the marine sedimentary record, using paleontological, sedimentological, and geochemical criteria

Catalog #260 — SAVE $50 GSA price: $75

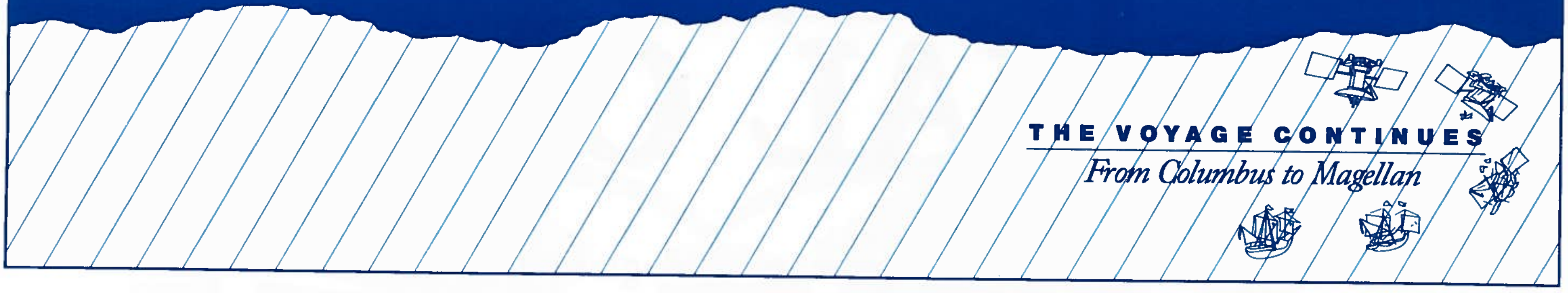
Geology of England and Wales

"This long-awaited, new volume presents the first detailed summary of the geology of England since the *Handbook of Geology of Great Britain,* published by Evans & Stubblefield in 1929. It is well produced with plentiful maps and illustrations."—*Geoscientist,* Volume 2, No. 2.

Catalog #273 — SAVE $49 GSA price: $75 (hardback)

Catalog #274 — SAVE $17 GSA price: $40 (softback)

GSA 1992 ANNUAL MEETING • CINCINNATI, OHIO



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 Education (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 (3), 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.

GSA Short Courses

All courses sponsored by GSA will be held immediately before or after the GSA Annual Meeting. Increase the benefits of attending the GSA meeting by participating in one of GSA's professional instruction programs. The courses are designed for several different professional levels. A GSA Certificate of Completion will be given to each registrant. We hope you will find a course that meets your needs.

Enrollment. Course participation is open to GSA members and nonmembers. Registration for the 1992 Annual Meeting is not required. Registration forms for the short courses and the annual meeting will appear in the August issue of *GSA Today*. HOWEVER, IF YOU WOULD LIKE TO REGISTER NOW, CONTACT THE COURSE REGISTRAR AND RECEIVE A GSA SHORT COURSE BROCHURE AND REGISTRATION FORM. Save significantly by registering in advance. On-site registration will be $25 additional and based on availability. PREREGISTRATION DEADLINE IS SEPTEMBER 25, 1992.

Cancellation. Fees will be refunded if we are notified by October 2. Registration substitutions may be made at any time. For more information, contact Edna Collis, Course Registrar, GSA headquarters, (303) 447-2020 or 1-800-472-1988.

Tax Deduction. Expenses for continuing professional education (including registration fees, travel, lodging, and meals) undertaken to maintain and improve professional skills are generally tax deductible in whole or in part (Treas. Reg. 1-162-5, Coughlin vs. Commissioner, 203F2d307).

Note: The GSA shuttle service does not begin until Sunday, October 25. However, most downtown GSA hotels are within easy walking distance of the Convention Center.

Geographic Information System Software: Facts and Fiction. Friday, October 23, 8 a.m. to 5 p.m., Saturday, October 24, 8 a.m. to 5 p.m., Sunday, October 25, 8 a.m. to 5 p.m., Cincinnati Convention Center.

GIS software is used extensively in academia to complete research work; in government to manage, analyze, and display spatial information; and in industry to explore and develop mineral, forest, agriculture, and land resources as well as environmental applications. This workshop will provide a technical forum where attendees will learn about GIS software capabilities and see actual demonstrations provided by vendors. Before the workshop, GIS software vendors will be invited to participate and given a choice of data sets and a set of problems to complete. Vendors will be required to submit a set of deliverables based on the problem set(s). Three data sets will be provided, and vendors can choose to work with any or all of the information. The data will cover petroleum, mining, and environmental applications.

- Day one—Introduction to the various GIS applications including maps, spatial information, earth science usage, examples of GIS, GIS components; data input and output; data sources, quality, and errors; spatial data models; DEMs; data management; GIS analysis functions; methods of data analysis and spatial modeling and interpolation; selecting and implementing GIS; sources of GIS; training needs for GIS personnel; pitfalls of selecting, installing, and using GIS; and capabilities of public domain and commercially available GIS.
- Days two and three—The vendors will demonstrate how they analyzed the data set(s).

Faculty: **Stephen A. Krajewski**, Vice-President, Industrial Ergonomics, Inc., Denver, Colorado; Ed.D., Pennsylvania State University. For the past eight years, Krajewski's work has focused on helping end-users select, install, and use microcomputers and technical applications software for geological, geophysical, engineering, and environmental applications. He has conducted workshops on microcomputer applications for several professional societies and for industries both in the United States and abroad. **Betty Gibbs**, President, Gibbs Associates, Boulder, Colorado; M.S., Colorado School of Mines. Since the early 1970s Gibbs has worked with mining companies as an engineer specializing in computer applications. Through her engineering career in surface and underground mining operations she has emphasized development of computer programs for mining applications and has used numerous commercial programs. Since 1982 she has evaluated in detail over 50 programs for a variety of mining-related computer programs. Gibbs writes columns and articles on computer applications for a wide variety of mining and related publications, as well as her own publications. As a consultant since 1982, Gibbs has provided computer-related services or information to over 400 companies.

Limit: 50. Fee: $275, students $255; includes course manual and lunch all three days.

Note: To allow the participating vendors as much time as possible to prepare, this course has an advance preregistration deadline of August 25. For advance preregistration, call the GSA Course Registrar today.

How to Do Anything with Mohr Circles (Except Fry an Egg): A Short Course About Tensors for Structural Geologists. Saturday, October 24, 8 a.m. to 5 p.m., Sunday, October 25, 8 a.m. to 12 noon, Cincinnati Convention Center. Cosponsor: *Structural Geology and Tectonics Division.*

This course is a hands-on exercise, in which participants will make their way through a short-course workbook, with the help of the instructor. It is intended for students and teachers of structural geology who know what a vector is but who have little or no understanding of second-order tensors. Tensors abound in structural geology, but there is hardly any room for instruction about them in typical geology curricula. This course presents a Mohr circle approach to the subject that is believed to be an efficient teaching approach, and rich in practical applications. Geometry is put before algebra, matching the bent of many structural geologists. Topics to be covered include:

- the general nature of tensors,
- the universality of Mohr circles for tensors,
- the finite deformation tensor,
- the velocity gradient tensor,
- the stress tensor,
- the tensor transformation rule,
- Mohr diagrams for three-dimensional tensors.

Faculty: **Winthrop D. Means**, Dept. of Geological Sciences, State University of New York at Albany; Ph.D., University of California, Berkeley. Means is the author of an elementary text on stress and strain theory (1976, Springer-Verlag) and co-author of a structural geology textbook (1976, Wiley). His research centers around the development of microstructure in deforming materials, using deformation apparatus mounted on a microscope stage. He has been among geologists publishing papers over the past ten years that have exploited Mohr's diagram and considerably enlarged its application.

Limit: 30. Fee: $150, students $130; includes two course manuals and lunch on Saturday.

Introductory Rock and Paleomagnetism. Saturday, October 24, 8 a.m. to 5 p.m., Sunday, October 25, 8 a.m. to 12 noon, Cincinnati Convention Center. Cosponsor: *Geophysics Division.*

Paleomagnetism is one of the most broadly applicable disciplines in geophysics, having uses in such diverse fields as geomagnetism, tectonics, paleoceanography, and sedimentology. Although the potential applications are quite varied, the fundamental techniques are remarkably uniform. Thus, a grounding in the basic tools and theory can open the door to a great many of the applications of paleomagnetic techniques. This introductory level course will cover the following material:

- introduction—review of the general properties of Earth's magnetic field and paleomagnetic coordinate systems,
- rock magnetism—sketch the basis for understanding how rocks get and stay magnetized, beginning with the response of all materials to external magnetic fields and extend this theory to understanding the behavior of permanently magnetized materials,
- field and laboratory techniques—description of the techniques used from field sampling to measuring of a variety of paleomagnetic data,
- paleomagnetic tricks—statistical analysis of the data and an overview of paleomagnetic plotting preferences,
- tectonic applications—summary of the most prevalent applications of paleomagnetic techniques to tectonic studies including apparent polar wander and continental drift, microplate studies and the potential for assessing tectonic strain using the anisotropy of magnetic parameters,
- stratigraphic applications—techniques of magnetostratigraphy and environmental magnetism. We will review the origin of the geomagnetic reversal time scale and potential uses of the magnetostratigraphic technique.

Faculty: **Lisa Tauxe**, Scripps Institution of Oceanography, La Jolla, California; Ph.D., Columbia University. Tauxe has been an active researcher and educator in the field of paleomagnetism since 1983. She is currently an associate professor of geophysics at Scripps and teaches several classes to undergraduates in addition to advanced classes and seminars for graduate students.

Limit: 40. Fee: $150, students $130; includes course manual and lunch on Saturday.

Environmental/Engineering Geology and Land-Use Planning—An Interface Between Science and Regulations. Sunday, October 25, 8 a.m. to 5 p.m., Cincinnati Convention Center. Cosponsor: *Engineering Geology Division.*

ATTENTION STUDENTS: The Engineering Geology Division will SUBSIDIZE THE FIRST FIVE STUDENTS WHO ARE VALID DIVISION MEMBERS. The student MUST PAY THE FULL COURSE FEE when registering, but will be reimbursed $50 after the GSA meeting by the Engineering Geology Division.

This course is aimed at those who are interested in understanding the use of geological principles in the regulatory context of land-use planning. Its purpose is to develop an improved understanding of how geological principles and simple data-gathering techniques can be incorporated into or guide land-use regulations. One emphasis will be upon concepts and sources of information. Another will be on information required for various types of land-use regulations and how this information can be applied to specific cases. Because of time constraints, a limited number of examples will be discussed, but from these should come an appreciation of broad principles. Topics covered include:

- NEPA and environmental impact statements—use and misuse,
- land-use planning in the broad context together with concepts of land capability,
- the coastal environment,
- slopes and land-use regulations—approaches,
- waste disposal—solid, low-level radioactive, and sewage,
- urban runoff—what do principles of sedimentation and geomorphology tell us?
- ground water—availability, long-term supply, conjunctive use, and protection,
- provision for building materials.

The ultimate objective of this course is to provide the participants insight into how they may develop appropriate approaches to the solution of land-use planning problems in their respective communities.

Faculty: **Charles W. Welby**, Dept. of Marine, Earth, and Atmospheric Sciences, North Carolina State University; Ph.D., Massachusetts Institute of Technology. During the past 20 years, Welby has taught an upper division course, Environmental Geology, and served on several municipal and county boards and task forces dealing with land-use planning matters and development of regulations. He is currently chairman of the Engineering Geology Division of GSA and chairman of the North Carolina Radiation Protection Commission. **Jerome V. DeGraff**, Forest Geologist, USDA Forest Service; M.S., Utah State University. DeGraff has spent the past 15 years providing geology input to land-use issues in National Forests in Utah and California. More recently, he has served as a technical specialist to governmental and international agencies involved with

Annual Meeting *continued on p. 110*

Annual Meeting *continued from p. 109*

regional development issues in developing countries. He is chairman-elect of the Engineering Geology Division and Manager of the Landslide Committee of the Association of Engineering Geologists.

Limit: 50. Fee: $130, students $110; includes course manual and lunch.

Paleosols for Sedimentologists. Sunday, October 25, 8 a.m. to 5 p.m., Cincinnati Convention Center. Cosponsor: *Sedimentary Geology Division.*

ATTENTION STUDENTS: The Sedimentary Geology Division will SUBSIDIZE ALL STUDENTS WHO ARE VALID DIVISION MEMBERS. The student MUST PAY THE FULL COURSE FEE when registering, but will be reimbursed $50 after the GSA meeting by the Sedimentary Geology Division. To be reimbursed, students must apply in writing to Mary J. Kraus, Dept. of Geology, University of Colorado, Boulder, CO 80309-0250.

This course is intended as an introduction for sedimentologists and stratigraphers who are concerned primarily with pre-Quaternary siliciclastic depositional systems and basin analysis but have little or no previous experience with paleosols. The course focuses on the fundamental aspects of paleosol description, recognition, and interpretation, concentrating on field and petrographic features, key terminology, and utility of paleosols for reconstructing basin history and paleoclimate. Participants will have ample opportunity to examine pedogenic features in hand sample and thin section, as well as representative profiles of soils and paleosols. Specific topics to be covered are:

- description and recognition of basic pedogenic features, such as root traces, peds, cutans, and nodules,
- identification and origin of master soil/paleosol horizons, including A, E, spodic B, oxic B, vertic B, argillic B, calcic B, and C,
- classification of paleosols,
- variables controlling soil/paleosol development and preservation, such as composition and grain size of parent, landscape variability, climate, time, and diagenesis,
- case study of the interpretation of Plio-Pleistocene paleoclimate using field, petrographic, and isotopic characteristics of paleosols of the southern Rio Grande rift.
- case study of the role of tectonics on the development of paleosols in Plio-Pleistocene alluvial-fan and fluvial strata of the southern Rio Grande rift.

Faculty: **Greg H. Mack**, Dept. of Earth Sciences, New Mexico State University, Las Cruces; Ph.D., Indiana University. Mack specializes in interpretation of the influence of tectonism and paleoclimate on depositional environments of Phanerozoic siliciclastic sediment. His current research involves the use of paleosols to interpret Permian, Cretaceous, and late Tertiary paleoclimate. **W. Calvin James**, Dept. of Geological Sciences, Ohio State University, Columbus; Ph.D., Indiana University. James's research focuses on the modification of siliciclastic rock texture and composition by pedogenic and early diagenetic processes. His current research includes pedogenesis and early diagenesis of nonmarine sedimentary rocks of the Rio Grande rift.

Limit: 30. Fee: $180, students $160; includes course manual and lunch.

Phase I—Preliminary Site Assessments (PSAs). Sunday, October 25, 8 a.m. to 5 p.m., Cincinnati Convention Center.

This course is designed for entry-level professionals in the environmental field (i.e., geologists, hydrogeologists, and environmental scientists) who are interested in learning about the importance of conducting PSAs as well as how they are conducted. Attendees will learn how to evaluate a property to assess whether it is or could be contaminated (soils and/or ground water). Attendees will address important considerations relating to approach and rationale for identifying environmental knowns about a subject property and how to use available hydrogeologic/geologic and public domain information to identify or speculate on potential unknowns. This course will present general concepts technical professionals should know to meet expected "due diligence" requirements. Topics covered:

- what are Phase I Preliminary Site Assessments?,
- why are Phase I Preliminary Site Assessments performed?,
- environmental regulations (overview),
- liability issues,
- who requests Phase I Preliminary Site Assessments?,
- who performs Preliminary Site Assessments?,
- how are Phase I Preliminary Site Assessments performed?,
- reporting requirements,
- case studies.

Faculty: **Jeffrey L. Peterson**, Environmental Manager, GeoStrategies, Inc., Hayward, California; M.S., California State University. Currently Peterson's responsibilities include technical guidance and mentorship to the more than 30 professional geologists, hydrogeologists, engineers, and environmental scientists employed at GeoStrategies. Peterson is a registered professional geologist, a registered environmental assessor, and a certified environmental inspector. He has been an instructor at the University of California—Extension, Santa Cruz, in the Hazardous Materials Certification Program, and is a contributing author of the book *Principles of Contaminant Hydrogeology.*

Limit: 40. Fee: $155, students $135; includes course manual and lunch.

Practical Tracing of Ground Water, with Emphasis on Karst Terranes. Sunday, October 25, 8 a.m. to 5 p.m., Cincinnati Convention Center. Cosponsor: *Hydrogeology Division.*

ATTENTION STUDENTS: The Hydrogeology Division will SUBSIDIZE THE FIRST STUDENT WHO IS A VALID DIVISION MEMBER. The student MUST PAY THE FULL COURSE FEE when registering, but will be reimbursed $50 after the GSA meeting by the Hydrogeology Division.

Aimed at the professional geologist or hydrologist, this course will introduce participants to the applications of tracer tests and practical mechanics of how to conduct ground-water tracing tests in karst terranes, granular aquifers, and fractured rocks, as well as how to select the most appropriate tracer, how to interpret tracer tests that are positive, and how to interpret those that are negative. Greatest emphasis will be on terranes in limestone. Topics covered:

- principles of tracing,
- toxicity of tracers,
- cost of tracer investigations,
- simultaneous use of several tracers,
- interpretation of tests in which tracer is recovered,
- sources of tracers,
- introduction to fluorescent dyes,
- introduction to other tracers,
- applications of tracing to ground-water monitoring,
- case studies.

Faculty: **James F. Quinlan**, Quinlan & Associates, Nashville, Tennessee; Ph.D., University of Texas at Austin. Quinlan is a self-employed consulting hydrogeologist. Previously, for 16 years, he was a research geologist for the National Park Service at Mammoth Cave, Kentucky. Quinlan has worked in karst terranes of more than 26 states, Puerto Rico, Guam, and 23 foreign countries. He is author or co-author of more than 180 publications on karst-related topics and tracing. He and co-author Ralph Ewers received the GSA Engineering Geology Division's E.B. Burwell, Jr. Award in 1986 for a paper on the principles of ground-water monitoring in karst terranes. A Fellow of GSA and a former member of the Board of Directors of the Association of Ground Water Scientists and Engineers, Quinlan has specialized in environmental applications of tracer tests, evaluation of waste disposal sites in limestone terranes, and sinkhole development and remediation. **E. Calvin Alexander, Jr.**, Dept. of Geology and Geophysics, University of Minnesota, Minneapolis; Ph.D., University of Missouri. A professor at the University of Minnesota since 1973, Alexander is author or co-author of more than 100 publications on isotopic investigations, ground-water studies, and environmental geology. His research includes isotopic studies of ground-water age or residence times and tracing in a variety of aquifers and hydrogeological settings.

Limit: 50. Fee: $135, students $115; includes course manual and lunch.

Environmental Applications of Shallow Seismic Reflection. Friday, October 30, 8 a.m. to 5 p.m., Hyatt Regency Hotel. Cosponsor: *Geophysics Division.*

This course provides a practical overview of the types of seismic reflection surveys that are commonly applied in shallow geological settings. The decades-old use of reflection techniques in exploration for petroleum and other mineral resources is well established in contrast to their application to near-surface environmental problems, which dates only from the mid-1980s. An overview of the basic theoretical background without the use of calculus will be followed by discussions of instrumentation, shallow seismic energy sources, and field parameter design. A discussion of seismic data processing emphasizes the unique processing considerations that are necessary for shallow reflection work. The main topics to be covered will include:

- elastic parameters and seismic waves,
- field parameters for shallow reflection,
- seismic energy sources for shallow applications,
- pitfalls and noise,
- processing shallow seismic reflection data,
- environmental case histories,
- shallow-S-wave reflections,
- critical path management of geophysical field work,
- projected trends, uses, and research needs.

Faculty: **Don W. Steeples**, Chief Geophysicist, Kansas Geological Survey, Lawrence; Ph.D., Stanford University. Since 1977, Steeples has specialized in shallow high-resolution seismic reflection research. He has done consulting and/or contract research for Amoco Production Company, Arco, Chevron, Conoco, Getty Oil, Mobil Research, Phillips Petroleum, Los Alamos and Livermore National Laboratories, U.S. Army Corps of Engineers, U.S. Bureau of Reclamation, U.S. Geological Survey, and others. He is the co-founder and president of Great Plains Geophysical, Inc., a consulting firm. Steeples also operates a western Kansas wheat farm. **Richard D. Miller**, Chief, Exploration Services, Kansas Geological Survey, Lawrence; M.S., University of Kansas. Since 1983, Miller has managed the Kansas Geological Survey's high-resolution seismic reflection field crew. He is primarily responsible for processing Survey-acquired seismic-reflection data. He has also been a consulting geophysicist—specializing in shallow high-resolution seismic reflection acquisition and CDP processing—to a score of environmental, engineering, oil, transportation, and mining companies. His scientific interests include both P- and S-wave shallow high-resolution seismic reflection data acquisition and CDP processing for applications to engineering and ground-water problems, acquisition of high-resolution seismic reflection data for shallow stratigraphic studies, cost-effective acquisition techniques for shallow seismic reflection studies, and crustal studies involving earthquake energy propagation. He has jointly published more than 30 papers and obtained research funding in excess of $1.2 million. He is a member of SEG and KWWA.

Limit: 50. Fee: $145, students $125; includes course manual and lunch.

CINCINNATI

CINCINNATI MUSEUM OF NATURAL HISTORY

A Taste of Cincinnati

October 28, GSA Annual Meeting Special Event

Join us for a special evening at the Cincinnati Museum of Natural History located at the renovated Union Terminal. From a delightful menu of activities, *you* can create the perfect evening. Delicious food, wonderful exhibits, good music, and more await you. After enjoying a true Cincinnati buffet, choose several of many activities offered. You will have a tough time fitting it all in! Explore the fascinating museum with a walk through the Ice Age or the incredible Kentucky limestone cave, take in the African Reflections exhibit, visit with friends while listening to quiet music, or try the latest dance steps to a livelier band. *You* decide how to spend the perfect evening!

Next Stop... Union Terminal

Mya Poe, Cincinnati Museum Center

When Cincinnati opened its impressive new Museum Center two years ago at Union Terminal, the residents wondered if the beautiful, domed building could survive on its own after 18 years of quiet neglect.

One of the last grand municipal train stations built during the Railway Era, Union Terminal has endured for over 60 years. The classic half-dome building was designed to accommodate 17,000 passengers and 216 trains per day. When the station opened in 1933, it was proclaimed "America's most beautiful railroad station."

Indeed, representing the best in Art Deco, Union Terminal is a building of superlatives. The highest half-dome in the world, it was a tribute to the architectural genius of New Yorkers Alfred Fellheimmer and Steward Wagner and Philadelphian Paul Cret. In addition to its dramatic curves and grand symmetry, the Terminal housed the largest collection of secular mosaics in the United States. The tile mosaics created by Winold Reiss and Pierre Bourdelle included two 105-foot rotunda murals, 14 mosaics of Cincinnati industry, two mosaics from the famous Rookwood Pottery foundry, and a host of other small mosaics, carvings, and paintings. Moreover, with a then-hefty price tag of $41 million, Union Terminal was one of the most expensive train stations ever built. Yet, this masterpiece struggled through a tough, uncertain history—until now.

Union Terminal was dedicated on March 31, 1933. Business was brisk during the war years of the 1940s, when many area residents departed and returned from military service through the station. However, by the late 1950s, with the decline of passenger trains, it became obvious that the Terminal faced a dim future as a rail center. When the station closed in 1972, and its 14 mosaic murals were removed and relocated at the Greater Cincinnati Airport (to prevent their likely destruction), someone scrawled a wry elegy across the "closed" sign: "Cincinnati Union Terminal: Died Young."

Hoping to save the building from demolition, city officials purchased ads in the *Wall Street Journal*:

The Museum Center, 1991. *The Museum Center.*

Cincinnati Museum of Natural History Exhibit, The Cavern. *Cincinnati Museum of Natural History.*

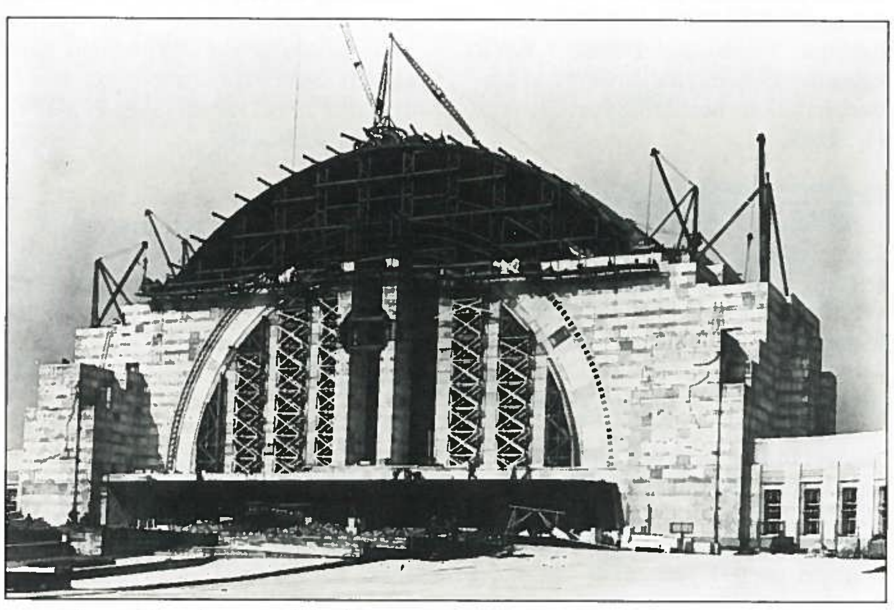
"World-famous Cincinnati Union Terminal for lease—$1 per year." Developers jumped at the opportunity, and for a while the Terminal was even a shopping center. However, none could make it a success in the recession-ridden early 1980s. Once again, Union Terminal had become a sad reminder to Cincinnati of its fading glory.

The Terminal's fate took a turn for the better when the Cincinnati Museum of Natural History and The Cincinnati Historical Society combined resources and developed a joint museum project plan. When the initial phase of the Museum Center opened in November 1990 with an OMNIMAX Theater and some temporary exhibits, such as the immensely popular Dinamation, the huge crowds testified that Union Terminal was alive and well again.

Today, with more than 500,000 square feet (approximately 14 football fields), the Museum Center is home to the Cincinnati Museum of Natural History (CMNH), the Cincinnati Historical Society Museum and Library (CHS), the Robert D. Lindner Family OMNIMAX Theater, and the Cincinnati Arts Consortium Gallery. Food service, museum shops, and a visitor's center help to fill out the majestic rotunda.

The Terminal's original movie theater, now the Scripps Howard Newsreel Theater, has been restored and is used for special film presentations, live programs, and previews of coming attractions at the Museum Center. Another popular location, the Rookwood Tea Room, has been returned to its former splendor and now serves as an ice cream parlor. Even the whistles of trains can once again be heard echoing around the building. Amtrak, the national rail service, returned passenger service to the station in July 1991.

With a fanfare of events, the Museum Center had its official Grand Opening ceremonies on November 2, 1991. Both the CMNH and CHS premiered several ambitious, permnent walk-through exhibits. CMNH unveiled its replicas of a Kentucky limestone cavern and sprawling glacier with an ice cave, neighboring forest, and array of extinct ice-age animals, while CHS introduced the story of the city's early history with dramatic life-size recreations of the first settlements and of the Cincinnati riverfront during the mid-1800s. In that opening month alone, the Museum Center welcomed more than 50,000 visitors to explore its "worlds of wonder."



Union Terminal Station, 1932. *Cincinnati Historical Society.*

The new Museum Center has given CMNH the luxury of extra space that it previously lacked to develop its highly innovative exhibits. Featuring exhibits for all ages in many areas of interest, CMNH offers visitors an interactive, educational, and fun experience.

At the Museum's 7200-square-foot Children's Discovery Center, children can gain hands-on insights about how the human body functions and how humans have changed the environment in the past 500 years. The exhibit even includes "Captain Digesto," a pinball machine that shows how the digestive system works.

Other CMNH exhibits—including *Earth Stories*, *The Cavern*, and *Cincinnati's Ice Age*—are strongly based upon the interactive element. In fact, by walking through the damp, dark subterranean passages of the cavern or out of the chilly, winding walkways of the ice cave onto the glacial outwash plain and forest beyond, visitors can experience the sights, sounds, smells, and changing temperatures of these environments. Artifacts, fossils, computers, interactive games, and labeled descriptions all help to involve visitors in the learning experience.

On October 28, 1992, join GSA and the Cincinnati Museum of Natural History for a Taste of Cincinnati. From a wonderful menu of activities, you can design your own evening, making it one that you and your guest will remember for years to come. Whether it's spending time with a colleague, enjoying the foods of Cincinnati, exploring CMNH (leisurely field work!), or enjoying good music, it's all there for you.

Cincinnati's Union Terminal: a stunning, superlative, timeless beauty. The Museum Center has it all, plus the Cincinnati Museum of Natural History—a museum that strives to be as world class as the building it calls home.

GSA Penrose Conferences

May 1992

The Origin and Evolution of the Coast Mountains, British Columbia, Yukon, and Alaska, May 16–22, 1992, Bowen Island, British Columbia. Information: George E. Gehrels, Dept. of Geosciences, University of Arizona, Tucson, AZ 85721, (602) 621-6026, fax 602-621-2672; Maria Luisa Crawford, Dept. of Geology, Bryn Mawr College, Bryn Mawr, PA 19010, (215) 526-5111, fax 215-526-5086; James W.H. Monger, Geological Survey of Canada, 100 West Pender Street, Vancouver, B.C. V6B 1R8, Canada, (604) 666-6743 or 0529, fax 604-666-1124.

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

May

First Canadian Symposium on Geotechnique and Natural Hazards, May 6–9, 1992, Vancouver, British Columbia. Information: Organizing Secretary, Geohazards '92, 970 Burrard St., Vancouver, BC V6Z 1Y3, Canada, (604) 663-1651, fax 604-663-1940.

Institute on Lake Superior Geology Annual Meeting, May 7–9, 1992, Hurley, Wisconsin. Information: Albert B. Dickas, 203 Administration, University of Wisconsin–Superior, Superior, WI 54880, (715) 394-8311, fax 715-394-8107.

Third Goldschmidt Conference, May 8–10, 1992, Reston, Virginia. Information: Bruce R. Doe, U.S. Geological Survey, 923 National Center, Reston, VA 22092, (703) 648-6205, fax 703-648-6191.

Lower Palaeozoic of Ibero-America (International Conference, IGCP-IUGS/UNESCO) and International Workshop: Natural Resources of the Circum-Gondwanan Lower Palaeozoic, May 8–12, 1992, Mérida, Spain. Information: Juan Carlos Gutiérrez-Marco, Instituto de Geología Económica, Facultad de Ciencias Geologicas, 28040-Madrid, Spain, fax 34-1-5439162.

15th Annual Symposium on Systematics and Process, May 9, 1992, Chicago, Illinois. Information: Vivian Ploense, Collections and Research, Field Museum of Natural History, Roosevelt Road at Lake Shore Drive, Chicago, IL 60605-2496, (312) 922-9410, x416.

GSA Cordilleran Section Meeting, May 11–13, 1992, Eugene, Oregon. Information: A. Dana Johnston, Dept. of Geological Sciences, University of Oregon, Eugene, OR 97403-1272, (503) 346-5588.

Hydrocarbon and Mineral Resources of the Uinta Basin Symposium, May 11–13, 1992, Vernal, Utah. Information: Roger Bon, Utah Geological Survey, 2363 Foothill Dr., Salt Lake City, UT 84109-1491, (801) 467-7970.

GSA Rocky Mountain Section Meeting, May 13–15, 1992, Ogden, Utah. Information: Sidney R. Ash, Dept. of Geology, Weber State University, Ogden, UT 84408-2507, (801) 626-6908.

International Congress on Technology and Technology Exchange, May 13–15, 1992, Evry, France. Information: Janet Weisgerber, (412) 391-2913; Ruby Glasgow, (412) 795-5300, 7125 Saltsburg Rd., Pittsburgh, PA 15235-2297, fax 412-795-5302.

10th Industrial Minerals International Congress, May 17–20, 1992, San Francisco, California. Information: Industrial Minerals, Park House, Park Terrace, Worcester Park, Surrey KT4 7HY, England, phone 081 330 4311, fax 081-337-8943, telex 21383, or Industrial Minerals, 220 Fifth Avenue, New York, NY 10001, 1-800-METAL 25, (212) 213-6202, fax 212-213-6273.

Pan-American Current Research on Fluid Inclusions (PACROFI IV), May 22–24, 1992, Lake Arrowhead, California. Information: Michael A. McKibben, Dept. of Earth Sciences, University of California, Riverside, CA 92521-0423, (714) 787-3444, fax 714-787-4324.

The Euramerican Coal Province: Controls on Tropical Peat Accumulation in the Late Paleozoic, May 24–27, 1992, Wolfville, Nova Scotia, Canada. Information: John H. Calder, Nova Scotia Dept. of Mines and Energy, P.O. Box 1087, Halifax, Nova Scotia B3J 2X1, Canada, (902) 424-5364, fax 902-424-0528; Martin R. Gibling, Dept. of Geology, Dalhousie University, Halifax, Nova Scotia B3H 3J5, Canada, (902) 494-2355.

Second International Symposium on Environmental Studies of Tropical Rainforests (UNCED '92), May 24–29, 1992, Rio de Janeiro, Brazil. Information: Organizing Committee, Caixa Postal/P.O. Box 3591, Av. Pasteur, 404/3º (CPRM) Urca, Rio de Janeiro, RJ, CEP 22290, Brasil, phone (021) 295-4347, (021) 295-0032, R 425/243, telex (021) 38806 SFLA BR, fax 021-262-5946.

Project PANGEA (GSGP) Research Workshop, May 24–29, 1992, Lawrence, Kansas. Information: Project PANGEA, P.O. Box 5061, Station A, Champaign, IL 61825-5061, (217) 333-2076.

6th Congress of the Geological Society of Greece with Emphasis on the Geology of the Aegean, May 25–27, 1992, Athens, Greece. Information: D. Papanikolaou, Dept. of Geology, University of Athens, Panepistimioupoli, Zografou, 15784 Athens, Greece, phone (01) 72.42.743, fax (+3.01) 72.42.743.

Geological Association of Canada–Mineralogical Association of Canada Joint Annual Meeting, May 25–27, 1992, Wolfville, Nova Scotia, Canada. Information: Wolfville '92, Gary Sonnichsen, Acadia University, Wolfville, Nova Scotia B0P 1X0, Canada, (902) 542-1902, fax 902-542-1454, E-mail: WFVILL92@ace.acadiau.ca.

Third International Conference on Engineering, Construction and Operations in Space, May 31–June 4, 1992, Denver, Colorado. Information: Stein Sture, SPACE 92 Technical Co-Chairman, Dept. of Civil, Environmental, and Architectural Engineering, University of Colorado, Boulder, CO 80309-0428, (303) 492-7651, fax 303-492-7317.

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.

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. (*Abstract deadline: May 15, 1992.*)

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, Durham, England, September 13–18, 1992. 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.

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

■ **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.

April

■ **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

■ **International Basin Tectonics and Hyrdrocarbon 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.

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 AA-40315.

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

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

GSA SECTION MEETINGS

■ 1992

Cordilleran, Eugene, Oregon
Eugene Hilton Conference Center, May 11–13

A. Dana Johnston, Dept. of Geological Sciences, University of Oregon, Eugene, OR 97403-1272; (503) 346-5588

Rocky Mountain, Ogden, Utah
Radisson Suite Hotel, May 13–15

Sidney R. Ash, Dept. of Geology, Weber State University, Ogden, UT 84408-2507; (801) 626-6908

■ 1993

South-Central	March 15–16	Texas Christian University, Fort Worth, Texas
Northeastern	March 22–24	Sheraton Inn Conference Ctr., 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

May *BULLETIN* and *GEOLOGY* Contents

Are you missing out? If you're not a *Bulletin* or *Geology* subscriber, you may miss the articles listed below. But it's not too late, you can still subscribe and receive all 1992 issues, even if you've already paid your 1992 dues. Just call Membership Services today at 1-800-472-1988.

The Geological Society of America
BULLETIN
Volume 104, Number 5, May 1992

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GEOLOGY

VOLUME 20
NO. 5
P. 385–480
MAY 1992

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The Department of Geological Sciences invites applications for a two-year temporary faculty position commencing September 1992. The position requires a Ph.D. Teaching responsibilities include three courses (quarter-system) per year, and applicants must be qualified to teach: history of the earth (non-majors and majors); stratigraphy/basin analysis; and an upper-division course in sedimentary processes/depositional environments.

Applicants should send a statement of research and teaching interests, curriculum vitae, and names of three references to Chairman, Department of Geological Sciences, AJ-20, University of Washington, Seattle, WA 98195. Priority will be given to applications received before May 31, 1992.

University of Washington is building a culturally diverse faculty and strongly encourages applications from female and minority candidates. AA/EOE.

UNIVERSITY OF WASHINGTON
Lecturer in Geological Sciences

The Department of Geological Sciences invites applications for a faculty position as Lecturer. This is a nine-month, non-tenure track position, renewable annually. Applicants must have a Ph.D. by the time the appointment commences on September 16, 1992. The responsibilities will include teaching approximately three large-enrollment (75 to 500 students), lower-division courses per year, and coordinating the department's teaching assistant program, which currently encompasses about 20 TAs. We want to enhance and expand our lower-division curriculum serving undergraduate non-majors in the University; existing courses include Introduction to Physical Geology, Geology of the Northwest, Geology of National Parks, The Great Ice Age, and Planetary Geology. We want to hire a person who can demonstrate superior abilities as a lecturer in large classes and who can provide evidence of his or her dedication to undergraduate teaching. These qualities will be the primary criteria we use for initial appointment and future evaluations of merit.

Applicants should send a statement of teaching accomplishments and interests, curriculum vitae, and the names of three referees who can specifically evaluate teaching and lecturing abilities to the Chairman, Department of Geological Sciences, AJ-20, University of Washington, Seattle, WA 98195. Priority will be given to applications received before May 31, 1992.

University of Washington is building a culturally diverse faculty and strongly encourages applications from female and minority candidates. AA/EOE.

UNIVERSITY OF SOUTH CAROLINA — AIKEN

Assistant Professor, tenure track, Ph.D. with concentration in mineralogy, petrology or structure, start fall 1992. To teach introductory geology and occasional upper level mineralogy, petrology or structure courses. The successful candidate will be expected to maintain an ongoing research program in the context of an undergraduate institution. Professional interest in conducting research related to environmental problems is desirable. Interest and experience in working with practicing precollege teachers also is desirable. Send letter of application, transcripts, three letters of reference, and a brief description of research interests by June 8 to Chair, Geology Search Committee, Dept. of Physical Sciences, USC-Aiken, Aiken, SC 29801. USCA is an AA/EO employer.

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/EOE employer; minorities and women encouraged to apply.

Apply F. Andrew Schoolmaster, Department of Geography, Box 5277, Denton, TX 76203-5277.

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Qualifications: A Ph.D. in geology, engineering, hydrology, hydrogeology, or a closely related field is required. A broad based hydrology background and interest in water quality, contaminant transport, and field applications are desirable. Good oral and written communication skills are necessary.

Salary: Commensurate with experience and within the Assistant/Associate Cooperative Extension Specialist rank in the University of California.

Date Available: July 1, 1992.

Application: Applications and inquiries should be directed by May 31, 1992 to Larry Schwankl, Search Committee Chair, Cooperative Extension Specialist position in Hydrology/Hydrogeology, Department of Land, Air, and Water Resources, University of California, Davis, California 95616, telephone (916) 752-1130. Applications should include a resume, official undergraduate and graduate academic transcripts; statements of research and teaching interests and experience; copies of publications and reports; a summary or abstracts of the Ph.D. dissertation; and names, addresses, and telephone numbers of at least three references.

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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 to 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.

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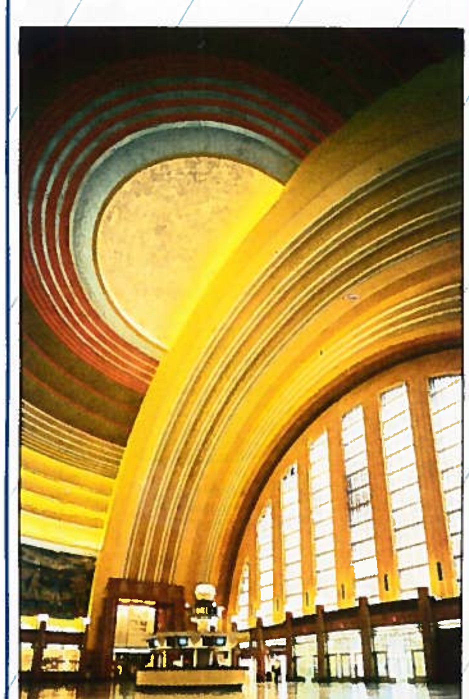

CINCINNATI

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