

# GSA TODAY

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View of the Transantarctic Mountains to the northwest from the summit of Mt. Griffith (3095 m, lat 85°53'S, long 155°30'W). Most of the exposure in the foreground is plutonic rock of the Ross orogen. The dark cliffs of Breyer Mesa in the background are topped by an exhumed part of the mid-Paleozoic Kukri peneplain, formed by erosion following the Ross orogeny. On the skyline is the Rawson Plateau, containing late Paleozoic to Triassic sedimentary rocks of the Beacon Supergroup which overlie the unconformity. Amundsen Glacier flows from left to right in the middle ground of the photo. *Photo by Ed Stump.*

## The Ross Orogen of the Transantarctic Mountains in Light of the Laurentia-Gondwana Split

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### ABSTRACT

The recent hypothesis that the margins of the western United States and Antarctica were conjugate prior to the breakout of Laurentia from Gondwana is consistent with the record of events in the Late Proterozoic–early Paleozoic Ross orogen of the Transantarctic Mountains. Isotopic data indicate that basement to the Ross orogen is 2.0–1.7 Ga continental crust, temporarily matching basement in the southwestern United States. The onset of activity in the Ross orogen was Late Proterozoic basin development with widespread deposition of turbidites. Rifting within this basin is indicated by bimodal volcanism dated at ~750 Ma, coincident with volcanism in the basal Windermere Supergroup in North America. Actual separation is presumed to have occurred shortly before accumulation of Early Cambrian platform carbonates on the margins of both continents. Subsequent to this, the histories of the two margins evolved independently. Limited data indicate that plutonism had begun in the Ross orogen by ~550 Ma. By the Middle Cambrian an association of carbonates and bimodal volcanics was accumulating outboard of the Early Cambrian carbonate platform. Deformation, metamorphism, and voluminous plutonism culminated during the Late Cambrian with cooling ages ~500 Ma. This activity, recorded throughout widespread parts of Gondwana, occurred while the western margin of Laurentia remained passive.

### INTRODUCTION

Marking the boundary between East and West Antarctica, the Transantarctic Mountains are a major intra-continental chain that extends for 3500 km across Antarctica, reaching heights >4000 m (Fig. 1). The interior or plateau flank of the Transantarctic Mountains dams the East Antarctic Ice Sheet; the front of the range rises with spectacular escarpments from the Ross and Weddell embayments and the intervening West Antarctic Ice Sheet. The present-day mountains have undergone episodic uplift since the Early Cretaceous (Stump and Fitzgerald, 1992) and have been modeled as a major rift shoulder structure (Fitzgerald et al., 1986; Stern and ten Brink, 1989). The unifying geological feature of the mountains is a middle Paleozoic erosion surface (Kukri peneplain) that separates gently tilted, Devonian to Triassic sedimentary rocks (Beacon Supergroup) and Jurassic continental tholeiites (Ferrar Group) from a Proterozoic to early Paleozoic orogenic belt (Ross orogen) (see photograph). The recent hypothesis (SWEAT) by Moores (1991), amplified by Dalziel (1991)

and Hoffman (1991), that the western United States was contiguous with Antarctica during the Proterozoic, with subsequent rifting and continental drift, provides a powerful framework for interpretation of the geological history of the Ross orogen of the Transantarctic Mountains.

On a local scale, mapping in these mountains is similar to the Basin and Range, in that very good outcrops are separated by expanses of cover (ice or alluvium). On a continental scale, however, the breadth of the Transantarctic Mountains is narrow (300–0 km) compared to the Cordillera, so the spatial

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record of the Ross orogen is incomplete, and the continuity of certain tectono-stratigraphic sequences along the mountains is not observable. Nevertheless, the present-day Transantarctic Mountains appear to follow closely the axis of the Ross orogen, with younger accreted and/or displaced blocks composing West Antarctica, and Proterozoic and Archean cratonic rocks making up the outcrops around the perimeter of East Antarctica, and presumably the crust beneath the East Antarctic Ice Sheet.

A long-standing view of the Ross orogen is that it developed along a passive continental margin that was affected by two orogenic episodes (e.g., Elliot, 1975)—the first in the Late Proterozoic (Beardmore orogeny), and the latter in Cambrian-Ordovician time (Ross orogeny). How the passive margin originated was not directly considered. Moreover, interpretations of the timing and extent of the Beardmore orogeny have undergone repeated revisions, and the true nature of this event is still uncertain.

GEOLOGIC HISTORY

Sm-Nd model ages from granitic rocks in northern Victoria Land and the central Transantarctic Mountains suggest that continental crust of Early Proterozoic age (2.0–1.7 Ga) underlies most of the mountain range (Borg et al., 1990; Borg and DePaolo, 1991). The same technique indicates that much of the Cordillera in the southwestern United States is underlain by rocks of similar age (Bennett and DePaolo, 1987). A Proterozoic supercontinent with these two areas matched is supported by these data. Direct links of age provinces may be difficult, however, for as Borg and DePaolo (1991) point out, fragments may have been displaced obliquely along the margins during the breakup.

The one place in the Transantarctic Mountains where Early Proterozoic age rocks are known in outcrop is in the Miller and Geologists ranges, where a varied suite of multiply deformed, high-grade metamorphic rocks (Nimrod Group) is dominated by quartzofeldspathic schists and gneisses, but includes amphibolites, marbles, calc-schists, and quartzites. The rocks carry a pervasive shear fabric through much of their outcrop (Goodge et al., 1991). A Pb-Pb zircon age on the Aurora orthogneiss indicates magma generation within part of the Nimrod Group at ~1.7 Ga (Goodge et al., 1991). It is possible that metamorphic rocks with similar lithologies (Koettlitz and Skelton groups) cropping out throughout southern Victoria Land are correlative with the Nimrod Group. In various studies the Koettlitz and Skelton groups have been considered to be higher grade equivalents of Late Proterozoic pelites and Cambrian carbonates exposed to the south of Byrd Glacier (e.g., Grindley, 1981; Laird, 1981), although no fossils have been found in the carbonates to substantiate this. Recently, Rowell et al. (1991) demonstrated that the Skelton Group underwent multiple deformation during the Proterozoic. This precludes a Cambrian age and suggests correlation with Nimrod Group, but early Beardmore sedimentation (see below) is another possibility for the metasedimentary rocks in southern Victoria Land.

The initial sedimentation in the Ross orogen occurred in a deep-water basin parallel to the Transantarctic Mountains, in which quartzose turbidites of the Beardmore Group were deposited from the Pensacola Mountains (Patuxent Formation) through

the Queen Maud Mountains (La Gorce Formation) to at least the central Transantarctic Mountains (Goldie Formation) (Schmidt et al., 1965; Smit and Stump, 1986; Gunn and Walcott, 1962). These rocks are lacking in rock fragments and have a lithology characteristic of a metamorphic-plutonic source. Conformably underlying the Goldie Formation in the Cobham Range, just outboard of the Miller and Geologists ranges, is the Cobham Formation, containing carbonates, quartzites, and pelites indicative of a shallow-water, marginal facies of the basin (Laird et al., 1971). Whether these rocks have exposed correlatives in southern Victoria Land, as mentioned above, or in northern Victoria Land, as discussed below, is uncertain. Of note, a diamictite of possible glaciogenic origin has been found within the Goldie Formation on Cotton Plateau in close proximity to marine volcanics (Stump et al., 1988).

That rifting occurred during formation of the Beardmore basin is suggested by bimodal volcanism in the Patuxent Formation (Storey et al., 1991), basalts in the Goldie Formation in the Ramsey Glacier area (Wade and Cathey, 1986), and bimodal volcanism in the Goldie Formation at Cotton Plateau (Stump et al., 1991). The basalts in the Goldie Formation are intruded by gabbro, both of which have Sm/Nd ratios and initial  $\epsilon_{Nd}$  values indicative of generation in an oceanic setting (Borg et al., 1990). The basalts of the Patuxent Formation have continental affinities (Frischbutter and Vogler, 1985; Storey et al. 1991).

The best isotopic estimate of the age of the Beardmore Group is from a Sm-Nd mineral isochron on the gabbro within the Goldie Formation with a date of  $762 \pm 24$  Ma (Borg et al., 1990), indicating that sedimentation had begun by that time and suggesting that most if not all of the deposition occurred in the Late Proterozoic. On the basis of isotopic data from meta-sedimentary rock, Borg et al. (1990) suggested, pre-SWEAT, that the Beard-

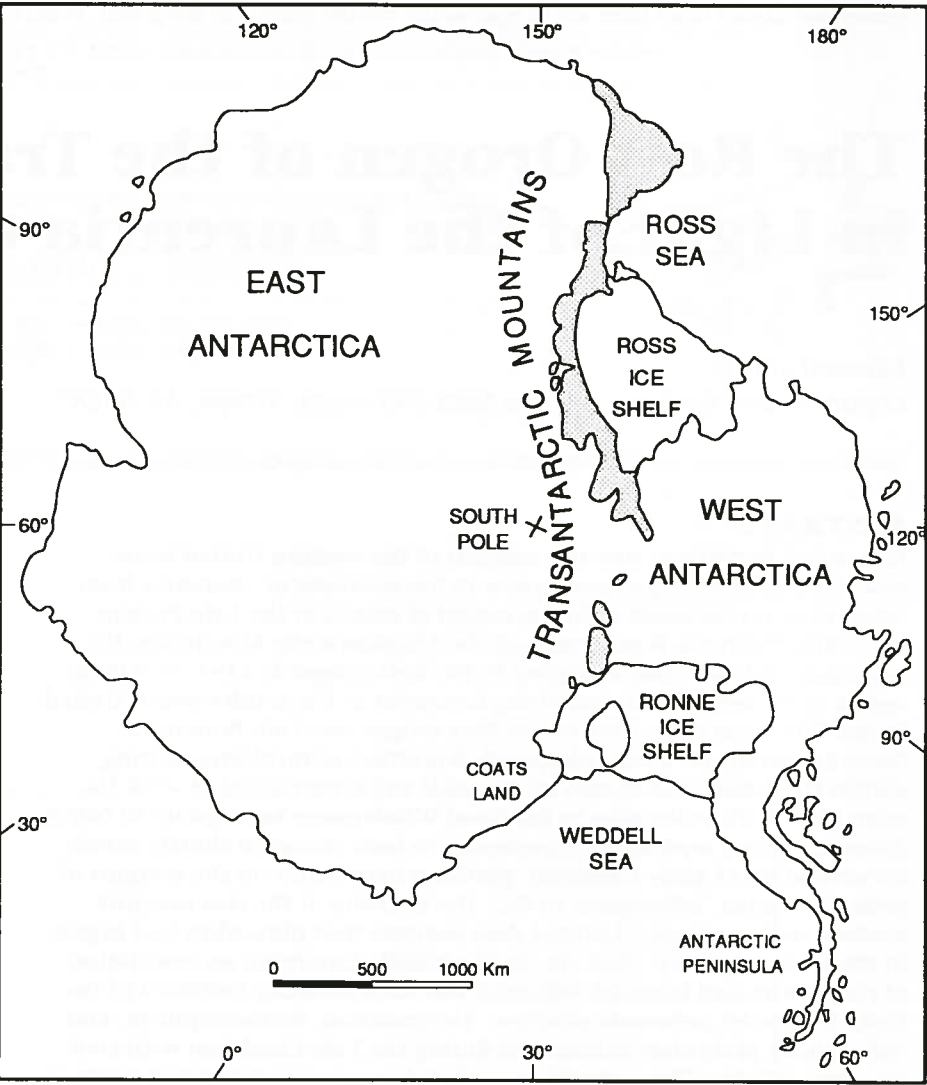
more basin was two sided, with a 1.7 Ga continental source for part of the Goldie Formation on the outboard (Ross Sea) side.

In western North America, two major sequences of noncrystalline, Proterozoic rocks occur within the Cordillera. Both are postulated to have been deposited in association with rifting events. The earlier suite, exemplified by the Belt and Purcell supergroups, is Middle Proterozoic and has no apparent counterparts in Antarctica.

The younger suite is represented by sequences at several widely separated localities in the United States, from Death Valley to Idaho, and by the relatively continuous belt of Windermere Supergroup in Canada and northeastern Washington. The sequences in the western United States appear to have been deposited in local basins or a shelf environment (Stewart, 1972), and in general apparently are lacking in turbidites, which are characteristic of all but the westernmost deposits in Antarctica. This may, however, simply reflect what parts of the rift basin are preserved on the respective continents. Presumably the basin deepened outboard of the deposits now seen in the western United States. An association of volcanics and diamictites, characteristic of the lower parts of the sequences in the western United States (Crittenden et al., 1971; Miller, 1985) finds its counterpart in the Goldie Formation of the Transantarctic Mountains.

Based on Sm-Nd and Rb-Sr dating of volcanics near the base of the Windermere Supergroup in northeastern Washington (Devlin et al., 1988), a recent estimate on the initiation of rifting on the North American side is about  $750 \pm 30$  Ma, coincident with the date on gabbro from Cotton Plateau. Magmatic rocks of this same age are found at several other localities farther to the north in the Canadian Cordillera (Roots and Parrish, 1988; Jefferson and Parrish, 1989).

The notion of a Late Proterozoic Beardmore orogeny in the Transantarctic Mountains was proposed by Grind-



**Figure 1.** Location map for Antarctica. Shading indicates Transantarctic Mountains. Orientation of the continent with 150°E at the top was chosen for compatibility with maps in Figure 2.

ley and McDougall (1969). Evidence for deformation was angular unconformities with Lower Cambrian Shackleton Limestone overlying folded Goldie Formation in the Nimrod Glacier area (Laird et al., 1971) and Middle Cambrian Nelson Limestone over Patuxent Formation in the Pensacola Mountains (Schmidt et al., 1965). The age for this event was suggested as 680 to 620 Ma (Grindley and McDougall, 1969), on the basis of several isotopic determinations from silicic porphyries (Wyatt Formation and Thiel Mountains porphyry) in the Queen Maud and Thiel mountains (Ford, 1964; Faure et al., 1968) that had no known field relations to either the Beardmore Group or the Cambrian limestones. Subsequently, the Wyatt Formation was observed to intrude folded Beardmore Group rock (Stump et al., 1986), sedimentary rocks interbedded with the Thiel Mountains porphyry were found to contain fossils (Storey and Macdonald, 1987), and the age of the Thiel Mountains porphyry was revised to ~500 Ma (Pankhurst et al., 1988). Rowell et al. (1992) have pointed out that deformation of the Patuxent Formation is constrained only to have been pre-Nelson Limestone, and they have suggested that the folding in the Pensacola Mountains included a phase that was Early to Middle Cambrian.

Several angular contacts between Shackleton Limestone and underlying Goldie Formation were mapped in the Nimrod Glacier area as unconformities by Laird et al. (1971). In each of the localities where they have visited them, Rowell et al. (1986) have interpreted these contacts as tectonic. At a critical locality on the northwest flank of Cotton Plateau, the trough and eastern limb of a syncline of Shackleton Limestone overlies truncated Goldie Formation (Laird et al., 1971). The contact along the near-vertical limb was highly sheared, probably accompanying the folding. In the trough of the syncline, Shackleton Limestone is flat-lying and truncates recumbent folds in Goldie Formation. A yellow clay-rich zone marks the contact. The basal beds of Shackleton Limestone (micaceous sandstone) are not sheared, nor do they show other evidence of movement parallel to the contact with Goldie Formation. Stump et al. (1991) concurred with Laird et al. (1971) that the contact is an angular unconformity, but in light of accumulating evidence, reinterpretation as a thrust fault might be warranted. Accepting that all contacts of Shackleton Limestone and Goldie Formation are tectonic still does not preclude the possibility of folding of the Goldie Formation prior to deposition of Shackleton Limestone, but also the Goldie folding may have followed Shackleton deposition with subsequent juxtaposing of the two formations.

The Cotton Plateau locality is unique in that only there have two episodes of deformation been demonstrated in Goldie Formation rocks (Stump et al., 1991). Elsewhere only one generation of folding has been reported for the Goldie (Gunn and Walcott, 1962; Grindley, 1963; Laird, 1963), throughout and adjacent to a broad area of infolded Shackleton Limestone, whose deformation is, by definition, Ross orogeny. The earlier folding of Goldie Formation at Cotton Plateau may be the same generation as is seen elsewhere in the Goldie, and the younger deformation (primarily cleavage and mesofolds) may be a local feature related to the shearing in the eastern limb of the Shackleton syncline.

As can be seen, the concept of the Beardmore orogeny as a Late Proterozoic episode, distinct from the Cam-

brian-Ordovician Ross orogeny, has become blurred. As one focuses on the separation of Gondwana and Laurentia, the uncertainty of the absolute age of the Cambrian-Precambrian boundary and the duration of the Cambrian period loom as other obstacles to understanding the sequence of events surrounding the breakup. Regardless of the details, however, it is apparent that once drift had begun, the North American margin remained passive while the Antarctic margin and a considerable part of the rest of the Gondwana supercontinent underwent intense orogenic activity.

On the basis of tectonic subsidence curves from all continents except Antarctica, Bond et al. (1984) estimated the global breakup of a supercontinent between 625 Ma and 555 Ma, with an estimate of  $577.5 \pm 22.5$  Ma for the western United States. The Harland et al. (1982) time scale was used to do projections, with an age of 590 Ma for the Precambrian-Cambrian boundary. On the basis of interpretations of stratigraphic sequences in the Adelaide fold belt, von der Borch (1980) postulated that breakup occurred in southeastern Australia at about the Precambrian-Cambrian boundary.

In the Early Cambrian, carbonates began to accumulate along the platform margins of both western North America and Antarctica, by which time presumably drift had begun. Except for similar, initial sedimentation, the newly formed continental margins evolved with distinct and independent histories. In the central Transantarctic Mountains, the Shackleton Limestone was deposited during a short interval between middle and late Early Cambrian (Atdabanian to Botomian), (Debrenne and Kruse, 1986; Rowell et al., 1988; Rowell and Rees, 1989; Rees et al., 1989). The only other known, in situ Early Cambrian limestones in the Transantarctic Mountains are found in the Argentina Range to the northeast of the Pensacola Moun-

tains (Rowell et al., 1992). One may postulate continuity of an Early Cambrian carbonate shelf spanning these localities, since the 1200 km distance between them is covered by rocks of the Beacon Supergroup and by ice.

A continuation of Shackleton Limestone to outcrops north of Byrd Glacier, however, would appear not to be justified. Some marbles do exist in the Koettlitz and Skelton groups of southern Victoria Land (Findlay et al., 1984), but they are not nearly as extensive as the Shackleton Limestone and are interbedded with clastic metasedimentary rock, arguing for their correlation with parts of the Nimrod Group or lower Beardmore Group. Furthermore, deformed Skelton Group is intruded by granite with a crystallization age of  $500 \pm 4$  Ma (Rowell et al., 1991). Several authors (Grindley and Laird, 1969; Grindley, 1981; Borg et al., 1989) have suggested that the marked geologic discontinuity that occurs across Byrd Glacier, with metamorphosed Skelton Group extensively intruded by plutonic rocks to the north and folded, low-grade to unmetamorphosed Shackleton Limestone to the south, is the result of right-lateral, strike-slip displacement. However, this may also reflect angular irregularities in the original continental margin that occurred during the breakup. No platform carbonates resembling Shackleton Limestone occur in northern Victoria Land.

Outboard of the Early Cambrian platform deposits are carbonates of Middle Cambrian age, including parts of the Liv Group of the Queen Maud Mountains (Stump, 1982) and the Nelson Limestone of the Pensacola Mountains (Schmidt et al., 1965). Both the Nelson Limestone and the Leverett Formation of the Liv Group are dated, from trilobites, as Middle Cambrian (Palmer and Gatehouse, 1972). In addition to its carbonates, the Liv Group also contains appreciable coarse-grained

**Ross Orogen** continued on p. 30



The Geological Society of America

## Congressional Science Fellowship 1992-1993



The Geological Society of America is accepting applications for the 1992-1993 Congressional Science Fellowship. The Fellow selected will spend a year (September 1992-August 1993) in the office of an individual member of Congress or a congressional committee. The program provides an opportunity to gain a better understanding of science and technology issues facing Congress and to advise on a wide range of scientific issues as they pertain to public policy questions. The American Association for the Advancement of Science conducts an orientation program and assists the Fellow seeking a congressional staff position in which he or she can work on major legislative issues.

### Criteria

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matters outside the Fellow's particular area, and a strong interest in working on a range of public policy problems.

### Award

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### To Apply

Procedures for application and detailed requirements are available in the geology departments of most colleges and universities in the United States or upon request from: Executive Director, Geological Society of America, P.O. Box 9140, Boulder, CO 80301.

**DEADLINE FOR RECEIPT OF ALL APPLICATION MATERIALS IS FEBRUARY 15, 1992**

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For information on obtaining an application or for additional information, please contact: Chrysalis Scholarship, Association for Women Geoscientists Foundation, Macalester College Geology Dept., 1600 Grand Ave., St. Paul, MN 55105-1899.

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For details on the 1992 GeoVentures, call your GeoVentures Coordinator today: 1-800-472-1988 or 1-303-447-2020.



Photo by Jay Temple

## GSA GEOTRIP

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#### Scientific Leaders

Stan Beus, Northern Arizona University  
Ivo Luchitta, U.S. Geological Survey, Flagstaff

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April 26, Sunday ..... Depart Las Vegas for arrival at Lee's Ferry  
April 27–May 3,  
Monday through Sunday.. River days  
May 3, Sunday ..... Take-out Pierce Ferry (Lake Mead) for bus trip  
back to Las Vegas  
May 4, Monday ..... Travel day from Las Vegas to home

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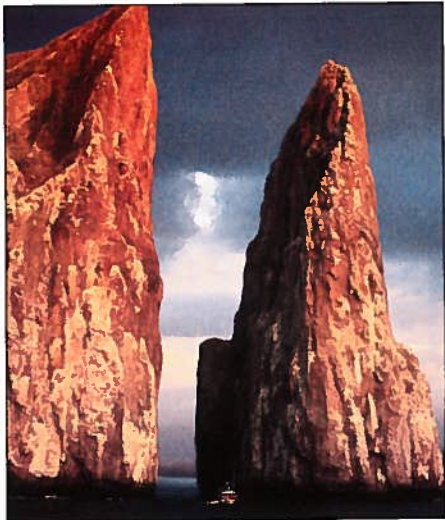
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Photos by Bob Evans



## GSA GEOTRIP

### Galapagos Islands and Ecuador

Co-sponsored by American Association for the Advancement of Science

July 5–15, 1992

#### Scientific Leaders

William S. Wise, University of California, Santa Barbara, is a volcanic petrologist with extensive experience with volcanoes, magma evolution, and island formation. In addition to being a GSA Fellow, he is an able and experienced trip leader.

The professional field naturalist accompanying the trip is Cynthia Manning, a field biologist familiar with tropical environments, currently a resident of Quito. In addition, scientists from the Darwin Research Station will provide informal lectures.

The purpose of this trip is to explore the remote and scientifically fascinating Galapagos Islands and the Andean highland of Ecuador. This geologic and natural history expedition offers an exceptional opportunity to experience the unique flora and remarkably approachable fauna of these islands, together with expanding awareness of the ongoing geological processes in the eastern Pacific region.

**Co-sponsor: American Association for the Advancement of Science.** GSA is offering this unique opportunity in co-sponsorship with AAAS in order to provide an opportunity for members of both scientific communities to travel and learn together. This educational excursion is to one of the most extraordinary locations on Earth; it is a place to remember—a trip of a lifetime.

**Itinerary.** Days 1 and 2 will be spent traveling to and getting familiar with Quito, which sits in an Andean valley at 9300 feet. Days 3 through 9 will be spent exploring eight of the Galapagos Islands, stopping at Plaza Island, Hood Island, Santa Cruz Island (home of the Darwin Research Station), Floreana, Barrington, Tower Island, Tagus Cove, Punta Espinosa, James and Bartholomew Islands. The day lectures on the geology of the region will be combined with field excursions to the habitats of marine iguanas, rare waved albatross, flamingos, red-footed and masked boobies, and many other exotic species. Between hikes there will be ample time for snorkeling in coves, with the strong possibility of sighting sea lions.

**Daily Transport.** Motorcoach is the mode of transport in Ecuador, but the exploration between islands is aboard the *Isabela II*, the newest (and many say best) of the ships serving these islands. The air-conditioned, 162' motorboat provides comfort and convenience. It has a maximum of 34 cabins, which all face outside and have twin or double beds (no bunk beds), and each has a private bath. Three full, excellent meals are served daily aboard ship. A skiff takes small groups ashore for morning and afternoon field exploration of between one and two hours each.

**Expedition Cost.** The land cost for GSA members is \$3290 U.S. plus airfare. The nonmember fee is \$3390. *If a guest has previously traveled on a GSA GeoTrip, the nonmember \$100 additional fee will be waived.* We find the price to be quite reasonable compared to similar offerings. In addition, Betchart Expeditions, Inc., has earned an excellent reputation with other scientific groups. The fee includes double occupancy lodging in Quito and aboard the *Isabela II*; transfers and ground transportation; meals as indicated, including three meals per day aboard the *Isabela II*; entrance fees; baggage handling; leadership; and reading materials.

**The expedition fee does not include** airfare; some meals (estimated cost to participants is \$40); tips to Galapagos guide or boat crew; any personal items such as alcoholic beverages, laundry, snorkeling equipment, phone calls, snacks, personal insurance, or foreign airport departure taxes.

**Airfare and Airline Ticketing.** Airfare roundtrip from Miami to Quito is currently \$734 plus tax based on an excursion fare with Ecuatoriana Airlines. All air bookings and ticketing will be handled by Betchart Expeditions Inc., (800) 252-4910. **PLEASE NOTE:** All expedition members will fly as a group; limited independent travel arrangements are available. Airfares are subject to change, and are generally lowest when booked early.

**Single Accommodations.** Single rooms are available for an additional \$125 in Ecuador and \$650 in the Galapagos. If you do not have a roommate or we cannot assign you one, you must pay the extra cost of a single. (The single fee is exceptionally high because the second space in the cabin could be purchased by another full-paying traveler.)

**Registration, Deposits, and Payments.** Registration is open to everyone, but **GSA Members will be given preference.** A deposit of \$300 will hold your place until February 28, but because of the popularity of the *Isabela II*, **full payment is due on March 1** in order to secure space. This amount goes directly to the Ecuadorian provider on March 1 and is nonrefundable unless your place is resold; then, a \$100 processing fee will apply. Minimum age: 18. Limit: 30 persons.

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 Leaders

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

Durango, Colorado, was founded more than a century ago as the supply center for the mining camps of the San Juan Mountains. Located at the boundary of the Colorado Plateau and the Colorado Rockies, the town is now the recreational center for some of the most scenic, historic, and geologically diverse country in the west. 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. The area is home to the historic Durango and Silverton Narrow Gauge Railroad, Anasazi Indian ruins, ghost towns, and spectacular mountain wildflowers and scenery.

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 narrow gauge, and visit the high peaks. Local activities available outside of class include golfing, hiking, rafting, and touring.

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.  
\$75 deposit is due with your reservation, which is refundable until April 1;  
less \$20 processing fee.

**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, 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 of the White Mountains, California

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

Scientific Leaders

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

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.  
\$75 deposit is due with your reservation, which is refundable until April 1;  
less \$20 processing fee.

**Total balance due: May 1**

Minimum age: 21 years. Limit: 30 persons.

**Fee includes** classroom programs and materials, field excursions; lodging in barack style dormitories; breakfast and lunch each day; welcoming and farewell events. **Not included** is 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.

GEOVENTURES REGISTRATION FORM

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Please keep in mind that the GeoVentures fill quickly and it is best to make a decision early.

If you would like to send a deposit to hold your reservation, please pay by check or credit card, which will be used only for this deposit. (Future charges will be authorized by you first.) You will receive further information and a confirmation of your registration within one week after your reservation.

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Each GeoVenture has its own set of cancellation dates which will be sent out to registrants and provided in response to phone queries.

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GH922 — Bishop, California, GeoHostel	\$ 75	_____	_____

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arenites, but the predominant lithology is a bimodal suite of volcanics with voluminous rhyolites and lesser basalts (Stump, 1985). This volcanic activity may represent lingering extensional effects of the breakup located in outer parts of the Antarctic continental margin (Dalziel, 1991).

Northern Victoria Land is composed principally of three terranes, of which the eastern two (Bowers and Robertson Bay) are allochthonous and were emplaced after or during the late stages of the Ross orogeny (e.g., Bradshaw et al., 1985; Gibson and Wright, 1985; Kleinschmidt and Tessensohn, 1987). The western, autochthonous Wilson terrane is underlain by schists and gneisses (Wilson and Lanterman metamorphics, Priestley Schist) whose protoliths were mainly graywacke and shale, with some calcareous parts. For the most part, these rocks were multiply deformed and metamorphosed during one prograde metamorphic episode to amphibolite facies (Kleinschmidt and Skinner, 1981). The majority of the K-Ar and Rb-Sr mineral dates from the Wilson terrane are between 500 and 470 Ma, typical of cooling following the Ross orogeny (Kreuzer et al., 1987). Limited Rb-Sr, whole-rock isochron dates indicate that metamorphism may have begun in places as early as 550 Ma (Adams and Hörndorf, 1991). A preliminary report of organic fragments from the Priestley Formation indicates a post-Precambrian age (Lombardo et al., 1989). The metasedimentary rock of the Wilson terrane

may be Proterozoic, Early Cambrian, or both, and may straddle or postdate the continental breakup. In South Australia, by comparison, Late Proterozoic Adelaidean shelf sedimentary strata are followed by turbidites of the Early Cambrian Kanmantoo Group (von der Borch, 1980). Apparently, the depositional setting in northern Victoria Land following the breakup was quite different from that recorded throughout the rest of the Transantarctic Mountains.

The passive or extensional continental margin changed to one of subduction with resultant compressive deformation, metamorphism, and magmatism of the Ross orogeny. The simplistic view of a Cambrian-Ordovician episode that began with folding of Early and Middle Cambrian sedimentary rocks and ended with cooling of metamorphic and plutonic rocks around 510–470 Ma has been expanded by ongoing research to recognize multiple tectonic events, manifested either locally or throughout the Transantarctic Mountains.

The onset of activity is difficult to place. Age determinations on several plutonic rocks from northern and southern Victoria Land are older than most throughout the Ross orogen. These include the Sturgeon Island granodiorite ( $599 \pm 21$  Ma; Rb-Sr, whole-rock isochron; Vetter et al., 1984), deformed, plutonic rocks of the Wilson terrane ( $544 \pm 4$  Ma, U-Pb, zircon; Black and Sheraton, 1990), the Carylon granodiorite ( $568 \pm 10$  Ma; Rb-Sr, whole-rock isochron; Felder and Faure, 1980), and a granite intruding the Skelton Group ( $550 \pm 4$  Ma; U-Pb, zircon; Rowell et al.,

1991). Whether one uses the Harland et al. (1990) time scale, with the Precambrian boundary at 570 Ma, or that of Odin et al. (1983), with the boundary at 530 Ma, it would appear that plutonic activity had begun in parts of the orogen before deposition of Early Cambrian Shackleton Limestone.

Deformation took various forms throughout the Transantarctic Mountains. A major shear zone in the Proterozoic Nimrod Group of the Miller and Geologists ranges has long been recognized; thrusting is thought to have occurred during the Early to Middle Proterozoic formation of the metamorphic rocks (Grindley, 1972). Goodge et al. (1991) demonstrated a considerably oblique component to the movement with a left-lateral sense relative to the axis of the Transantarctic Mountains. Stump et al. (1991) suggested that this shearing was coincident with the older deformation (Beardmore orogeny) of the Goldie Formation at Cotton Plateau. Most recently, Walker and Goodge (1991) have presented U-Pb age data, on zircons from plutons bearing the shear fabric, that indicate magmatic crystallization at 540 to 534 Ma. These new data push the shear zone development in the Miller Range into the framework of the early Ross orogeny, and out of the range of the traditional Beardmore orogeny or older events. Again, how this movement is interpreted with respect to the deposition of the Early and Middle Cambrian limestones of the Transantarctic Mountains depends on the time scale used. On the basis of isotopic data, Borg et al. (1990) have postulated a major lower crustal boundary

and suture zone along Marsh Glacier, between the Miller Range and Cotton Plateau. It is possible that this juxtapositioning was early-Ross rather than Beardmore or earlier, as previously thought.

In the Nimrod Glacier area Shackleton Limestone is tightly folded. Overlying an erosion surface on Shackleton Limestone is the Douglas Conglomerate, which contains clasts of folded Shackleton Limestone, but no fossils to help determine its age (Rees et al., 1987). The Douglas itself has been deformed at least twice prior to deposition of the Beacon Supergroup. The composition of the Douglas (Pantaja and Rees, 1991), the multiple, nonmetamorphic deformations of the Shackleton and Douglas, the apparent simplicity of deformation in the lower lying Goldie Formation, the tectonic character of most, if not all, of the observed contacts between the Goldie and the Shackleton, and the geometry and style of folding suggest a foreland fold and thrust belt.

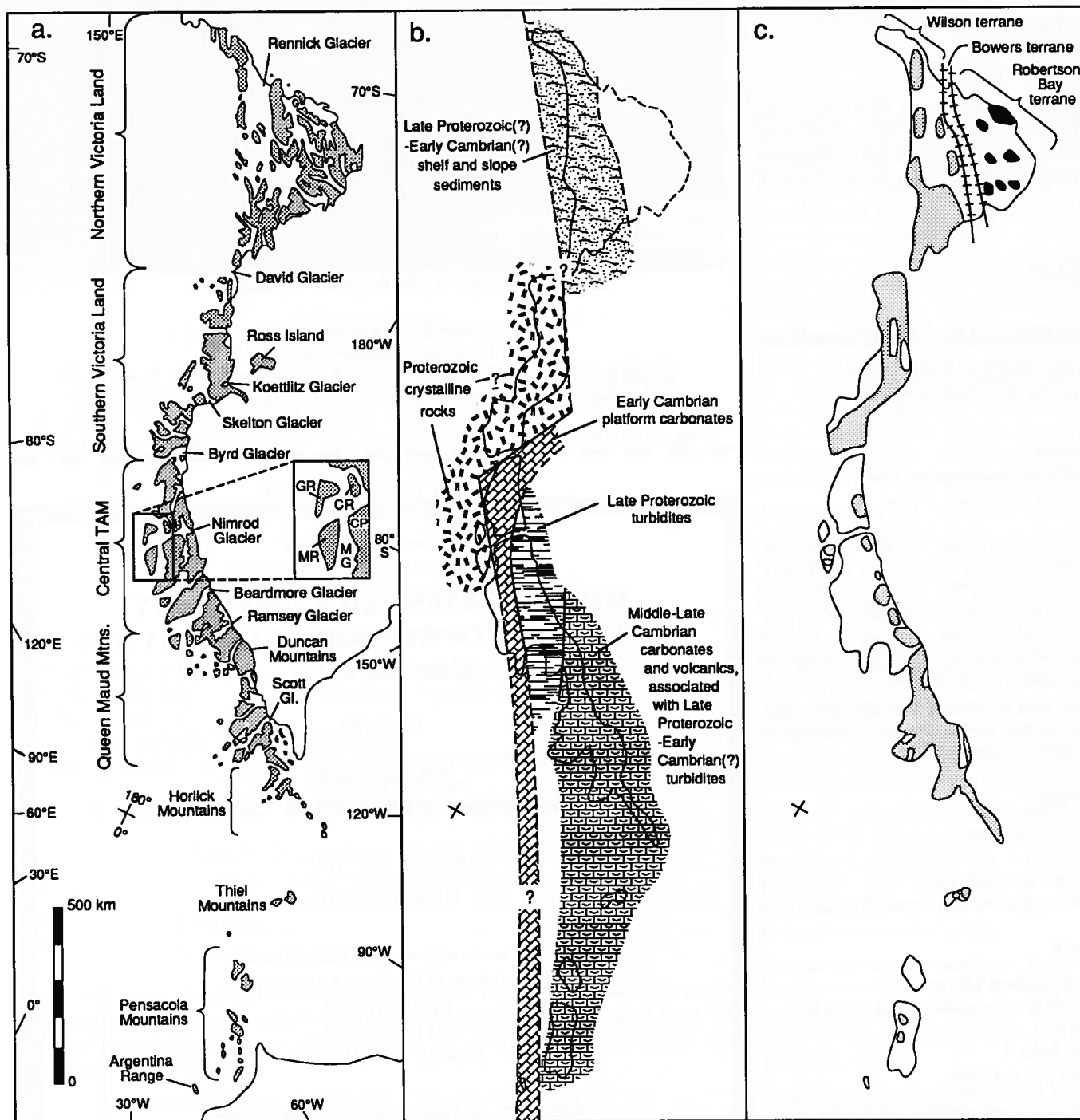
Thrust faulting has been identified at two places in the central Transantarctic Mountains. In the Duncan Mountains, Duncan Formation is thrust over Fairweather Formation (Liv Group) (Stump, 1981). Traditionally, Duncan Formation has been correlated with Beardmore Group (Stump, 1982), but it could represent a Cambrian slope sequence deposited outboard of the belt of volcanics and carbonates of Liv Group, and later thrust upon it. At the head of Scott Glacier, La Gorce Formation (Beardmore Group) is thrust over Wyatt Formation (Stump et al., 1986). Wyatt Formation is undoubtedly correlative with the Thiel Mountains porphyry, which recently has been dated at  $493 \pm 24$  Ma (Pankhurst et al., 1988); thus, this fault occurred late in the sequence of events that are encompassed by the Ross orogeny. In the central Scott Glacier area, a right-lateral, strike-slip fault has juxtaposed La Gorce and Wyatt formation rocks (Stump and Fitzgerald, 1988).

In the Pensacola Mountains, Middle Cambrian Nelson Limestone and overlying silicic volcanics (Gambacorta Formation) were folded into open structures during the traditional Ross event (Schmidt et al., 1978). Constrained as only pre-Middle Cambrian by the unconformity beneath Nelson Limestone, the folding of Patuxent Formation could be an Early Cambrian rather than a Late Proterozoic event, as suggested by Rowell et al. (1992).

Regardless of the structural variations along the Transantarctic Mountains, a tremendous pulse of magmatism ended the Ross orogeny (e.g., Borg et al., 1987); K-Ar and Rb-Sr dates are largely between 510 and 470 Ma (Stuiver and Braziunas, 1985). As research in these mountains continues, it may be useful to subdivide the Ross orogeny, as has been done for orogenic episodes in the Cordilleran, for it has become increasingly apparent that its evolution was complex and varied in both space and time. The history of the Ross orogen spans the breakout of Laurentia from Gondwana, the period of greatest complexity having occurred after the split as the newly formed margin rearranged itself. If the magmatic activity at about 750 Ma in both the Transantarctic Mountains and western North America signals the onset of rifting, then the rift to drift transition took perhaps as much as 200 m.y.

## PANNOTIOS TECTONISM

The Ross orogeny of the Transantarctic Mountains is the Delamerian orogeny of Australia (Rutland et al., 1981). It is the Pan-African of Africa



**Figure 2.** a: Location map for Transantarctic Mountains. CP = Cotton Plateau, CR = Cobham Range, GR = Geologists Range, MG = Marsh Glacier, MR = Miller Range. b: Principal lithotectonic divisions of the Ross orogen in the Transantarctic Mountains. c: Shading indicates outcrop areas of plutonic rocks of the Ross orogen with  $\pm 500$  Ma cooling ages. Terrane boundaries are indicated for northern Victoria Land. Black indicates Devonian plutonic rocks in northern Victoria Land.

(Kennedy, 1964) and the Brasiliano of South America (Cordani et al., 1973). It is an episode of continental crustal consolidation as great as any in Earth history. Besides the development of interconnected zones of high mobility, large parts of the cratonic nuclei were thermally reactivated. Throughout a large sector of coastal East Antarctica (long 0° to 110°E), the K-Ar dates on Archean and Early Proterozoic cratonic rocks are ±500 Ma (Craddock, 1972). Mobile belts in South America and Africa had begun orogenic activity in the Proterozoic, at least as far back as 650 Ma (Cordani et al., 1973; Kröner et al., 1978). Compressive tectonics had begun in parts of Gondwana prior to the breakout of Laurentia and continued afterwards.

The culmination of activity prior to cooling ~500 Ma occurred as all the cratonic nuclei of Gondwana sutured together, producing the supercontinent, perhaps in a scenario similar to that proposed by Hoffman (1991), but including subduction and orogenic activity along the Pacific margin of Australia, Antarctica, and at least southern South America. Lacking an alternative, I proposed “Pannotios” (Greek: pan = all, notios = southern) as a unifying term to designate the cycle of tectonic activity common to the Gondwana continents that resulted in the formation of the supercontinent (Stump, 1987). Southern Hemisphere geologists have long recognized the common heritage shared by the southern continents (du Toit, 1937), but the SWEAT hypothesis expands our view to the global interconnectedness of events during the Late Proterozoic–early Paleozoic.

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Robert L. Fuchs

**Paul Bailly Joins Board of Trustees**

Former GSA President Paul A. Bailly was appointed to the Foundation's Board of Trustees at its October meeting in San Diego. He fills the vacancy left by McLain Forman, who has completed his five-year term. Paul Bailly has given generously of his time and talents to GSA, culminating with his term as president in 1983. In addition, he has been very active in many other earth science organizations, including the Society of Economic Geologists, which he served as president in 1981. He received the Jackling Award given by the American Institute of Mining Engineers in 1979 and was the Henry Krumb lecturer for that organization in 1975-1976. He also holds memberships in a number of other scientific and professional organizations. Bailly has served on advisory committees to the University of Minnesota, Stanford University, and the Colorado School of Mines. He is a director of the Mineral Information Institute and has been on several National Research Council and National Academy of Sciences boards.

Born in France in 1926, Bailly attended the University of Nancy and then Yale University, and he received a Ph.D. degree in mineral deposits from Stanford University. His professional career includes 15 years with Kennecott Copper and Bear Creek Mining (president of the latter for seven years). He was president and a director of Occidental Minerals Corporation from 1968 until 1983. Since 1984 he has been the president of Fulcrum Management, Inc., which oversees two mineral venture capital partnerships. Bailly is at present a director of six public mineral resource companies. Bailly brings important business experience and leadership to the Foundation's Board. Trustee Charles Mankin noted, "I am extremely pleased that Paul Bailly will be serving on the Foundation's Board of Trustees. He brings a very extensive national and international background in both science and industry to our group, and he is widely known among both the members of

our profession and the companies and organizations that are supportive of the work of GSA."

**Board Chooses Mankin as Chairman**

Charles J. Mankin, Director of the Oklahoma Geological Survey, has been selected by the Foundation's Board of Trustees to be its chairman for the coming year. Mankin joined the Board in 1987 and is in the final year of a five-year term. Charlie Mankin is well known among GSA members, and he enjoys widespread recognition throughout the science. He is a forceful spokesman for earth science in both the government and industry arenas. He is active in many geological organizations, foremost among them Sigma Gamma Epsilon, American Association of Petroleum Geologists, and American Institute of Professional Geologists. Mankin replaces F. Beach Leighton as chair; Beach continues as a Trustee.

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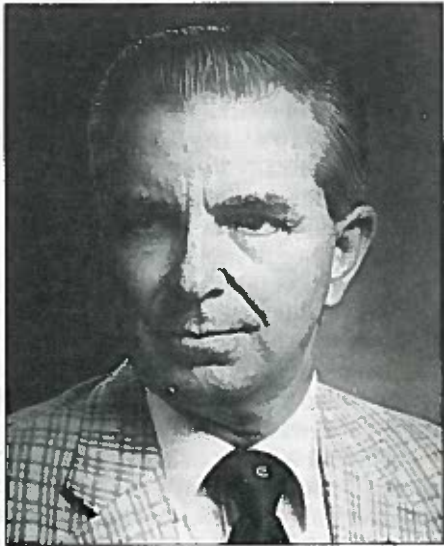
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Washington Report provides GSA membership with a monthly window on the activities of the federal agencies, Congress and the legislative process, and international interactions that could impact the geoscience community. In future issues, Washington 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.

Acronym Immersion—101: Part 2

This month's Washington Report completes the acronym immersion started in January. By the time you finish this month's column, you will have been exposed to 500 useful acronyms with which you can navigate your way through Washington, D.C., and the earth sciences community.

With these acronyms under your belt, you are now qualified to come to Washington to fill a rotational program management vacancy or to testify before Congress.

ICWQ—International Commission on Water Quality  
ICWRS—International Commission on Water Resources Systems  
IDNDR—International Decade for Natural Disaster Reduction  
IEA—International Energy Agency  
IFPS—International Federation of Palynological Societies (IUGS)  
IFSEG—International Federation of Societies of Economic Geologists  
IGAC—International Global Atmospheric Chemistry Project (IGBP)  
IGBP—International Geosphere-Biosphere Programme (ICSU)  
IGC—International Geological Congress  
IGCP—International Geological Correlation Programme (IUGS/UNESCO)  
IGS—International Glaciological Society  
IGU—International Geographical Union (ICSU)  
IGY—International Geophysical Year  
IHO—International Hydrographic Organization  
IHP—International Hydrological Programme  
IHS—Indian Health Service (HHS)  
IIASA—International Institute for Applied Systems Analysis (ICSU)  
ILP—International Lithosphere Program  
IMA—International Mineralogical Association (IUGS)  
IMC—International Meteorological Committee  
IMF—International Monetary Fund  
IMF—Interplanetary Magnetic Field  
IMS—International Magnetospheric Study  
INHIGEO—Committee on History of Geological Sciences  
INMARSAT—International Maritime Satellite  
INQUA—International Union for Quaternary Research (ICSU/IUGS)  
INS—Immigration and Naturalization Service  
INT—Department of Interior (used by DOS, see DOI)  
IOC—Intergovernmental Oceanographic Commission  
IOCG—International Organization on Crystal Growth  
IOM—Institute of Medicine  
IPA—Interagency Personnel Agreement  
IPA—International Palaeontological Association (IUGS)  
IPA—International Permafrost Association  
IPCC—Intergovernmental Panel on Climate Change  
IRIS—Imaging Radiometer for Ionospheric Studies  
IRS—Internal Revenue Service (TRSY)  
ISC—International Seismological Centre  
ISHTAR—Inner Shelf Transfer and Recycling Project  
ISPRS—International Society for Photogrammetry and Remote Sensing  
ISSC—International Social Science Council  
ISSS—International Society of Soil Science (ICSU)  
ISTP—International Solar-Terrestrial Program  
ITEX—International Tundra Experiment  
ITIR—Intermediate and Thermal Infrared Radiometer (EOS)  
IUCr—International Union of Crystallography (ICSU)

IUGG—International Union of Geodesy and Geophysics (ICSU)  
IUGS—International Union of Geological Sciences (ICSU)  
IUHPS—International Union of the History and Philosophy of Science (ICSU)  
IUPAC—International Union for Pure and Applied Chemistry (ICSU)  
IUPAP—International Union of Pure and Applied Physics (ICSU)  
IWC—International Whaling Commission  
IWGGCDM—Interagency Working Group for Global Change Data Management  
JERS-1—Japanese ERS-1  
JGOFS—Joint Global Ocean Flux Study (SCOR/IGBP)  
JIC—Joint Ice Center  
JIRP—Juneau Icefield Research Project  
JOI—Joint Oceanographic Institutions  
JOIDES—Joint Oceanographic Institutions for Deep Earth Sampling (NSF)  
JPL—Jet Propulsion Laboratory (NASA)  
JSC—Johnson Space Center (NASA)  
JUS—Department of Justice  
KSC—Kennedy Space Center (NASA)  
LAB—Department of Labor  
LAF—Lower Atmospheric Facilities (NSF)  
LAWS—Laser Atmospheric Wind Sounder (EOS)  
LEADEx—Leads Experiment  
LOICZ—Land-Ocean Interactions in the Coastal Zone Project (IGBP)  
LRC—Langley Research Center (NASA)  
LTER—Long-Term Ecological Research Sites (DOE/MAB)  
MAB—Man and the Biosphere (DOS)  
MARAD—U.S. Maritime Administration (DOT)  
METC—Morgantown Energy Technology Center (DOE)  
MIMR—Multifrequency Imaging Microwave Radiometer (EOS)  
MMC—Marine Mammal Commission  
MMS—Minerals Management Service (DOI)  
MNAP—Managers of National Antarctic Programs  
MODIS-N—Moderate-Resolution Imaging Spectrometer—Nadir (EOS)  
MODIS-T—Moderate-Resolution Imaging Spectrometer—Tilt (EOS)  
MOU—Memorandum of Understanding  
MSA—Mineralogical Society of America  
MSFC—Marshall Space Flight Center (NASA)  
MSHA—Mine Safety and Health Administration (LAB)  
MSS—Landsat Multi-Spectral Scanner  
NAD—Nansen Arctic Drilling Program  
NAE—National Academy of Engineering  
NAGT—National Association of Geology Teachers  
NAP—National Academy Press  
NARL-UIC—Naval Arctic Research Laboratory—Ukpeagvik Inupiat Corporation  
NAS—National Academy of Sciences  
NASA—National Aeronautics and Space Administration  
NATO—North Atlantic Treaty Organization  
NAVOCEANO—Naval Oceanographic Office (DOD)  
NBS—National Bureau of Standards  
NCAP—Nansen Centennial Arctic Program  
NCAR—National Center for Atmospheric Research  
NCEER—National Center for Earthquake Engineering Research  
NCP—National Climbing Program  
NEA—National Endowment for the Arts  
NEB—National Energy Board  
NEH—National Endowment for the Humanities  
NEHRP—National Earthquake Hazard Reduction Program  
NEIC—National Earthquake Information Center (USGS)  
NEPA—National Environmental Policy Act  
NEPERF—Naval Environmental Prediction Research Facility (DOD)

NES—National Energy Strategy  
NESDIS—National Environmental Satellite Data and Information Service (NOAA)  
NESTA—National Earth Science Teachers Association  
NGA—National Geothermal Association  
NGO—Non-Governmental Organization  
NGS—National Geographic Society  
NHAP—National High Altitude Photography Program (USGS)  
NIH—National Institutes of Health (HHS)  
NIST—National Institute of Standards and Technology (DOC)  
NLRB—National Labor Relations Board  
NMD—National Mapping Division (USGS)  
NMFS—National Marine Fisheries Service (NOAA)  
NMML—National Marine Mammal Laboratory (NOAA)  
NMNH—National Museum of Natural History (SI)  
NOAA—National Oceanic and Atmospheric Administration (DOC)  
NOARL—Naval Oceanographic and Atmospheric Research Laboratory (DOD)  
NODC—National Oceanographic Data Center (NOAA)  
NOS—National Ocean Service (NOAA)  
NOSC—Naval Ocean Systems Center (DOD)  
NPR—National Public Radio  
NPRa—National Petroleum Reserve—Alaska  
NPS—National Park Service (DOI)  
NPS—Naval Postgraduate School (DOD)  
NRA—National Rifle Association  
NRC—National Research Centers (NSF)  
NRC—National Research Council  
NRC—Nuclear Regulatory Commission  
NSA—National Security Agency  
NSB—National Science Board (NSF)  
NSB—North Slope Borough, Alaska  
NSC—National Security Council  
NSF—National Science Foundation  
NSIDC—National Snow and Ice Data Center (NOAA)  
NSS—National Speleological Society  
NTIS—National Technical Information Service (DOC)  
NTSB—National Transportation Safety Board  
NUSC—Naval Underwater Systems Center (DOD)  
NWS—National Weather Service (NOAA)  
NWT—Northwest Territories, Canada  
NWTRB—Nuclear Waste Technical Review Board  
NWWA—National Water Well Association  
OAPEC—Organization of Arab Petroleum Exporting Countries  
OAR—Office of Oceanic and Atmospheric Research (NOAA)  
OAS—Office of Aircraft Services (DOI)  
OCEANAV—Oceanographer of the Navy (DOD)  
OCS—Outer Continental Shelf  
OCSEAP—Outer Continental Shelf Environmental Assessment Program (MMS)  
ODP—Ocean Drilling Program (NSF)  
OES—Bureau of Oceans and International Environmental and Scientific Affairs (DOS)  
OIES—Office of Interdisciplinary Earth Sciences (UCAR)  
OIG—Office of the Inspector General  
OMB—Office of Management and Budget (EOP)  
ONR—Office of Naval Research (DOD)  
OPEC—Organization of Petroleum Exporting Countries  
OPM—Office of Personnel Management  
OSB—Ocean Studies Board (NRC)  
OSHA—Occupational Safety and Health Administration (LAB)  
OSM—Office of Surface Mining Reclamation and Enforcement (DOI)  
OSSA—Office of Space Science and Applications (NASA)  
OSTP—Office of Science and Technology Policy (EOP)  
OTA—Office of Technology Assessment (U.S. Congress)  
PAGES—Past Global Changes (IGBP)  
PHS—Public Health Service (HHS)  
PICES—Pacific International Council for the Exploration of the Sea  
PMEL—Pacific Marine Environmental Laboratory (NOAA)  
PRB—Polar Research Board (NRC)  
PS—Paleontological Society  
PS—U.S. Postal Service  
PSFG—Permanent Service on Fluctuations of Glaciers  
RADARSAT—Radar Remote Sensing Satellite (Canada)  
REU—Research Experience for Undergraduates Program (NSF)  
RFPs—Requests for Proposals  
RMAG—Rocky Mountain Association of Geologists

RRC—Regional Research Centers (IGBP)  
SAR—Synthetic Aperture Radar (EOS)  
SBA—Small Business Administration  
SBIR—Small Business Innovative Research Program (NSF)  
SCAR—Scientific Committee on Antarctic Research (ICSU)  
SC-IDNDR—Scientific Committee for the International Decade for Natural Disaster Reduction (ICSU)  
SC-IGBP—Scientific Committee for the International Geosphere-Biosphere Programme (ICSU)  
SCOPE—Scientific Committee on Problems of the Environment (ICSU)  
SCOR—Scientific Committee on Ocean Research (ICSU)  
SCOSTEP—Scientific Committee on Solar Terrestrial Physics (ICSU)  
SCS—Soil Conservation Service (USDA)  
SEC—Securities and Exchange Commission  
SEG—Society of Economic Geologists (IUGS)  
SEM—Space Environmental Monitor (EOS)  
SEMS—Seafloor Earthquake Measurement System  
SEPM—Society for Sedimentary Geology  
SGA—Society for Geology Applied to Mineral Deposits (IUGS)  
SGE—Sigma Gamma Epsilon  
SI—Smithsonian Institution  
SIL—International Association of Limnologists  
SIR—Shuttle Imaging Radar (NASA)  
SLAR—Side-Looking Airborne Radar  
SMME—Society for Mining, Metallurgy, and Exploration  
SMI—Smithsonian Institution (used by DOS, see SI)  
SMMR—Scanning Multichannel Microwave Radiometer (NOAA)  
SPE—Society of Petroleum Engineers  
SSA—Seismological Society of America  
SSA—Social Security Administration  
SSM/I—Special Sensor Microwave/Imager (NOAA)  
SSSA—Soil Science Society of America  
START—Global Change System for Analysis, Research and Training (IGBP)  
STCs—Science and Technology Research Centers (NSF)  
STEP—Solar-Terrestrial Energy Program (DOE)  
STL—Space and Technology Laboratory (NASA)  
STRI—Smithsonian Tropical Research Institute (SI)  
SVP—Society of Vertebrate Paleontology  
SWCC—Second World Climate Conference  
TACT—Trans-Alaska Crustal Transect  
TALI—Trans-Alaska Lithosphere Investigation  
TAPS—Trans-Alaska Pipeline System  
TLUI—Traditional Land Use Inventory  
TM—Landsat Thematic Mapper  
TOGA—Tropical Ocean and Global Atmosphere Experiment  
TOMS—Total Ozone Mapping Spectrometer  
TOPEX—Poseidon Ocean Topography Experiment  
TRSY—Department of the Treasury  
UAF—Upper Atmospheric Facilities (NSF)  
UCAR—University Corporation for Atmospheric Research  
UN—United Nations  
UNCED—United Nations Conference on Environment and Development  
UNCLOS—United Nations Conference on the Law of the Sea  
UNDRO—Office of the United Nations Disaster Relief Coordinator  
UNEP—United Nations Environmental Programme  
UNESCO—United Nations Educational, Scientific and Cultural Organization  
UNOLS—University National Oceanographic Laboratory System (NSF)  
UNPUOS—United Nations Outer Space Committee  
USAF—U.S. Air Force  
USAP—U.S. Antarctic Program, formerly U.S. Antarctic Research Program  
USCG—U.S. Coast Guard  
USDA—U.S. Department of Agriculture  
USGS—U.S. Geological Survey  
USSAC—U.S. Science Advisory Committee (ODP)  
WCP—World Climate Programme  
WCRP—World Climate Research Programme (ICSU/WMO)  
WDC—Panel on World Data Centers (ICSU)  
WGMS—World Glacier Monitoring Service  
WHO—World Health Organization  
WMO—World Meteorological Organization  
WOCE—World Ocean Circulation Experiment (WCRP)  
WOVO—World Organization of Volcano Observatories  
WRD—Water Resources Division (USGS) ■

## Flow and Associated Transport in Basins: Driving Forces, Coupling, and Geologic Controls

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There is an increasing awareness of the importance of basin-scale subsurface flow and transport in a number of geologic processes. Recent theoretical and site-specific studies indicate that the direction and rate of regional flow can be a critical control on such geological problems as the occurrence of ore deposits, accumulation of petroleum, and large-scale fracturing and faulting. The extent that basin-scale flow influences these problems depends upon several common elements such as (1) the magnitude and variability (both spatial and temporal) of permeability within the basin; (2) the magnitude of topographic driving forces; (3) the rate and magnitude of sedimentation and erosion; and (4) the presence or absence of fluid and heat sources. A Penrose Conference on Flow and Associated Transport in Basins: Driving Forces, Coupling, and Geologic Controls was held at Bodega Bay, California, from February 24 to March 1, 1991, to discuss the state of understanding of water and brine migration in the crust. The objective of this conference was to bring together scientists from several disciplines to discuss what is known or can be inferred about the driving forces and geologic controls on basin-scale transport.

The conference brought together more than 60 participants from five countries. The participants included hydrogeologists, sedimentary petrologists, geophysicists, petroleum geologists, and economic geologists from academia, government research agencies, petroleum research laboratories, and hydrogeologic consulting companies. While the group was diverse, they were united by their interest in low-temperature, upper crustal processes in which basin-scale fluid flow plays a role. The energy level and interaction at the talks and during free time were generally outstanding; communication barriers across subdisciplines were negligible.

The conference was organized into four morning, one afternoon, and three evening sessions; three afternoons were filled by additional presentations of ongoing work and by informal discussions among the conferees. John Bredehoeft led off on Monday morning with a controversial presentation on the hydrodynamics of the Uinta Basin. The controversy was sparked by his mathematical representation of hydrocarbon generation and maturation kinetics. His model results indicated that overpressures in the Uinta Basin can be explained by present-day

hydrocarbon generation in the reservoir or source rock. The congenial criticism during this presentation fostered an attitude of open discussion that carried through the entire conference.

The first day focused on the hydrogeologic framework of sedimentary basins and on topography as a driving force for flow. Several site-specific studies illustrating important points were presented. Graham Fogg presented the results of his work on sand-body interconnectedness in East Texas Wilcox Group sandstones; Fogg's results provide perspective on strategies for scaling-up of permeability. Stefan Bachu presented the first of many studies of the Alberta or Western Canada sedimentary basin. Bachu argued that the regional-scale permeability of aquifers in the Alberta basin is too low to allow significant advective transport of heat. Dave Chapman provided background on the thermal analysis of basins and presented results indicating that the basin-scale permeability of aquifers, as deduced from coupled fluid-flow and heat-flow models, is intermediate between cores (low) and well tests (high). Ken Belitz presented model results indicating Darcy flow rates in the Cretaceous Dakota sandstone of 0.03 to 0.10 m/yr in the Denver basin and 0.10 to 1.0 m/yr in the adjacent midcontinent, values significantly lower than previously incorporated into paleohydrologic models. Tom Corbet evaluated the role of erosional unloading on regional flow; his results indicate that it is difficult to distinguish between equilibrium and disequilibrium pressure distributions in sedimentary basins, and that the closed potentiometric low in the Alberta basin can be explained by erosional unloading. Rainer Senger evaluated the importance of density-driven convection during the hydrodynamic development of the Palo Duro basin, Texas. His results suggest that buoyancy effect may be important prior to the development of significant topographic gradients. Sean Willet presented the results of his study of paleo-flow in the Western Canada basin. Willet demonstrated the utility of using fission tracks, coal moisture content, and organic-matter maturity in the reconstruction of paleoflow regimes. Jeff Nunn and Dave Demming's analysis of regional brine migration in the midcontinent shed light on several problems associated with the invocation of topographically driven flow as an explanation for Mississippi Valley-type (MVT) Pb-Zn

deposits. Jean Bahr discussed pressure anomalies in discharge areas in the Michigan basin.

The second day's presentations focused on energy and heat transport at the basin scale, and again several site-specific studies illuminated important points. Ghislain deMarsily, in a study of the Dogger aquifer of the Paris basin, demonstrated the usefulness of using  $^3\text{He}/^4\text{He}$  as a tracer for leakage across faults. Dave Demming presented his analysis of heat flow in the Colville basin, Alaska, and concluded that topographically driven flow is the best explanation for the observed heat-flow data. Demming's study prompted many of the participants to question the high permeabilities needed to transport heat advectively. Steve Ingebritsen presented the results of his study of heat flow and ground-water flow in the Cascades volcanic arc, providing some perspective on the transport properties of different rock types. Colin Williams discussed heat-flow studies in three areas of central California (Santa Maria basin, Ventura, and Elk Hills). His results suggest conductive heat flow at depth with perturbation by ground-water flow at shallow depths. Tim Harper argued that coupled processes should be investigated from the perspective of thermodynamics and dynamical analysis. Chi-Yuen Wang followed with a computational analysis of coupled processes in the Cascadia basin, Canada. His model predicts periodicity in porosity, fluid flow, and heat flow. Jerry Szymanski put forward an argument for a dynamical analysis of the data set at the proposed repository site at Yucca Mountain, Nevada. Knut Bjorlykke presented one of the few geochemically oriented studies; he demonstrated the utility of feldspar leaching as an indicator of the degree of flushing. Chris Duffy presented a dimensional analysis of the subsurface hydrology of playa lakes in the Great Basin. Alan Dutton presented geochemical data from New Mexico and western Texas, and demonstrated that the present-day distribution of solutes can be viewed as an inheritance of a paleoflow system; as a result, solute distributions can be used to reconstruct paleohydrologic conditions. Jeff Hanor presented several case studies from the northern Gulf Coast which demonstrated that evaporite dissolution can drive flow over large distances and can displace topographically driven flow systems. Vishnu Ranganathan presented a quantitative analysis demonstrating that diffusion can remove large volumes of salt. Ranganathan concluded that diffusion may be currently operative in the Red Sea basin, where evaporites are present, and may explain the high-TDS brines in the Illinois basin, where evaporites are absent.

The Wednesday morning session focused on flow and transport in areas of active deformation. Chi-Yuen Wang discussed his finite element model, which can be used to study the mechanics of coupled fluid flow, heat flow, and deformation in evolving basins with listric growth faults; he applied the model to a rift basin in the Mediterranean. Shemin Ge, motivated by Jack Oliver's tectonic squeegee hypothesis, presented her finite-element analysis of coupled fluid flow and deformation along a thrust fault. Ge demonstrated that episodic slip can cause expulsion of fluids in the vicinity of the fault, and that pressure transients are dissipated in hundreds to millions of years. Shirley Dreiss explored compaction, dewatering, and pore pressure in the Barbados accretionary wedge. Dreiss's modeling demonstrated the importance of incor-

porating tectonic movement in the analysis of flow direction. Charles Carrigan, motivated by Szymanski's concerns at Yucca Mountain, presented an analysis of water-table response to dike emplacement; Carrigan's modeling indicated that the water-table response will generally be small if fluid flow is driven by elastic deformation. Stuart Rojstaczer presented a case for temporal variation in permeability based upon the response of Coast Range streams to the Loma Prieta earthquake.

The Wednesday evening session provided an opportunity for the geochemists to convince the hydrogeologists of the utility of geochemistry in the interpretation of flow fields. Jim Boles presented a petrologic and isotopic study of the San Joaquin basin, which indicates upward cross-formational flow on the order of 1 cm/yr. Elizabeth Burton discussed anomalous magnetization as an indicator of hydrocarbon accumulation and introduced the audience to "Toth flow" as a term for topographically driven fluid flow—whether the terminology takes hold remains to be seen. Udo Fehn discussed the fundamentals of using cosmogenic isotopes (iodine and chlorine) as tracers. Eric Mountjoy presented his study of the geothermometry of Devonian dolomites at Pine Point. Mountjoy's data indicate a progressive downdip increase in temperature of late-stage dolomites, in contrast to the predictions of the paleohydrologic model of Grant Garven. Mountjoy concluded that the Presqu'île barrier was the conduit for the updip movement of basin brines. Mark Feldman used strontium isotopes and mass-balance arguments to demonstrate that meteoric water penetrates to a depth of 5000 feet beneath the Kern River in the San Joaquin Valley, California.

Thursday's sessions focused on flow and transport in areas of active fluid sources. In the session on hydrocarbons, John Burrus impressed the audience with an integrative investigation of the Mahakam Delta, Indonesia. That study demonstrated the insights that can be generated when seismic stratigraphy, sedimentology, and petroleum engineering are brought to bear in a comprehensive numerical simulation model. The model incorporates two-phase flow (hydrocarbons and water) driven by topography, hydrocarbon generation, and temperature. Jerry Sweeney discussed a new model to investigate the relative importance of compaction and hydrocarbon generation in the development of excess pore pressure during sediment burial. Joe Toth presented his hydraulic theory of secondary migration of hydrocarbons; he presented case studies from France, the Persian Gulf, and China. Gary Couples argued that localization of fluid flow in sedimentary basins is required to explain the regional transport of hydrocarbons and to explain the large quantities of heated water delivered to sites of ore deposition. Lori Summa presented the audience with a dilemma: the volume of silica cement in Gulf Coast sediments requires fluid velocities that are orders of magnitude higher than predicted by topographically driven or compaction-driven flow, and ruled out localized flow because "you can't focus flow everywhere." Summa suggested that convection might be a viable alternative.

In the session on ore deposits, Larry Cathles used mass-balance arguments to demonstrate that the mineralization of the Kupferschiefer shale in the Lubin basin, southeast Poland, can be explained by expulsion of overpressured pore fluids from the underlying

Rotliegendes. Cathles suggested that shale can be as permeable as a dune sand during the loading of a pull-apart basin. Lynton Land presented a wealth of petrologic and geochemical evidence for large-scale transport in the Gulf of Mexico sedimentary basin, including what is believed to be evidence for large-scale convection and extra-basinal fluxes. Dave Leach also presented a wealth of petrologic, geochemical, and stratigraphic evidence for large-scale movement of fluids; this time documenting regional brine migration associated with MVT deposits in the midcontinent United States. Michael McKibben discussed intrusion-driven brine diapirism in the Salton Trough, California. McKibben noted that the hypersaline brines are heat-driven and believes that this case study is an analog for exhalative stratiform ore deposits in ancient lacustrine rift basins. Rick Sanford presented his paleoreconstruction and numerical modeling of the formation of tabular-type uranium deposits in the Colorado Plateau.

Pat Domenico, on behalf of the conveners, presented a summary of the findings of the conference. The conveners noted that we have a reasonably good conceptualization of fluid flow in basins in their young and mature states, we understand the process of compaction in the early stages of basin flow, and we understand the role of topographically driven flow in mature basins. What is lacking, however, is an understanding of the hydrologic evolution between these end members. For example, free convection, while not observed readily, is commonly invoked to obtain the volumes of water needed to explain some geochemical signatures in basins. The conveners also noted that we have difficulty interpreting many field observations such as the source of cements, dolomitization, and potassium metasomatism. This inability suggests that rock-water interaction theory is not always compatible with transport theory. Finally, the conveners noted that we seem to implicitly assume that many anomalies—ore deposits, petroleum accumulations, and anomalous heat flow—are the result of long-distance fluid flow. It may be that in some instances, they are related to short or localized flow events.

Prior to the conference, the conveners outlined a set of questions that they believed formed a common denominator among researchers working on such diverse issues as ore and petroleum resources, toxic waste isolation, diagenesis, and crustal failure. These questions included: What are the rates of flow and residence times of fluids in basins? Under what conditions are faults barriers or conduits for flow? What is the spatial variability of

permeability in the upper crust? How does permeability vary as a function of time? How do regional-scale permeabilities relate to field measured values? To what extent do compaction and heat influence flow and transport? What is the extent and magnitude of fluid sources in the upper crust? Each of these questions was addressed at least peripherally during the four-and-a-half days of the conference. The answers to these questions proved to be quite site specific, and few generalities were gleaned. Through a wide variety of geophysical, geochemical, and computational tools, this conference showed that basin-scale flow and transport were sometimes necessary, but not always sufficient, mechanisms to explain many geological observations about the crust. ■

### Penrose Conference Participants

Jean Bahr	Philip Koch
Barbara Bekins	Lynton Land
Kenneth Belitz	David Lawrence
Allan Bennison	David Leach
Knut Bjorlykke	Paul D. Lundegard
James Boles	Hans Machel
Robert Braun	Ghislain deMarsily
John D.	Jon Martin
Bredehoeft	Glen Mattioli
John Burrus	Michael McKibben
Elizabeth Burton	Brian McPherson
Charles Carrigan	Eric Mountjoy
Lawrence Cathles	Jean Moran
David Chapman	Christopher Neuzil
Thomas Corbet	Jeff Nunn
Gary Couples	Victor V.
David Deming	Palciauskas
Patrick A.	Vishnu
Domenico	Ranganathan
Shirley Dreiss	Stuart Rojstaczer
Christopher Duffy	Richard Sanford
Alan Dutton	Jan Schultz
Udo Fehn	Rainer Senger
Mark Feldman	Lori Summa
Graham Fogg	Jerry Sweeney
Shemin Ge	Jerry Szymanski
Jeffrey Hanor	Jozsef Toth
T. R. Harper	Joana Vizgirda
Charles Harvie	Chi-Yuen Wang
Steve Ingebritsen	Herb Wang
Lori Juergens	Sean Willett
Cheryl Knight	Colin Williams

## SAGE REMARKS

Edward E. "Dr. Ed" Geary, Educational Programs Coordinator

## Beyond the Plaster-of-Paris Volcano: Science Fairs Are an Opportunity Waiting for Us

Beth C. Schwarzman

Member, GSA Education Committee

Students at the precollege level across the country define "hot" science by the projects that enter and win in science fairs. In this universe of student science, earth science is barely present. The most common representative of earth science at science fairs is the standard baking soda and vinegar eruption from a plaster-of-paris demonstration volcano.

All the same, fourth graders are experienced rock collectors, experts on dinosaur nomenclature, and fascinated by natural processes from volcanoes and earthquakes to glaciers and beaches. What on Earth happens to this curiosity and knowledge between fourth grade and those science fair projects that await five or six years down the line?

In those intervening five or six years most students either never study earth science, or worse, they get turned off by a dull class taught by someone trained to teach basketball or Shakespeare. The absence of earth science in science fairs is a symptom of a larger, multifaceted problem: (1) few teachers ever learned earth science, so it is no surprise that they don't teach it; (2) the world regards earth science as a "baby" science without the rigor or glamour of the "real" sciences; (3) earth science requires us to integrate physics, chemistry, and biology to get the big picture, and many students and teachers find this daunting.

Now *that's* daunting. Solving this larger problem will take time and effort; SAGE, GSA's precollege initiative, is a promising framework for that effort. Nevertheless, there are things you and I can do *this month* that will have an immediate impact. Here are some suggestions.

1. Arrange to give a prize for Distinction in Earth Science at your local science fair. It doesn't matter that only one or two projects may be in the running, or that you have to stretch the definition of earth science a bit. You will bring earth science to the attention of the stu-

dents, parents, and teachers, and things will improve next year. The prize can be as simple as a handwritten certificate; you can add a token cash prize or a book (the cash is more popular). Talk to the organizers of your local fair to find out how to do this most effectively.

2. Develop a list of earth science projects for your area and get it to science teachers or the science fair organizers. The current range of science fair projects is very limited. You can lead students away from plaster-of-paris and toward sedimentology, hydrology, petrology, or paleontology. You might suggest: studying the history of a marsh from cores, assessing the relation between grain size and rock type in beach or river deposits, determining the relation of soil types to topography or underlying geology, assessing the constraints on meandering stream flow, or modeling the effects of abrasion on potential fossils. You have probably already thought of many other lab and field projects appropriate to students and your area.
3. Volunteer to be a judge at the science fair. Most fairs need more judges. It takes only a few hours and the students treasure the contact with a scientist. Not only will you be helping the individual student, but you will probably be the first earth scientists those students have met. (And it's fun.)
4. Become a partner in GSA's Partners for Excellence program, and encourage the local teachers to join you.

These actions are not a magic bullet solving all the problems of earth science education in three pleasant hours, but they will begin to improve the climate for earth science. By leaving the office or lab for a few hours we each can show students and teachers that earth science is serious science and might even be serious fun. Science fairs are an opportunity waiting for us. ■

### Student Support Available for PANGEA Workshop

Project PANGEA is a research initiative of the Global Sedimentary Geology Program with broadly based objectives that include the causal connection of large-scale global climatic change and mantle CO<sub>2</sub> flux, the long-term evolution of sea water isotopic composition from Pennsylvanian through Jurassic time, and evaluation of the role of astronomical forcing factors in solar-driven climatic change. The Sedimentary Geology Division of GSA is offering to provide support (\$200-\$250) for a small number of the Division's student members who plan to attend Project PANGEA's initial Research Planning Workshop in Lawrence, Kansas, May 23-28, 1992.

To apply for support to attend the workshop, student members of the Sedimentary Geology Division should send a brief statement of interest and advisor endorsement to: Mary J. Kraus, Secretary-Treasurer, GSA Sedimentary Geology Division, Dept. of Geological Sciences, Campus Box 250, University of Colorado, Boulder, CO 80304.

Applications will be approved on an as-received basis, subject to review of qualifications. There is a possibility that matching funds will be available from another sponsor of the workshop. For information about Project PANGEA, contact George deV. Klein, (217) 333-2076; fax 217-244-4996.

### In Memoriam

**Charles W. Chesterman**  
Calistoga, California  
March 25, 1991

**Harry D. MacGinitie**  
Napa, California  
January 29, 1987

**David B. Remick**  
Houston, Texas  
June 12, 1991

**William A. Rice**  
Alliance, Ohio  
October 1991

**Douglas B. Sterrett**  
Washington, D.C.

# GSA Employment Service

## Looking for a New Job?

Are you looking for a new position in the field of geology? The GSA Employment Service offers an economical way to find one. Potential employers use the service to find the qualified individuals they need.

You may register any time throughout the year. Your name will be provided to all participating employers who seek individuals with your qualifications. If possible, take advantage of GSA's Employment Interview Service, which is conducted each fall in conjunction with the Society's Annual Meeting. The service brings potential employers and employees together for face-to-face interviews. Mark your calendar for October 26-29 for the 1992 GSA Annual Meeting in Cincinnati, Ohio.

To register, complete the application form below, prepare a one- to two-page résumé, and mail it with your payment to GSA headquarters. One-year listing for GSA Members and Student Associates in good standing: \$30, nonmembers: \$60.

**NOTE TO APPLICANTS:** If you plan to interview at the GSA Annual Meeting, GSA must receive your material no later than August 15, 1992. If we receive your materials by August 15, your record will be included in the information employers receive prior to the meeting. Submit your forms early to receive maximum exposure! Don't forget to indicate on your application form that you would like to interview in October. Good luck with your job search!



*The Geological Society of America*

3300 Penrose Place • P.O. Box 9140 • Boulder, Colorado 80301

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GSA \_\_\_\_\_  
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Ltr. \_\_\_\_\_

### APPLICATION FOR EMPLOYMENT MATCHING SERVICE

(Please type or print legibly with black ink)

TITLE: Dr. ☐ Mr. ☐ Ms. ☐ Mrs. ☐ Miss ☐

NAME (last name first) \_\_\_\_\_ DATE \_\_\_\_\_

MAILING ADDRESS \_\_\_\_\_

CITY \_\_\_\_\_ STATE \_\_\_\_\_ ZIP CODE \_\_\_\_\_

DATE AVAILABLE \_\_\_\_\_ TELEPHONE (\_\_\_\_\_) \_\_\_\_\_ / \_\_\_\_\_ VISA \_\_\_\_\_  
area code Business Home If not U.S. citizen, list visa

**EXPERIENCE** Must use specialty codes listed below.

Choose three that best describe your expertise in order of importance.

1. \_\_\_\_\_ 2. \_\_\_\_\_ 3. \_\_\_\_\_

**PRESENT SPECIALTY**

Choose one from codes listed below \_\_\_\_\_

**YEARS EXPERIENCE IN THIS SPECIALTY** \_\_\_\_\_

**PRESENT EMPLOYER** \_\_\_\_\_

**TYPE OF POSITION DESIRED** (Check as many boxes as apply.)

Interested in: ☐ Academic ☐ Government ☐ Industry ☐ Other

Specific interest: ☐ Administration ☐ Exploration/Production ☐ Field ☐ Research ☐ Teaching

Will accept employment in: ☐ U.S. only ☐ U.S. with foreign assignments ☐ Either

**GIVE NUMBER OF YEARS EXPERIENCE FOR ANY OF THE FOLLOWING THAT ARE APPLICABLE**

Administrative \_\_\_\_\_ Exploration/Production \_\_\_\_\_ Field \_\_\_\_\_ Research \_\_\_\_\_ Teaching \_\_\_\_\_ Total geological experience \_\_\_\_\_

**KNOWLEDGE OF FOREIGN LANGUAGES:** ☐ French ☐ German ☐ Russian ☐ Spanish ☐ Other \_\_\_\_\_

**ACADEMIC TRAINING**

College or University \_\_\_\_\_ Degree (rec'd or expected) \_\_\_\_\_ Year \_\_\_\_\_ Major \_\_\_\_\_ Minor \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Postgraduate work beyond highest degree in (field) \_\_\_\_\_ Number of years \_\_\_\_\_

**SPECIALTY CODES** Select those that best describe your ability. Use codes in bold face only when other breakdowns are inadequate.

100 Economic Geology	223 low temperature	350 Mathematical Geology	454 paleobotany	620 Remote Sensing
101 coal geology	224 stable isotopes	351 computer science	455 paleoecology	621 photogeology
102 geothermal, etc.	225 geochronology	352 statistical geology	500 Petroleum Geology	622 photogrammetry
103 metallic deposits	250 Geomorphology	400 Mineralogy	501 exploration	630 Science Editing
104 nonmetallic deposits	300 Geophysics	401 crystallography	502 subsurface strat.	650 Sedimentology
105 mining geology	301 seismic	402 clay mineralogy	520 Petrology	651 sed. processes
120 Engineering Geology	302 gravity/magnetics	410 Museum (curator)	521 igneous	652 sed. environments
150 Environmental Geology	303 seismicity	420 Oceanography	522 metamorphic	720 Stratigraphy
160 Public Education & Communication	304 paleomagnetism	421 marine geology	523 sedimentary (clastic)	750 Structural Geology
200 General Geology	320 Hydrogeology	422 coastal geology	524 sedimentary (carb.)	751 tectonics
220 Geochemistry	321 hydrochemistry	450 Paleontology	525 experimental	752 tectonophysics
221 organic	322 ground water	451 invertebrate	550 Planetology	753 rock mechanics
222 high temperature	323 surface water	452 vertebrate	575 Quaternary Geology	800 Volcanology
	330 Library	453 micropaleontology	600 Regional Geology	

Résumé must be attached, **limited to two pages**, typewritten on one side only, to be acceptable for reproduction to employers. Include your name, address, and phone number; concise details of work experience; and majors/minors on degrees.

Fee: \$30 if you are a Member or Student Associate of GSA in good standing (Member # \_\_\_\_\_), \$60 if you are not a member of GSA. Payment in U.S. funds (check, money order, or charge information **must accompany form**).

**Make check payable to the Geological Society of America. This application will be active for 1 year.**

☐ Check / Money Order ☐ MasterCard ☐ VISA ☐ Diners Club ☐ American Express ☐ Barclay Card ☐ Carte Bleue ☐ Access Card ☐ EuroCard or Optima

Card Expires (Mo/Yr) \_\_\_\_\_ Card Number \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Signature \_\_\_\_\_

Required for credit card payment

Date \_\_\_\_\_

I agree to release GSA or their representatives from responsibility for errors that may occur in processing or distributing this data. I understand that GSA makes **no guarantee** of contact by an employer in this service. I agree to notify GSA Employment Service immediately of (1) change of address, (2) acceptance of a position.

**Signature (required)** \_\_\_\_\_

I will/will not attend the 19 \_\_\_\_\_ GSA Annual Meeting in \_\_\_\_\_

5/91

APPLICANT FORM

# Looking for a New Employee?

When was the last time you hired a new employee? Did you waste time and effort in your search for a qualified geoscientist? Let the GSA computerized search file make your job easier.

How does it work? Complete the Employer's Request for Earth Science Applicants form below. Remember to specify educational and professional experience requirements as well as the specialty area or areas of expertise your applicant should have. The GSA computer will take it from there.

You will receive a printout that includes the applicants' names, addresses, phone numbers, areas of specialty, type of employment desired, degrees held, years of professional experience, and current employment

status. Résumés for each applicant are sent with each printout at no additional charge. For 1992, the cost of a printout of one or two specialty codes is \$150. (For example, in a recent job search for an analyst of inorganic materials, the employer requested the specialty codes of geochemistry and petrology.) Each additional specialty is \$50. A printout of the applicant listing in all specialties is available for \$350. (Specialty codes printed in boldface type are considered major headings. If you request a listing of one of the subspecialties, applicants coded under the major category will be included but not those coded under the other related subspecialties.) If you have any questions about your personalized computer search, GSA Membership Services will assist you.

The GSA Employment Service is available year long. However, GSA also conducts the Employment

Interview Service each fall in conjunction with the Society's Annual Meeting (this year in Cincinnati, Ohio, October 26-29). You may rent interview space in half-day increments from GSA. Our staff will schedule all interviews with applicants for you, the recruiter. In addition, GSA offers a message service, complete listing of applicants, copies of résumés at no additional charge, and a posting of all job openings.

## For additional information or submission of forms, please contact

T. Michael Moreland  
Manager, Membership Services  
Geological Society of America  
P.O. Box 9140, Boulder, CO 80301  
(303) 447-2020



## The Geological Society of America

3300 Penrose Place • P.O. Box 9140 • Boulder, Colorado 80301

### EMPLOYER'S REQUEST FOR EARTH SCIENCE APPLICANTS

(Please type or print legibly)

NAME \_\_\_\_\_ DATE \_\_\_\_\_

ORGANIZATION \_\_\_\_\_

MAILING ADDRESS \_\_\_\_\_

CITY \_\_\_\_\_ STATE \_\_\_\_\_ ZIP CODE \_\_\_\_\_ TELEPHONE (\_\_\_\_\_) \_\_\_\_\_  
area code Number

#### SPECIALTY CODES (see list below)

List the specialty code numbers that you wish to order, or ☐ check here if you want the entire file of applicants in ALL specialties.

1. \_\_\_\_\_ 2. \_\_\_\_\_ 3. \_\_\_\_\_ 4. \_\_\_\_\_ 5. \_\_\_\_\_ 6. \_\_\_\_\_

POSITION DATA: What position(s) do you expect to fill? \_\_\_\_\_

In what area(s)? \_\_\_\_\_

Degree requirements \_\_\_\_\_ Number of positions available \_\_\_\_\_

SPECIALTY CODES Select those that best describe your needs. Use codes in bold face only when other breakdowns are inadequate.					
<b>100 Economic Geology</b>	223 low temperature	<b>350 Mathematical Geology</b>	454 paleobotany	<b>620 Remote Sensing</b>	
101 coal geology	224 stable isotopes	351 computer science	455 paleoecology	621 photogeology	
102 geothermal, etc.	225 geochronology	352 statistical geology	<b>500 Petroleum Geology</b>	622 photogrammetry	
103 metallic deposits	<b>250 Geomorphology</b>	<b>400 Mineralogy</b>	501 exploration	<b>630 Science Editing</b>	
104 nonmetallic deposits	<b>300 Geophysics</b>	401 crystallography	502 subsurface strat.	<b>650 Sedimentology</b>	
105 mining geology	301 seismic	402 clay mineralogy	<b>520 Petrology</b>	651 sed. processes	
<b>120 Engineering Geology</b>	302 gravity/magnetics	<b>410 Museum (curator)</b>	521 igneous	652 sed. environments	
<b>150 Environmental Geology</b>	303 seismicity	<b>420 Oceanography</b>	522 metamorphic	<b>720 Stratigraphy</b>	
<b>160 Public Education &amp; Communication</b>	304 paleomagnetism	421 marine geology	523 sedimentary (clastic)	<b>750 Structural Geology</b>	
<b>200 General Geology</b>	<b>320 Hydrogeology</b>	422 coastal geology	524 sedimentary (carb.)	751 tectonics	
<b>220 Geochemistry</b>	321 hydrochemistry	<b>450 Paleontology</b>	525 experimental	752 tectonophysics	
221 organic	322 ground water	451 invertebrate	<b>550 Planetology</b>	753 rock mechanics	
222 high temperature	323 surface water	452 vertebrate	<b>575 Quaternary Geology</b>	<b>800 Volcanology</b>	
	<b>330 Library</b>	453 micropaleontology	<b>600 Regional Geology</b>		

#### Applicants seeking employment in:

☐ Academic ☐ Government ☐ Industry ☐ Other \_\_\_\_\_

#### Minimum degree required:

☐ None ☐ B.A. or B.S. ☐ M.A. or M.S. ☐ Ph.D.

#### Minimum professional experience:

☐ None ☐ 1-5 years ☐ 6-plus years

Employment in: ☐ U.S. only ☐ U.S. with foreign assignments ☐ Either

Foreign Languages: ☐ French ☐ German ☐ Russian ☐ Other \_\_\_\_\_ ☐ Not required

#### Experience desired (years):

	None	1-5	6-plus
Administrative	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Exploration/Production	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Field	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Research	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Teaching	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

I am interested in interviewing applicants through the GSA Employment Service at the 19\_\_\_\_ Annual Meeting in \_\_\_\_\_.

- I agree to use this service for valid recruiting purposes.
- I agree that no placement charges will be assessed to any applicant participating in the GSA Employment Matching Service.

See attached sheet for current fee schedule

Total fee enclosed ..... \$ \_\_\_\_\_

or invoice requested ..... \$ \_\_\_\_\_

Signature (required) \_\_\_\_\_ Date \_\_\_\_\_

5/91

EMPLOYER FORM

# CORDILLERAN SECTION, GSA 88th Annual Meeting

Eugene, Oregon  
May 11–13, 1992

The Cordilleran Section of the Geological Society of America will meet jointly with the Pacific Coast Section of the Paleontological Society of America and the Far Western Section of the National Association of Geology Teachers at the Hilton Hotel and Conference Center in Eugene. The meeting will be hosted by the Department of Geological Sciences, University of Oregon.

## ENVIRONMENT

The meeting will be held at the Eugene Conference Center, adjacent to the Hilton Hotel on 6th Avenue in downtown Eugene. The meeting site is centrally located with easy access to numerous restaurants, a variety of lodging options, the Willamette River and its adjacent jogging trails, and the University of Oregon campus. Eugene is located in the Willamette Valley, nestled between the beautiful Oregon coast to the west and the snow-capped High Cascades to the east. The weather in mid-May should be springlike with average high temperatures in the upper 60s (Fahrenheit) and overnight lows in the 40s. The area receives an average of two inches of rain during the month of May. Travel to Eugene is relatively easy; Interstate 5 passes through the city, and the Eugene Airport is serviced by several airlines. Amtrak train service and Greyhound Bus service are also available.

## REGISTRATION

**Preregister Today! Preregistration Deadline: April 17, 1992**

1. Considerable savings in registration fees accompany preregistration. Advance registration is suggested for all field trips and many of the special activities because of participation limits. Use the preregistration form provided in this announcement.
2. Badges must be worn for access to ALL activities.
3. Registration discounts are given to members of GSA, the Paleontological Society, and the National Association of Geology Teachers. Please indicate your affiliation(s) and member number and register using the member rates. Registration fees will be waived for high school students and K–12 earth science teachers (proper I.D. will be requested for badge pickup).
4. Full payment MUST accompany registration. Unpaid purchase orders are NOT accepted as valid registration. Charge cards are accepted as indicated on the preregistration form. Please recheck the charge card number given—errors will delay your registration. Your confirmation letter from GSA will be your receipt; no other receipt will be sent.
5. Register one professional or one student per form. Copy the form for your records.
6. Guest registration is required to attend activities or to visit the exhibit

- hall. To obtain the guest rate all guests MUST be accompanied by either a registered professional or student.
7. Current student ID is required to obtain student rates at both the on-site and preregistration counters. Students not carrying a current student ID when they arrive to pick up registration materials will be required to pay the professional fee.
  8. Preregistration forms *received* after the April 17th deadline will be charged at the *on-site* rates.

## CANCELLATIONS, CHANGES, AND REFUNDS

All requests for registration additions, changes, and cancellations must be made in writing and received by the GSA Registration Coordinator by *April 24, 1992*. GSA will refund advance registration fees for all such cancellations. NO REFUNDS WILL BE MADE ON CANCELLATION NOTICES RECEIVED AFTER APRIL 24, 1992. Refunds will be mailed from GSA after the meeting. Refunds for fees paid by credit card will be credited according to the card number on the preregistration form. NO refunds will be given for on-site registration and ticket sales.

## ON-SITE REGISTRATION SCHEDULE—Hilton Conference Center Foyer

- Sunday, May 10  
4:00 p.m. to 8:00 p.m.  
Monday, May 11  
7:00 a.m. to 4:30 p.m.  
Tuesday, May 12  
7:00 a.m. to 2:00 p.m.  
Wednesday, May 13  
7:30 a.m. to 12:00 noon

## STUDENT SUPPORT

The GSA Cordilleran Section has funds available for grants to support GSA Student Associates of the Cordilleran Section who are presenting papers at the meeting. Students are strongly encouraged to apply for these grants, and we anticipate that most students who qualify will be funded to some degree. Send applications to Section Secretary, Bruce A. Blackerby, Dept. of Geology, California State University, Fresno, CA 93740, (209) 278-2955; fax 209-278-5980. Applications should include certification that the student is presenting a paper and is a GSA Student Associate of the Cordilleran Sec-

tion. All letters must be received by March 15, 1992.

## SPECIAL EVENTS

After-hours events will include a no-host **Welcoming Party** for all registrants from 6:00 to 8:00 p.m. on Sunday, May 10, and **Alumni Gatherings** from 6:00 to 8:00 p.m. on Tuesday, May 12. The **National Association of Geology Teachers Far Western Section Luncheon** will be held Monday, May 11, at noon. Cost: \$15. The **University of California Department Heads Breakfast** will be held on Tuesday, May 12, at 8:00 a.m. Cost: \$10. The **Annual Luncheon for the Pacific Coast Section of the Paleontological Society of America** will be held Tuesday, May 12, at noon. Cost: \$15. The **GSA Cordilleran Business Luncheon** is scheduled for Wednesday, May 13, at noon. Cost: \$15. Tickets for luncheons and breakfast are available on the registration form. Preregistration is suggested.

## ACCOMMODATIONS

A block of rooms at the **Hilton Hotel**, site of the meeting, has been reserved for attendees. A special reduced rate of \$70 (single or double occupancy) has been arranged. Registrants with government I.D. cards can get special government agency rates of \$52.00 (single) and \$67.00 (double), on a space-available basis. Reservations can be made by calling the hotel's toll-free number, 1-800-937-6660. The local number is (503) 342-2000. Please call early and state that you are attending the 1992 GSA Meeting to receive these rates.

A variety of other housing options are available within 2 miles of the meeting site. Within walking distance: **Stage Stop Inn**—\$28.00–\$32.00, (503) 345-3391; **Campus Inn**—\$36.00–\$48.00, (503) 343-3376. A short drive or bus ride away: **New Oregon Motel**—\$40.00–\$52.50, (503) 683-3669; **Red Lion Inn**—\$54.00–\$64.00, (503) 342-5201; **Holiday Inn**—\$54.00, (503) 342-5181. To make reservations, telephone the motel directly and indicate that you are attending the 1992 GSA Meeting. Please call early because many of the special rates are on a space-available basis only. Most motels guarantee the quoted rates only up to three to four weeks before the meeting.

## TRANSPORTATION

Eugene can be easily reached by air via several airlines that service the Eugene Airport. United Airlines is offering special discounts to all attendees traveling to Eugene for the meeting. The discount is available for travel May 8 through May 16, inclusive. To receive 5% off super-saver fares or 40% off full coach, call the United Convention Desk at 1-800-521-4041, 8:00 a.m.–1 a.m. EST. Please give the GSA Meeting I.D. #524DP. Special discounts are available only on United flights in the United States. United will mail your tickets, or you may purchase them from your local travel agent. However, reservations for discounted fares *must* be made through United's convention desk.

For those traveling by car, Eugene is easily reached via I-5, which passes through the city. Free parking will be available at the convention center on a space-available basis. Eugene is also serviced by Greyhound Bus Lines and Amtrak rail service.

## TECHNICAL PROGRAM Symposia

Scheduled symposia and their conveners are:

1. **Tectonostratigraphy, Metamorphism, and Magmatism in Mesozoic Belts of the Klamath Mountains.** M. Allan Kays, University of Oregon; Greg Harper, SUNY, Albany.
2. **The Second Symposium on the Regional Geology of the State of Washington.** Eric Cheney, University of Washington; Ray Lasmanis, Washington Division of Geology and Earth Resources.
3. **Petrologic and Tectonic Evolution of Cordilleran Low-Temperature, High-Pressure Metamorphic Terranes.** Brian Patrick, University of California, Santa Barbara; John Goodge, Southern Methodist University.
4. **Mesozoic Batholiths of the Cordilleran Orogen.** J. Lawford Anderson, University of Southern California.
5. **Seismotectonics of the Pacific Northwest.** George Priest, Oregon Dept. of Geology and Mineral Industries; Craig S. Weaver, USGS, University of Washington.
6. **Paleontological Society Symposium, Neogene Paleoclimate and Paleoenvironmental Change in the Pacific Northwest.** Andrew Cohen, University of Arizona.
7. **Geological and Tectonic Evolution of Southwestern Alaska.** Stephen Boggs, USGS, Spokane.
8. **From Spreading Center to Subduction Zone: Magmatic Processes in the Pacific Northwest.** Katherine Cashman, University of Oregon, Donald A. Swanson, USGS, University of Washington; John R. Delaney, University of Washington.
9. **Mineralization Associated with Fault Processes.** Norm Brown, University of California, Santa Barbara.
10. **Magmatism Along the Northern Margin of the Basin and Range Province.** Anita Grunder, Oregon State University; William K. Hart, Miami University.

## PROJECTION EQUIPMENT

All slides must be 2" x 2" and fit standard 35 mm carousel trays. Two projectors and two screens will be available for all oral sessions. Overhead projectors will *not* be available. Please bring loaded carousel trays, if possible.

## POSTER SESSIONS

Poster sessions will be located adjacent to the exhibit area. Each poster presenter will be provided at least one board, approximately 4' x 6'.

## FIELD TRIPS

Both premeeting and postmeeting field trips are planned. Trips are technical in nature and can be physically demanding. Please check with the trip leader if you have any questions. General questions should be addressed to the field trip coordinator, Gregory J. Retallack, Dept. of Geological Sciences, University of Oregon, Eugene, OR 97403, (503) 346-4558; fax 503-346-4692.

All trips begin and end at the Conference Center in Eugene unless otherwise specified. Trip costs include transportation, field trip guide, soft drinks, and other services as noted by the following symbols: B—breakfast, L—lunch, D—dinner, ON—overnight motel lodging, OC—overnight camping. OW indicates that overland walks exceeding 3 km will be required. Some trips offer special subsidies for student participants.

Preregistration for field trips is recommended because of logistical limitations. Participants will be accepted on a first-come, first-served basis through GSA headquarters. PREGISTRATION DEADLINE: preregistration forms must be **received** at GSA headquarters by

## REGISTRATION FEES

	Advance* (by 4/17/92)	Advance* One-Day	On-Site	On-Site One-Day
Professional—Member	\$40	\$20	\$50	\$25
Professional—Nonmember	\$55	\$25	\$65	\$30
Student—Member	\$15	\$10	\$20	\$15
Student—Nonmember	\$20	\$15	\$30	\$20
Guest	\$10	N/A	\$10	N/A

\*Registration received by 4/17/92

April 17, 1992. The CANCELLATION DEADLINE is April 24, 1992.

The registration form and procedures are provided in this announcement. All field trip participants must also register for at least one day of the meeting. Registration for field trips after the preregistration deadline may be possible if logistics permit: contact the GSA Registration Coordinator at GSA headquarters. Although preregistration is advised, registration for post-meeting trips may be possible during the meeting in the registration area.

If GSA must cancel a trip because of logistical problems or registration requirements a full refund will be issued after the meeting. **Please be sure to consider cancellation deadlines and penalties imposed by airlines when arranging your travel plans.**

Some field trip guidebooks have been and are being published as articles in *Oregon Geology*, the journal of the Oregon Department of Geology and Mineral Industries. The Department also sells a variety of other excursion guides, maps, and publications concerning the geology of Oregon. For more information contact Klaus E. Neuendorf, 910 State Office Building, 1400 SW Fifth Ave., Portland, OR 97201; (503) 229-5580, fax 503-229-5639.

Oregon weather in May can be unpredictable. It will not be hot, but warm, sunny days or cold, blustery rain are equally possible. Snow is rare but not unheard of at this time of year in the Klamath Mountains and in eastern Oregon.

#### Premeeting

**1. Tectonostratigraphy, Metamorphism and Magmatism of the Mesozoic Belts of the Klamath Mountains.** Saturday, May 9, 8:00 a.m. to Sunday, May 10, 7:00 p.m. M. Allan Kays, Dept. of Geological Sciences, University of Oregon, (503) 346-4578; Mary Donato, U.S. Geological Survey, Menlo Park; Greg Harper (SUNY, Albany), c/o Dept. of Geological Sciences, University of Oregon. Cost: \$90 (1 ON, 2L). Limit: 20.

Participants on this trip will get an overview of Paleozoic to Jurassic allochthonous terranes in the northern Klamath Mountains. Special attention will be given to (1) ophiolitic rocks along the thrust-faulted contact between terranes, (2) the 141 Ma (K/Ar) White Rock tonalite to trondhjemite pluton that intrudes the thrust, and (3) andalusite-sillimanite metamorphism associated with the intrusion. A short raft trip through Late Jurassic Galice Formation turbidites, Rogue Formation metavolcanic rocks, and sheared rocks possibly correlative with the Josephine Ophiolite is planned as part of this excursion. All necessary equipment will be provided, but come with a change of clothes! Slippery river rocks and perhaps rain will be encountered, so shoes with gripping soles are recommended.

**2. Stratigraphic and Tectonic Framework of Tertiary Marine Forearc Basins and the Mist Gas Field, Northwest Oregon.** Friday, May 8, 8:00 a.m. to Sunday, May 10, 7:00 p.m. Alan R. Niem, Dept. of Geosciences, Oregon State University, (503) 737-1233; Brian McKnight, Dept. of Geology, University of Wisconsin, Oshkosh; H. Jack Meyer, Oregon Natural Gas Co. Cost: \$198 (2 ON, 3L). Limit: 15.

Eocene to Miocene marine siliciclastic and volcanic sequences along the scenic northwestern Oregon coast and lower Columbia River will be seen on this trip, which will emphasize sedimentary structures and lithofacies of storm-dominated deltas, beaches,

shelves, slopes, and submarine canyon heads. There will be opportunities to collect marine trace fossils, molluscs, and microfossils. Also of interest is the interaction of sedimentary and volcanic processes in creating these rocks. Lava deltas, arc-derived debris flows, phreatic breccias, spectacular invasive sills and dikes, peperites, and associated synsedimentary folds and breccias will be examined. The subsurface geology of the Mist gas field will be considered in the field, in cores and logs, and in seismic profiles. Also considered will be the plate-tectonic setting and structural development of the forearc basins and the adjacent offshore subduction zone.

**3. Middle Tertiary Rocky Coast Paleoenvironments and Tempêtes in the Oregon Western Cascades.** Sunday, May 10, 8:00 a.m. to 7:00 p.m. William N. Orr and Cynthia Shroba, Dept. of Geological Sciences, University of Oregon, (503) 346-4577. Cost: \$20 (1L). Limit: 20.

Richly fossiliferous late Oligocene sedimentary rocks near Scotts Mills in the central western margin of the Willamette Valley will be examined on this one-day excursion. These deposits are notable for excellent preservation of rocky coastal sedimentary facies and fossil assemblages, which are rare in the marine fossil record at large. Also preserved are sea stacks and tempestite deposits. These coastal sediments record the final marine regression from the Willamette Valley, associated with accretion of the Oregon Coast Range.

**4. Mid-Tertiary Paleosols and Paleoclimatic Changes in the High Desert of Central Oregon.** Friday, May 8, 6:00 p.m. to Sunday, May 10, 7:00 p.m. Gregory J. Retallack and Erick Bestland, Dept. of Geological Sciences, University of Oregon, (503) 346-4558. Cost: \$90 (2L, 2ON, 1OW). Limit: 20.

Paleosols within fluvial and volcanoclastic sediments of the Eocene to Miocene Clarno, John Day, and Mascall Formations create strikingly scenic color-banded badlands for which this high desert region of central Oregon is famous. The changing intensity and kind of weathering also provide a record of the transition from humid rain forest to dry steppe with the growth of the Oregon Cascade volcanoes and accretion of the Oregon Coast Range. A variety of volcanic

rocks, including a thick sequence of Eocene lahars, massive ash-flow tuffs of Oligocene age, and a sequence of flood basalts of the Columbia River Basalt Group, spectacularly exposed in Picture Gorge, will also be seen on this excursion. The volcanic rocks reflect reorganization of the volcanic arc along a new line of subduction following Oligocene accretion of the Oregon Coast Range. Paleoclimatic drying of central Oregon in part reflects a rain shadow resulting from the Oligocene and Miocene building of the Cascades, but also stepwise global paleoclimatic deterioration from the balmy days of the middle Eocene toward the Ice Ages of the past million years. A 6 km hike in hilly country is planned for the morning of May 9, mainly over trails, but with short stretches of rough ground.

**5. Active Faulting in South-central Oregon.** Friday, May 8, 7:00 p.m. to Sunday, May 10, 7:00 p.m. Ray Weldon and Silvio Pezzopane, Dept. of Geological Sciences, University of Oregon, (503) 346-4584; Patricia McDowell, Dept. of Geography, University of Oregon. Cost: \$84 (2B, 2L, 1D, 1ON, 1OC). Limit: 30.

This trip will focus on active tectonic deformation of the northwestern Basin and Range province in central Oregon. Faulting will be examined in open trenches across Holocene faults in latest Pleistocene lake beds, particularly the Crack-in-the-Ground fault in Fort Rock Valley. Also examined will be deformed shorelines around the Chewaucan Basin and late Pleistocene and Holocene pluvial, volcanic, and eolian stratigraphy. This deformation can be related to the tectonic history of the northwestern Basin and Range, as well as to the Cascades and the overall plate boundary in the Pacific Northwest. Friday night, May 9, will be spent camping at Summer Lake Hot Springs, which has excellent facilities, including heated and lit baths and showers, and a large indoor hot pool. Towels and tents will be provided, but not sleeping bags. Subsidies are available for student participants willing to help with arrangements; contact Ray Weldon.

**6. Landslides in the Portland Metropolitan Area.** Sunday, May 10, 8:00 a.m. to 5:30 p.m. Scott Burns, Dept. of Geology, Portland State University, (503) 725-3389. Cost: \$34. (1L). Limit: 40.

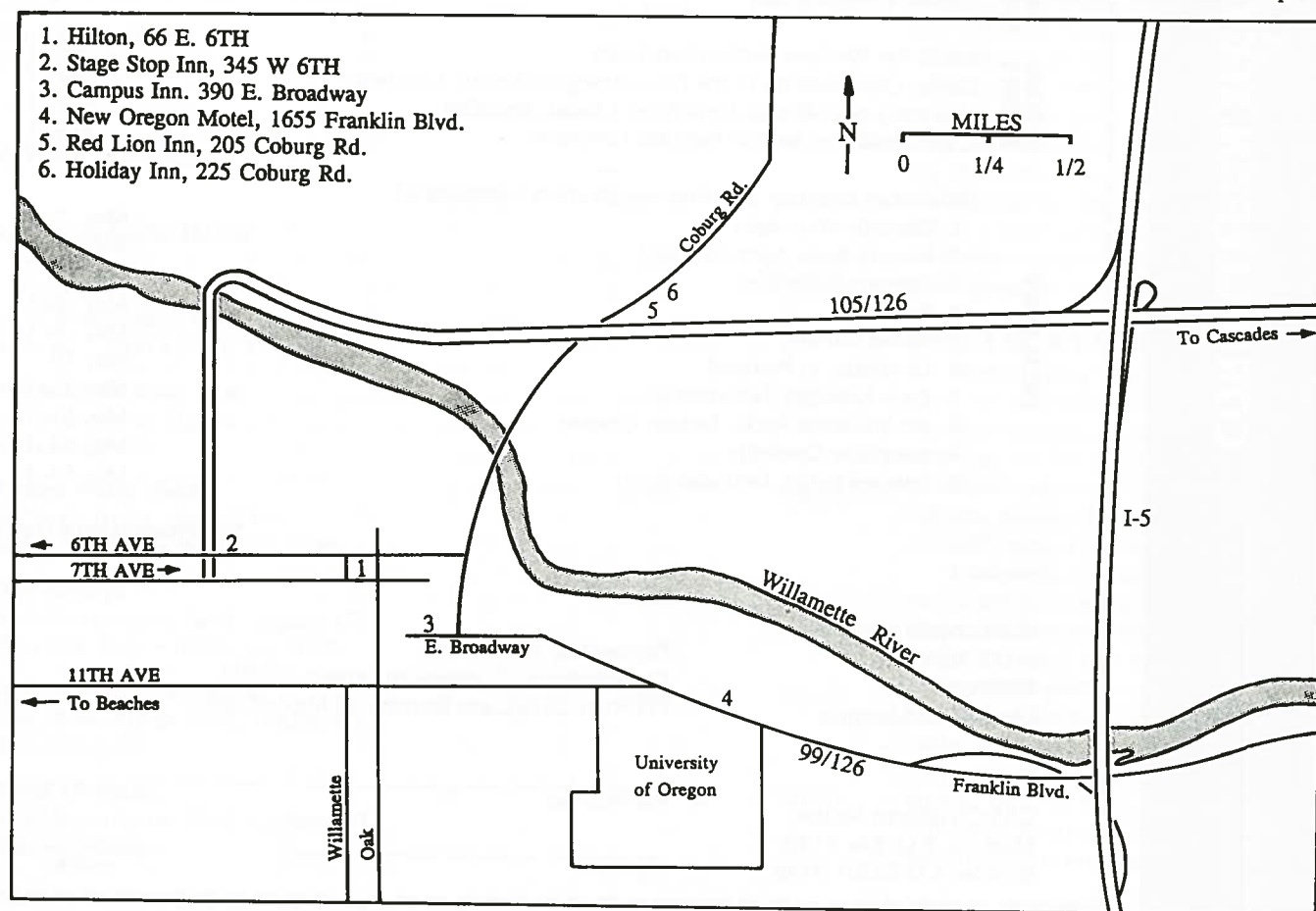
Landslides are common in Oregon and many have been studied in the Portland area. We will visit ancient and modern slides, focusing on their causes, mechanisms, failure planes, effects on human life, and repair work done after failures. In the Columbia Gorge, we will visit the Stark Street Bridge rockfall that occurred in 1990, the ancient Rooster Rock landslide, where we will see paleosol failure surfaces, and the massive Bonneville slide that moved on a low-angle failure surface. In Portland, we will visit the West Linn slide and the OMSI slide, both of which moved on the Vantage paleosol horizon, the Washington Park landslide that was reactivated by human activities in the early 1900s, and the lava tube sinkholes of St. Vincent Hospital. Our last stop will be west of Portland in the Coast Range at the site of the million-cubic-meter Wilson River landslide that occurred in April of 1991. Throughout the trip, we will stress how engineering geologists and geomorphologists in Oregon work to prevent landslides by understanding the parent material and associated failure surfaces. This trip originates at the Sheraton Hotel at Portland airport, and arrangements can be made with the trip leader for group accommodation the night before at an additional charge (\$69 single or double). Payment for overnight at the Sheraton should be made payable directly to the trip leader. Transportation following the excursion will be provided to both Portland airport and Eugene.

#### Postmeeting

**7. Early Paleozoic Tectonics and Sedimentation, Yreka and Trinity Terranes, California.** Wednesday, May 13, 3:30 p.m. to Saturday, May 16, 7:00 p.m. Timothy Wallin, Dept. of Geosciences, University of Nevada, Las Vegas, (702) 739-1092; Nancy Lindsley-Griffin, Dept. of Geology, University of Nebraska, Lincoln. Cost: \$233 (3L, 3ON). Limit: 30.

Early Paleozoic rocks of the Yreka and Trinity terranes record a complex history of crustal development, sedimentation, amalgamation, and metamorphism. We will examine the Early Cambrian through Devonian record of this area and discuss the nature of geologic events and brackets on their timing. Day one will be devoted to rocks of the Trinity complex, which record

*Cordilleran continued on p. 40*



a post-Middle Ordovician, pre-Late Silurian amalgamation of Cambrian metaplutonic rocks and Ordovician ultramafic rocks. Weather permitting, we will examine Late Silurian pegmatitic gabbro that may represent the roots of an arc. Day two will focus on the evidence for sedimentation, deformation, and magmatism in a Devonian arc-trench gap setting represented by part of the Yreka terrane. We will examine melange of the Gregg Ranch Complex, eugeoclinal sedimentary rocks of the overlying Gazelle Formation, and associated undeformed mafic volcanic rocks. Day three will consist of a traverse of roadcut and quarry exposures within terrigenous metasedimentary rocks and subjacent greenschist and blueschist melange of the

Yreka terrane. Discussions will focus on the origins of the rocks and models for the early Paleozoic tectonic development of the region.

*No traverses longer than 3 km are planned, but there will be hiking in rugged terrain and steep rocky slopes, perhaps in cold, rainy weather.*

**8. Pre-Tertiary Volcanic Arc and Melange Rocks of East-central Oregon.** Wednesday, May 13, 5:00 p.m. to Saturday, May 16, 3:00 p.m. Charles D. Blome, U.S. Geological Survey, Denver, (303) 236-5682; Merlynd K. Nestell, Dept. of Geology, University of Texas at Arlington; Ellen Bishop, Science Dept., Eastern Oregon State College; Howard Brooks, Oregon Dept. of Geology and Mineral Industries. Cost: \$156 (2L, 3ON). Limit: 20.

The Blue Mountains province of eastern Oregon contains pre-Tertiary volcanic-arc rocks exposed in erosional inliers surrounded by Cenozoic lavas. This trip will emphasize the tectonic evolution of three contiguous tectonostratigraphic terranes (Grindstone, Izee, Baker) in the western half of the province as shown by biostratigraphic, sedimentologic, and structural evidence. On the first day, we will examine some of the oldest rocks in Oregon in the remote high desert of the Grindstone melange terrane. Blocks in the melange include relatively unmetamorphosed and fossiliferous Devonian and Mississippian limestones, Permian limestone correlative with the McCloud Limestone in the Klamath Mountains, and Permian and Triassic chert and conglomerate. The second day will include stops that feature

ocean-floor deposits (Canyon Mountain ophiolite, Izee terrane), fossiliferous forearc volcanoclastic rocks (Izee terrane), and tectonic melange composed of serpentinite, metavolcanic rocks, and metamorphosed sedimentary rocks (Baker terrane). Discussions will focus on the varied models for development of the Blue Mountains arc, arc basin and accretionary complex. Moderate hiking to silicified limestone and siliciclastic rock exposures are planned. Bring footwear with sturdy, non-slip soles.

**9. The Josephine Ophiolite of Northwestern California.** Wednesday, May 13, 5:00 p.m. to Friday, May 15, 7:00 p.m. Gregory Harper (SUNY, Albany), c/o Dept. of Geological Sciences, University of Oregon, (503) 346-6000; Robert J. Alexander, Dept. of Geologi-

CORDILLERAN SECTION PREREGISTRATION FORM

PREREGISTRATION FORM

Cordilleran Section, GSA  
May 11-13, 1992

Please print or type • Copy for your records • Shaded areas are for your badge

IMPORTANT

1. Full Payment must accompany registration. Unpaid Purchase Orders not accepted as valid registration.
2. Use separate form for each registrant, professional or student.
3. PREREGISTRATION MUST BE POSTMARKED NO LATER THAN APRIL 17, 1992.  
Cancellation deadline for a full refund is April 24, 1992.
4. For registration information, please call the GSA Registration Coordinator at (303) 447-2020.

Name (Last)	(First)	Initial
Employer/University/Affiliation (for badge)		
Mailing address of affiliation indicated above		
Address		
City	State	ZIP code
Work Phone	Home Phone	Fax
Guest/Spouse Name (Last)	(First)	
City	State/Country	

Membership Affiliation A: ☐ GSA Member No. \_\_\_\_\_ B: ☐ NAGT C: ☐ PS

(Registration required for participation in all events.)

(PLEASE CHECK ONE):

			Full Meeting	or	1 Day	Qty	Amount
PREREGISTRATION FEES	Professional Member		( 1) \$40 <input type="checkbox"/>		( 2) \$20 <input type="checkbox"/>	1	\$ _____
	Professional Nonmember		( 3) \$55 <input type="checkbox"/>		( 4) \$25 <input type="checkbox"/>	1	\$ _____
	Student Member		( 5) \$15 <input type="checkbox"/>		( 6) \$10 <input type="checkbox"/>	1	\$ _____
	Student Nonmember		( 7) \$20 <input type="checkbox"/>		( 8) \$15 <input type="checkbox"/>	1	\$ _____
	Guest (fill in name above for badge)		( 9) \$10 <input type="checkbox"/>		N/A	1	\$ _____
	Secondary School Teacher		(42) \$ 0 <input type="checkbox"/>		N/A	1	\$ _____
GUEST EVENTS	High School Students		(45) \$ 0 <input type="checkbox"/>		N/A	1	\$ _____
	Willamette Valley Wineries	May 11	( 20) \$ 15				\$ _____
SPECIAL EVENTS	Central Oregon Coast	May 12	( 21) \$ 25				\$ _____
	NAGT Far Western Section Luncheon	May 11	( 60) \$ 15				\$ _____
	Pacific Coast Section of the Paleontological Society Luncheon	May 12	( 61) \$ 15				\$ _____
	University of California Department Heads Breakfast	May 12	( 62) \$ 10				\$ _____
	GSA Cordilleran Section Business Luncheon	May 13	( 63) \$ 15				\$ _____

(Minimum one-day meeting registration is required.)

FIELD TRIPS	1. Klamath Mountains	May 9-10	(100) \$ 90	1	\$ _____
	2. Forearc Basin, Mist Gas Field	May 8-10	(101) \$198	1	\$ _____
	3. Paleoenvironments	May 10	(102) \$ 20	1	\$ _____
	4. Paleosols	May 8-10	(103) \$ 90	1	\$ _____
	5. Active Faulting	May 8-10	(104) \$ 84	1	\$ _____
	6. Landslides in Portland	May 10	(105) \$ 34	1	\$ _____
	7. Early Paleozoic Tectonics	May 13-16	(106) \$233	1	\$ _____
	8. Arc/melange Rocks, Eastern Oregon	May 13-16	(107) \$156	1	\$ _____
	9. Josephine Ophiolite	May 13-15	(108) \$128	1	\$ _____
	10. Volcaniclastics, Deshutes Basin	May 13-15	(109) \$100	1	\$ _____

Total Remittance (full payment must be enclosed) \$ \_\_\_\_\_

Make checks payable  
in U.S. funds to  
**1992 GSA  
Cordilleran Meeting**

Mail to:  
GSA Cordilleran Section  
Meeting, P.O. Box 9140,  
Boulder, CO 80301-9140

Payment by (check one):

- ☐ Cash/check ☐ American Express ☐ VISA  
☐ Diners Club/Carte Blanche ☐ MasterCard

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expires

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CK# _____			
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Ref. A/P 2006 _____			
Refund ck# _____			

cal Sciences, SUNY, Albany. Cost: \$128 (2L, 2ON). Limit: 30.

On this trip to the Jurassic Josephine ophiolite we will examine excellent outcrops along the Smith River in all the units of this large and remarkably complete ophiolite complex. The effects of subseafloor hydrothermal metamorphism and associated oceanic faulting will be examined in the sheeted dike complex. The depositional contact of the Upper Jurassic Galice Formation, as well as the transition from hemipelagic to flysch sedimentation in that formation, will be examined. We will also see structural deformation and calc-alkaline dikes in the Galice Formation. The Josephine ophiolite represents a short-lived Jurassic back-arc basin thrust beneath western North America during the Nevadan orogeny. These exposures are slippery river rocks, so shoes with gripping soles are recommended.

**10. Sedimentology and Volcanology of Neogene Continental Volcaniclastic Rocks, Deschutes Basin, Central Oregon.** Wednesday, May 13, 5:00 p.m. to Friday, May 15, 7:00 p.m. Gary A. Smith, Dept. of Geology, University of New Mexico, (505) 277-2348; Edward M. Taylor, Dept. of Geosciences, Oregon State University. Cost: \$100 (2L, 2ON). Limit: 25.

Participants on this trip will examine a variety of late Miocene rocks of volcanic, sedimentary, and mixed volcano-sedimentary origins. Superb, little-deformed exposures of pyroclastic flows, falls and surges, fluvial channels and floodplains, debris flows, hyper-concentrated flows, and paleosols will be seen. Emphasis will be on criteria for distinguishing these deposits and on unique aspects of volcanoclastic alluvial sequences that record volcanic influences on sedimentation. Basin analysis results will be presented to illustrate the volcanic and tectonic development of the late Miocene central Oregon Cascade Range. This trip is sponsored by the Sedimentary Geology Division of GSA. Up to five student members of the division will receive rebates for half the field trip cost. Eligible students should apply to Mary Kraus, Dept. of Geological Sciences, University of Colorado, Boulder, CO 80302, (303) 492-7251.

**EXHIBITS**

Exhibits will be located in the main foyer of the Conference Center. The cost of standard booths is \$300 for commercial exhibitors and \$150 for educational and nonprofit institutions. For further information and space reservations, please contact meeting chairman A. Dana Johnston, Dept. of Geological Sciences, University of Oregon, Eugene, OR 97403, (503) 346-5588, fax 503-346-4692.

**GUEST PROGRAM**

A half-day tour of area wineries will be offered; **Willamette Valley Wines**, particularly the pinot noir, are rapidly gaining international reputations. Cost: \$15.

A full-day tour of the beautiful **Central Oregon Coast** will include stops at Oregon Dunes National Recreation Area, Heceta Head Lighthouse, and Sea Lion Caves. Cost: \$25.

**GENERAL INFORMATION**

For additional information, please contact the meeting chairman, A. Dana Johnston, Dept. of Geological Sciences, University of Oregon, Eugene, OR 97403, (503) 346-5588, fax 503-346-4692. ■

**Final Announcement**

**ROCKY MOUNTAIN SECTION, GSA  
45th Annual Meeting**

**Ogden, Utah  
May 13-15, 1992**

The Rocky Mountain Section of the Geological Society of America and the Rocky Mountain Section of the Paleontological Society of America will meet jointly in Ogden, Utah, May 13-15, 1992. The meeting is sponsored by the Department of Geology, Weber State University.

**OGDEN**

The meeting will be held at the Radisson Suite Hotel in downtown Ogden, a change from the original announcement because of overbooking at the Ogden Park Hotel. The Radisson is close to fine restaurants and interesting shops and is only a short walk from historic 25th Street and Union Station museums. The Ogden City Mall is located within one block of the Radisson. The weather in early May should be pleasant with springlike mild temperatures. Situated at the boundary of the Basin and Range and Middle Rocky Mountain physiographic provinces, the Ogden area has a variety of geologic features ranging in age from Precambrian to Holocene and varying from the igneous and metamorphic rocks of the Farmington Canyon Complex to the deposits of pluvial Lake Bonneville. Although the meeting site is adjacent to the Wasatch fault zone, the probability of a major earthquake occurring during the course of the meeting is considered remote. This variety of geologic features makes northern Utah an ideal classroom for students and professionals alike, as J. W. Powell, F. V. Hayden, G. M. Wheeler, G. K. Gilbert, E. Blackwelder, W. M. Davis, and A. J. Eardley discovered.

**REGISTRATION**

**Preregister Today! Preregistration Deadline: April 15, 1992.**  
1. Note that there is a savings in fees if you preregister! Preregistration also assists the local committee in making final plans for the meeting. The preregistration form is provided in this announcement.  
2. Badges must be worn for access to ALL activities.  
3. Registration discounts are given to GSA or associated society members. Associated societies that qualify for this discount are indicated on the preregistration form. Please indicate your affiliation(s) and member number to register at member rates. Proper ID will be requested for K-12 earth science teachers.  
4. Full payment must accompany the preregistration form. Unpaid purchase orders are not accepted as valid registration. Charge cards are accepted, as indicated on the form. Please recheck the charge card number given; errors will delay your registration. Your confirmation letter from GSA will be your only receipt.  
5. Please register only one professional or student per form; keep a copy for your records.

**REGISTRATION FEES**

	Advance (by April 15)	On-Site	One-Day Advance	One-Day On-Site
Professional—Member	\$45	\$60	\$30	\$30
Professional—Nonmember	\$60	\$70	\$30	\$30
Student—Member	\$25	\$30	N/A	N/A
Student—Nonmember	\$30	\$35	N/A	N/A
Secondary School Teacher	\$10	\$10	N/A	N/A
Guest	\$20	\$20	N/A	N/A
Nonregistrant Fee (Field Trips)	\$15			

**ROOM RATES**

	# on Map	Single	Double
<b>Radisson Suite Hotel</b>	1		
Suites		\$55.00*	\$55.00*
Rooms		35.00*	35.00*
2501 Washington Blvd., Ogden, UT (801) 627-1900 • (800) 333-3333			
<b>Western Colony Inn</b>	2	30.00	37.00
234 24th Street, Ogden UT (801) 627-1332			
<b>Ogden Park Hotel</b>	3	39.00	39.00
247 24th Street, Ogden, UT (801) 627-1190 • (800) 421-7599			
<b>Travelodge</b>	4	40.00	48.00
2110 Washington Blvd., Ogden UT (801) 394-4563 • (800) 255-3050			
<b>Ogden Imperial Motel</b>	5	23.00	28.00
1956 Washington Blvd., Ogden UT (801) 393-8667			
<b>Motel Orleans</b>	6	26.00	30.00
1825 Washington Blvd., Ogden, UT (801) 621-8350			

\*Price includes complimentary breakfast and complimentary cocktail socials.

6. Current student ID is required to obtain student rates at both the preregistration and on-site counters. Students not carrying a current student ID when they arrive to pick up their registration materials will be required to pay the professional fee.  
7. Preregistration forms received after the April 15th deadline will be charged at the ON-SITE rate.  
8. Guest registration is required to attend activities or to visit the exhibit hall. To obtain the guest rate all guests must be accompanied by either a registered professional or student.

For registration information, please call the GSA Registration Coordinator at (303) 447-2020.

**CANCELLATION,  
CHANGES, REFUNDS**

All requests for registration additions, changes, and cancellations must be made in writing and received by *April 22*. NO REFUNDS OR CREDITS WILL BE MADE ON CANCELLATION NOTICES RECEIVED AFTER THIS DATE. Refunds will be mailed from GSA after the meeting. Refunds for fees paid by credit card will be credited according to the card number on the preregistration form. NO refunds for on-site registration and ticket sales.

**ON-SITE REGISTRATION  
SCHEDULE—Radisson  
Suite Hotel**

Tuesday, May 12  
4:00 p.m. to 9:00 p.m.  
Wednesday, May 13  
7:00 a.m. to 4:30 p.m.  
Thursday, May 14  
7:00 a.m. to 2:00 p.m.  
Friday, May 15  
7:30 a.m. to 12:00 noon

A message board and general information center will also be available in the registration area for your convenience. The number during the meeting will be (801) 627-1190.

**HOUSING**

Because of other meetings, guest housing will be scarce in Ogden during the week of May 11-15, so participants are urged to make room reservations early. In order to help alleviate this problem, a block of rooms at the Radisson Suite Hotel, site of the meeting, has been reserved for participants at a special reduced rate. Additional housing is available at other motels and hotels in Ogden, several of which are within walking distance of the meeting site. The locations of some of these facilities are given on the index map. Reservations can be made by calling the hotel or motel directly. When contacting the Radisson identify yourself as a participant in the Rocky Mountain Section of GSA meeting. Rates given do not include taxes.

**SPECIAL EVENTS**

**Welcoming Party.** A welcoming party for all registrants will be held on Tuesday evening, May 12, from 7:00 to 9:00 p.m. in the ballroom of the Radisson Hotel (see motel locator and meeting area maps). Hors d'oeuvres will be available with a partially hosted bar.

**Banquet.** A banquet will be held on Thursday evening, May 14, in the Eleventh Floor Meeting Room of the Radisson Hotel. The evening will begin with a social gathering and cash bar at 6:30 p.m. followed by a roast beef and halibut buffet at 7:00 p.m. Guest speaker for the occasion will be Francis H. Brown, Dean of the College of Mines and Earth Sciences, University of Utah. Brown's talk is entitled Geological

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Framework for the Hominid Record in East Africa and will describe tephrostratigraphic studies that allow estimation of ages, correlation between widely separated localities, and reconstruction of regional and local paleogeography and paleoenvironments of hominid sites. During the social period and after the speaker there will be a Utah group presenting authentic western music for listening or dancing. Seating for the buffet is limited to 120, so preregistration is strongly advised. Cost: \$14.

The **GSA Rocky Mountain Section Business** meeting, will be held on Thursday, May 14, 1992, in Yester-Year's Restaurant in the Radisson Suite Hotel, at 12:00 noon. Cost: \$7. The **GSA Rocky Mountain Section Management Board** will meet for breakfast in the Yester-Year's Restaurant in the Radisson Suite Hotel on May 15, 1992, at 6:30 a.m. Cost: \$6.

## PARKING

Free parking for those attending the GSA Rocky Mountain Section Meeting is available in the public parking lot across 25th Street from the hotel (see index map). Most of the motels listed above are a short distance from the Radisson.

## COFFEE, SNACKS, AND LUNCH

To hold down costs, no free coffee or snacks will be provided during meeting hours. However, coffee, soft drinks, and limited snacks will be available at moderate cost in the Exhibits and Poster Display area in the ballroom. The Radisson Hotel houses two restaurants; several others are within a short walk of the hotel.

## FIELD TRIPS

Both premeeting and postmeeting field trips will be offered. Unless otherwise noted, all field trips begin and end at the Radisson Hotel in Ogden. For details about particular field trips, contact the field trip leaders listed or James R. Wilson, Field Trip Coordinator, Dept. of Geology, Weber State University, Ogden, UT 84408-2507, (801) 626-6208.

Preregistration for all field trips is required. Participants are accepted on a first-come, first-served basis through GSA headquarters.

The preregistration deadline is April 15, 1992. The preregistration form is provided in this announcement. Participants registering for a field trip only must pay a \$15 service fee in addition to the field trip charge.

The cancellation deadline is April 22, 1992. No refunds will be given if cancellation is received after this date. All cancellations must be in writing. If GSA must cancel a field trip due to logistics or registration requirements, a full refund will be issued after the meeting. Be aware of cancellation deadlines and possible penalties imposed by airlines. You may wish to cancel flight arrangements if a trip you have registered for is canceled.

**Field Trip Guidebook.** An extensive guidebook containing road logs for all the field trips will be published by the Utah Geological Survey and is included in the cost of all field trips except 5, 9, and 11. In addition, the guidebook will be of interest to many professionals because of the large number of articles discussing the geology of the areas visited by the field trips. Of particular interest will be the eight or more articles related to the mineral deposits of the Oquirrh Mountains (Bingham, Barney's Canyon, and Mercur), the four

articles detailing metamorphic and structural features of the eastern Great Basin, and the three articles relevant to the structure and stratigraphy in the Lakeside and Stansbury Mountains. Many other articles and detailed road logs will be found in the volume. The guidebook is available to all who preregister at a prepublication price of \$15; just present your confirmation letter at the Utah Geological Survey booth in the exhibit hall. It will be sold over the counter at the meeting at a slightly higher price and will be available after the meeting from the Utah Geological Survey.

## Premeeting

**1. Quaternary Volcanism, Tectonics, and Sedimentation in the Idaho National Engineering Laboratory (INEL) Area** (2 days). The trip leaves Monday, May 11, from Idaho Falls, Idaho, and ends in Idaho Falls on Tuesday, May 12, with transportation available to Ogden on Tuesday evening. William R. Hackett and Richard P. Smith, EG&G Idaho, Inc., (208) 526-6963. Cost: \$110 (includes transportation, 2 lunches, 1 night lodging, and guidebook). Limit: 18.

This trip emphasizes Quaternary and Neogene bimodal volcanism of the eastern Snake River Plain, the tectonics of the surrounding Basin and Range province, and the influence of volcanotectonic processes on fluvial, lacustrine, and eolian sedimentation in the INEL area. The regional geology of the eastern Snake River Plain will be discussed within the context of assessing volcanic and seismic risk at the INEL. Features to be visited include Holocene basalt lava fields, Pleistocene rhyolite domes, volcanic and structural features of Quaternary basaltic rift zones near INEL; Pleistocene glacial-outburst flood features; a trench site on the Lost River fault; faulting, sedimentation, and volcanic deposits along the northern margin of the eastern Snake River Plain; and Neogene rhyolite volcanics exposed around the margins of the plain. Some moderate hiking on both days.

**2. Structure and Fabric of Metamorphic Terrains in the Eastern Great Basin: Implications for Mesozoic Crustal Shortening and Extension** (4 days). The trip leaves by carryall from the Radisson Hotel in Ogden at 7:30 a.m. on Saturday, May 9, and returns late Tuesday afternoon, May 12. David M. Miller and Michael L. Wells, USGS, (415) 329-4923; Phyllis Camilleri and Arthur N. Snoke, University of Wyoming. Cost: \$230 (includes transportation, 2 breakfasts, 4 lunches, 1 dinner, 3 nights lodging, and guidebook). Limit: 27.

This trip will provide a cross section through four Mesozoic metamorphic terrains in the northeastern Great Basin as follows (1) Raft River Mountains—observe evidence for large-magnitude Cretaceous extension during greenschist facies conditions, and contractile deformation that both predates and postdates extension; (2) Pilot Range—examine folding and thrust faulting interpreted as synchronous with middle amphibolite facies metamorphism, which overlapped in time with the emplacement of a Late Jurassic pluton, and subsequent Cretaceous extension during greenschist facies conditions; (3) East Humboldt Range-Wood Hills-Pequop Mountains regions—discussion of the character and possible origins of Mesozoic regional metamorphism and polyphase contractile deformation; (4) East Humboldt Range (Clover Hill area)—examine high pressure (>7kbar) Mesozoic metamorphic rocks exposed in the upper limb of the

Winchell Lake fold-nappe. The trip will involve some rigorous hiking. Be prepared for possible chilly weather.

**3. Extraordinary Synorogenic and Anoxic Deposits Amidst Sequence Cycles of the Late Devonian-Early Mississippian Carbonate Shelf, Lakeside and Stansbury Mountains, Utah** (2 days). This trip departs by van from Ogden, Monday, May 11, at 8:30 a.m. (with a 9:30 a.m. stop at the Salt Lake City Airport) and returns to Ogden on Tuesday, May 12, in the late afternoon. Cost: \$125 (includes transportation, 1 breakfast, 2 lunches, 1 night lodging, and guidebook). K. M. Nichols and N. J. Silberling, USGS, (303) 236-5799; P. H. Cashman and J. H. Trexler, Jr., University of Nevada—Reno. Limit: 24.

Devonian-Mississippian strata of western Utah record a poorly known and partly controversial cyclic depositional history reflecting the interplay between tectonic and eustatic controls. Excellent exposures of these rocks will be examined in several short, easy hikes in the Stansbury and Lakeside Mountains at the southwest edge of the Great Salt Lake. Objectives will be: (1) to examine the unique lithic character of the synorogenic Devonian Stansbury Formation and discuss its paleotectonic significance, (2) to inspect characteristic exposures of the various rock units comprising the latest Devonian to Osagean carbonate depositional cycles and reflect on their setting within the regional Mississippian carbonate shelf, and, (3) to scrutinize deposits of the Delle phosphatic event, including those of the relatively well exposed type section of the Delle Phosphatic Member of the Woodman Formation in the Lakeside Mountains, and consider the evidence for their depositional environment and paleogeographic setting.

**4. Quaternary Geology and Geologic Hazards of Tooele and Northern Rush Valley, Utah** (1 day). This trip departs by van from the Radisson Hotel in Ogden at 8:00 a.m., Tuesday, May 12, and returns that evening about 5 p.m. Barry Solomon and Susan Olig, Utah Geological Survey, (801) 467-7970; Ben Everitt, Utah Division of Water Resources; Don Currey and Daning Wu, University of Utah; Ted Burr. Cost: \$55 (includes transportation, lunch, and guidebook). Limit: 30.

Participants will examine outcrop and trench exposures of prominent faults that offset Lake Bonneville deposits on the eastern margin of Tooele Valley. Near the city of Tooele significant damage occurred from flooding and debris flows during a period of high precipitation in 1983-1984. Flood protection measures will be discussed, evidence of recent debris flows will be inspected, and the recent highstand of ephemeral Rush Lake will be observed. A spectacular bar and spit complex at the town of Stockton will be examined and the details of paleolake history recorded in littoral deposits will be discussed. Geotechnical aspects of chemical weapons storage and disposal at the Tooele Army Depot will be addressed. The trip concludes with an inspection of enigmatic circular depressions in the northern Tooele Valley which resemble liquefaction-induced sand boils.

**5. Geologic Evolution of Antelope Island: Multiple Episodes of Deformation and Metamorphism** (1 or 2 days). This trip departs from the Comfort Inn at the Salt Lake Airport International Center at 7:45 a.m., Monday, May 11, and returns to the Comfort Inn that evening about 6 p.m.

On the second day, the trip leaves the Comfort Inn at 7:45 a.m., Tuesday, May 12, and returns to the Comfort Inn about 6:00 p.m. Transportation to Ogden will be available Tuesday evening after the field trip. Because of the low elevation of the causeway to Antelope Island, this trip may be canceled at the last minute if a storm or high winds cause flooding. Grant C. Willis, Hellmut H. Doelling, Mark E. Jensen, Utah Geological Survey, (801) 626-7970; W. Adolph Yonkee, Weber State University. Cost: \$45 for 1 day; \$70 for both days (includes transportation, handouts, and 2 lunches). Limit: 36.

On this trip we will focus on the long and complex tectonic history of northern Utah. Excellent exposures on Antelope Island provide an unsurpassed opportunity to examine tectonic features in a scenic setting surrounded by the Great Salt Lake. Participants will examine: (1) Archean(?) to Early Proterozoic metamorphism and intrusive history of the Farmington Canyon Complex, (2) Mesozoic semi-ductile shearing and greenschist facies metamorphism related to regional thrusting, and (3) Cenozoic sedimentation and tectonics. The first day will include vehicle travel and short hikes. The second day will be a strenuous all-day hike along the scenic ridge crest of the island to further explore its geologic evolution. Participants should bring a day pack and proper hiking attire. *You may register for either day or both days of this trip; priority will be given to those who wish to participate on both days.*

**6. Geologic Hazards of the Ogden Area, Utah** (1 day). The trip will depart by van Monday, May 11, from the Radisson Hotel in Ogden at 7:30 a.m. and will return after 6:30 p.m. M. V. Lowe, B. D. Black, K. M. Harty, W. E. Mulvey, Utah Geological Survey, (801) 467-7970; J. R. Keaton, Sergeant, Hauskins and Beckwith; A. R. Nelson, USGS; E. F. Pashley, Jr., Weber State University; S. R. Williams, Davis County Flood Control. Cost: \$55 (includes transportation, lunch, and guidebook). Limit: 28.

This trip, planned for professionals but also suitable for secondary school teachers and students, focuses on: (1) surface faulting events on the Weber segment of the Wasatch fault zone as seen in trenches and natural exposures, (2) recent (1983-1991) debris flow and landslides in the Ogden area, (3) older events such as a liquefaction-induced lateral spread landslide in Farmington, the Ogden River landslide complex, the Washington Terrace landslide complex, and landslides near Weber State University; and (4) debris flow hazard studies and land use planning in Davis County. Field attire is recommended; limited walking is involved.

**7. Geology, Geochemistry, and Mineral Deposits of the Oquirrh Mountains, Utah** (1 day). The trip departs by bus on Tuesday, May 12, from the Radisson Hotel in Ogden at 7:30 a.m. and will return at about 6:00 p.m. Paula N. Wilson, University of Utah, (801) 581-5553; Ricardo D. Presnell, Kennecott. Cost: \$45 (includes transportation, lunch, and guidebook). Limit: 41.

This trip will highlight recent geochemical and structural studies of mineral deposits in the Oquirrh Mountains; a range that is unique in its concentration and diversity of mineral deposits. The trip will consist of an overview of Kennecott's Bingham porphyry copper mine and tours of Kennecott's Barney's Canyon gold mine and Barricks Mercur

gold mine. Participants will view mineralization, alteration, and structures. Mine tours will include discussions of structural and stratigraphic control of gold deposition, relations between the Bingham system and gold mineralization, tectonic settings of gold and base metal mineralization, and evidence for possible Mesozoic age for gold deposits in the Oquirrh Mountains.

#### 8. Mesozoic and Early Tertiary Paleontology and Paleoenvironments of Northeastern Utah

(2 days). This trip departs by bus from the Comfort Inn—Airport (Salt Lake Airport International Center) at 7:00 a.m., Monday, May 11, stays overnight in Vernal, Utah, and ends at the Radisson Hotel in Ogden about 6:00 p.m., Tuesday, May 12. David D. Gillette, (801) 533-4563; Martha Hayden, Utah Division of State History; Sue Ann Bilbey and Aiden Hamblin, Utah Field House of Natural History; Daniel Chure, Scott E. Madsen, and Ann Elder, Dinosaur National Monument; Martin Lockley, Kelly L. Conrad, and Marc Paquette, University of Colorado—Denver; Emmett Evanoff and Logan D. Ivey, University of Colorado—Boulder; John T. Huber, University of Massachusetts. Cost: \$120 (includes transportation, guidebook, 2 lunches, 1 dinner). Limit: 40.

This trip, sponsored by the Rocky Mountain Section of the Paleontological Society, will visit sites in the Uinta Basin and Uinta Mountains of Utah and the Bridger Basin of Wyoming, including stops in Dinosaur National Monument. Highlights include the spectacular dinosaur quarry (Morrison Formation) in Dinosaur National Monument, an *Allosaurus* excavation in progress, discussions of local dinosaur tracks, stops in the classic Bridger Formation (middle Eocene), and descriptions of stratigraphy, sedimentation, and paleoenvironments of the Mesozoic and early Tertiary of this richly fossiliferous area.

#### During Meeting

**9. General Geology of the Ogden Area** (half day). This trip departs by bus from the Radisson Hotel at 1:00 p.m. on Friday, May 15, and returns about 6:30 p.m. James R. Wilson and Richard W. Moyle, Weber State University, (801) 626-6208; David S. Butts, Great Salt Lake Minerals Co. Cost: \$17 (includes transportation, handouts, and refreshments). Limit: 45.

This trip is designed for secondary school teachers, students, and professionals who wish to have a brief overview of some of the geologic features in the Ogden area. Participants will observe Lake Bonneville shoreline features and sediments; metamorphic rocks of the Farmington Canyon Complex; slickensides, hot springs, and fault scarps associated with the Wasatch fault zone; and landslide features. The trip will conclude by observing present economic use of the Great Salt Lake, with a tour of the evaporation ponds and other mineral extraction facilities of the Great Salt Lake Minerals Co.

#### Postmeeting

**10. Miocene Monzonitic Intrusions and Associated Megabreccias of the "Iron Axis" Region, Southwestern Utah** (2 days). This trip originates in Cedar City, Utah, departing from the Town and Country Inn at 8:00 a.m., Saturday, May 16, and ends in Cedar City in the late afternoon, Sunday, May 17. The trip will be in Cedar City for Saturday night. R. Blank and P. Rowley, (303) 236-1341, USGS; D. Hacker, Kent State University. Cost: \$48 (includes transportation, 1 dinner, and guidebook). Limit: 24.

**NOTE:** Participants are responsible for arriving in Cedar City in time for the trip. Cedar City is 285 miles south of Ogden on I-15. Sky West Airlines has several flights daily from Salt Lake City to Cedar City, including one postmeeting flight at 6:30 p.m. on Friday, May 15. No accommodations are provided in the fee, but a block of rooms has been reserved at the Town and Country Inn (\$38 single, \$44 double) which is near cafes and grocery stores. Call Town and Country, (801) 586-9900 to make your reservations.

The southwestern Utah 20–22 Ma monzonite province extends from the Markagunt Plateau to the Nevada border and includes a dozen exposed hypabyssal intrusions, in addition to other bodies known from drilling or inferred from aeromagnetism. Megabreccia sheets consisting of volcanic and sedimentary formations, 20 Ma or older, occur throughout the region. On this trip we will examine structural relations of the megabreccias to the intrusions of Iron Mountain, Stoddard Mountain, Pine Valley, and Bull Valley–Big Mountain. At Iron Mountain, the breccias appear to have been produced as gravity slides from an oversteepened intrusive dome. Farther southwest, megabreccia sheets are composed of material sloughed from the roof of the Bull Valley–Big Mountain intrusive arch as the magma rose rapidly, broke through to the surface, and was spread over the region as ash flows. Ash-flow tuff from the vent

zone blankets the penecontemporaneous megabreccias and also contains them as megaclasts and intercalated breccial layers. This trip will involve some strenuous hiking, including a 5-mile round-trip hike.

#### 11. Geologic Processes and Principles Along the Wasatch Front

(1 day). This trip will depart by van from the Radisson Hotel in Ogden at 8:30 a.m., Saturday, May 16, and return to Ogden in the late afternoon. S. K. Morgan, University of Alaska, (801) 750-3877; Susan U. Janecke and Peter T. Kolesar, Utah State University. Cost: \$18 (includes transportation, lunch, and road log). Limit: 48.

This trip is designed primarily for teachers (K–12) and those with a general interest in the geology of northern Utah. Emphasis will be on basic geologic processes and principles as observed in geologic features such as the Wasatch fault and landforms related to Lake Bonneville. Fault segmentation and the history of Lake Bonneville will be reviewed. The trip will follow the Wasatch Front from Ogden north through Brigham City, then swing east past the Cutler Narrows of the Bear River into the Cache Valley and Logan, Utah. The return route to Ogden will cross the Wellsville Mountains through Sardine Canyon.

**12. Mesozoic Tectonics of the Northern Wasatch Range, Utah** (1 day). This trip leaves by bus from

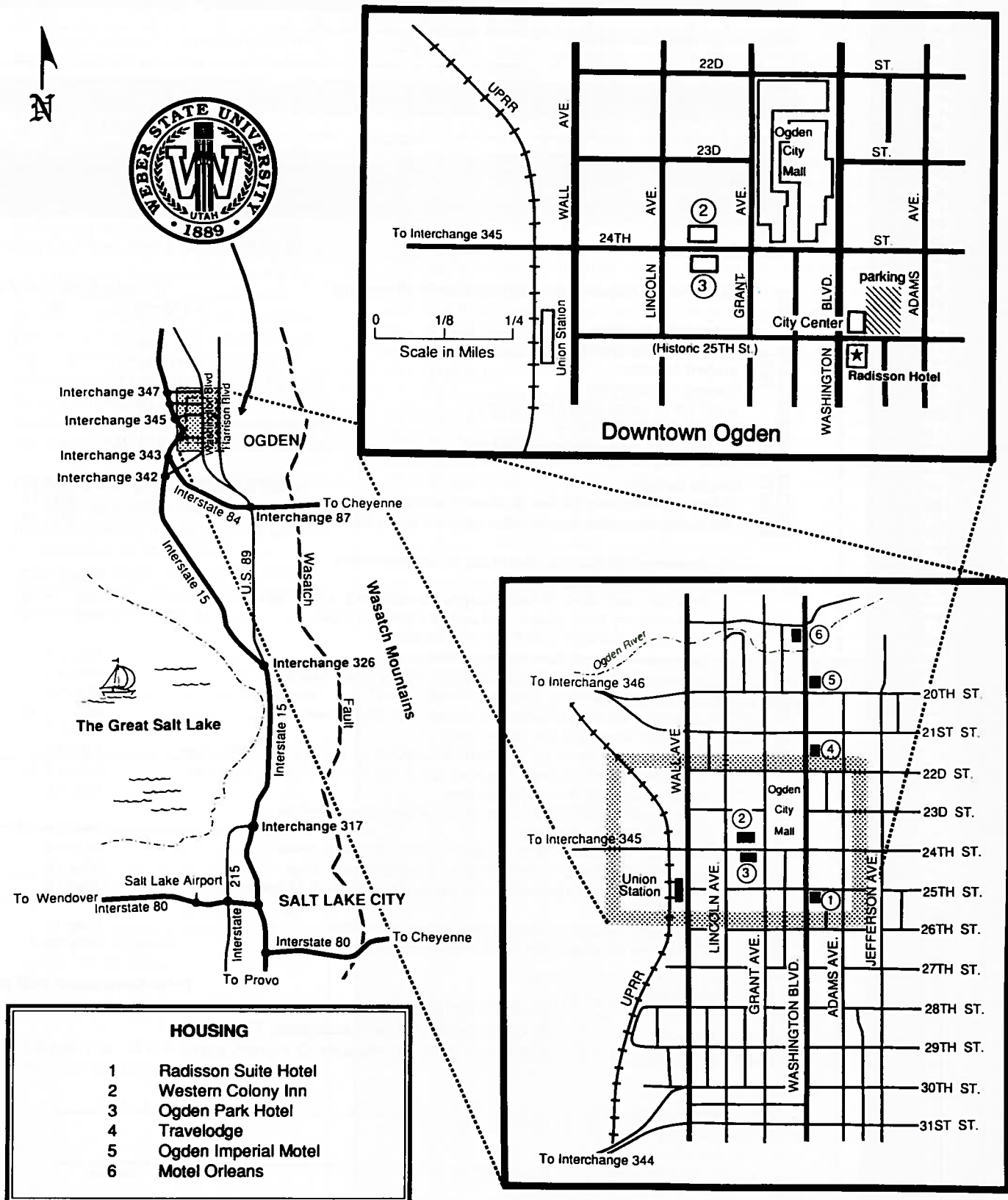
the Radisson Hotel at 7:30 a.m. on Saturday, May 16, and returns about 6:30 p.m. W. Adolph Yonkee, Weber State University, (801) 626-7419; James Evans, Utah State University; Peter DeCelles, University of Rochester. Cost: \$45 (includes transportation, lunch, and guidebook). Limit: 45.

This trip will focus on the tectonic and stratigraphic evolution of northern Utah during Mesozoic thrusting. Participants will examine internal deformation and fault rocks within thrust sheets, the record of regional uplift preserved in synorogenic deposits, and relations between Mesozoic compressional and later Tertiary extensional structures. Relations between deformation of basement and cover rocks in thrust sheets, mechanisms by which basement is incorporated into thrust sheets, and mechanisms of slip transfer and termination within regional thrust systems will be discussed. The trip will include critical examination of selected exposures, regional overviews, and short hikes.

#### 13. Late Proterozoic and Early Cambrian Stratigraphy, Paleobiology, and Tectonics: Northern Utah and Southeastern Idaho

(1 day). This trip leaves by van from the Radisson Hotel at 8:00 a.m., Saturday, May 16. Field stops will be completed in the vicinity of Pocatello, Idaho, about 7 P.M., with arrival back

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in Ogden about 8:30 p.m. Paul K. Link, Idaho State University, (208) 726-3721; Loren H. Smith, Harvard University. Cost: \$55 (includes transportation, lunch, and guidebook). Limit: 17.

Participants will examine critical exposures of the Late Proterozoic strata of the Willard thrust plate between Ogden, Utah, and Pocatello, Idaho. The rocks to be examined were deposited during the initial radiation of meta-zoans in latest Precambrian and Early Cambrian time and contain distinctive Early Cambrian trace fossils. Lower in the section is evidence of glacio-marine sedimentation and basaltic, rift-related volcanic activity. The intervening Brigham Group contains evidence of sea-level regressions, which produced spec-

tacular incised valleys filled with unique chaotic conglomerate. Rugged hiking shoes are recommended as some stops require climbs of up to 1000 feet. Participants continuing north after the meeting may wish to drive their own car and depart from Pocatello. Earth science teachers will find the trip a ready source of information relevant to their curriculum. Canine animal companions are welcome.

SYMPOSIA

The following symposia are planned for the Ogden meeting. 1. **Cretaceous and Tertiary Basin Evolution in the Eastern Great Basin.** Christopher J. Potter and Russell F. Dubiel, U.S. Geological Survey, Denver.

2. **Paleozoic Biochronology and Sequence Stratigraphy of the Eastern Great Basin, Utah and Nevada.** Michael E. Taylor and Thomas W. Henry, U.S. Geological Survey, Denver. 3. **Mesozoic Metamorphism and Tectonics of the Eastern Great Basin.** David M. Miller, U.S. Geological Survey, Menlo Park, California; Phyllis Camilleri, University of Wyoming, Laramie. 4. **Quaternary Cave Paleontology, Stratigraphy and Taphonomy.** Michael E. Nelson, Northeast Missouri State University, Kirksville; James Mead, Northern Arizona University, Flagstaff. 5. **Early Mesozoic Paleocology, Colorado Plateau.** David Gillette, Utah Historical Society, Salt Lake City.

6. **Upper Paleozoic Continental Margin, Paleogeography and Tectonics.** Walter S. Snyder and Claude Spinosa, Boise State University, Boise, Idaho. 7. **Geology, Geochemistry, and Mineral Deposit of the Oquirrh Mountains, Utah.** Paula N. Wilson, University of Utah, Salt Lake City; Ricardo Presnelli, Kennecott, Salt Lake City. 8. **Precambrian Geology of the Black Hills, South Dakota.** LaVern M. Friberg, University of Akron, Akron, Ohio; Jack A. Redden, South Dakota School of Mines and Technology, Rapid City.

POSTER SESSIONS

Each poster booth will provide three 4' x 8' horizontal tack boards

ROCKY MOUNTAIN SECTION PREREGISTRATION FORM

PREREGISTRATION FORM

Rocky Mountain Section, GSA ☆  
May 13-15, 1992

Please print or type • Copy for your records • Shaded areas are for your badge

IMPORTANT

- 1. Full Payment must accompany registration. Unpaid Purchase Orders not accepted as valid registration.
- 2. Use separate form for each registrant, professional or student.
- 3. PREREGISTRATION MUST BE POSTMARKED NO LATER THAN APRIL 15, 1992.  
Cancellation deadline for a full refund is April 22, 1992.
- 4. For registration information, please call the GSA Registration Coordinator at (303) 447-2020.

Name (Last) \_\_\_\_\_ (First) \_\_\_\_\_ Initial \_\_\_\_\_  
Employer/University/Affiliation (for badge) \_\_\_\_\_  
Mailing address of affiliation indicated above \_\_\_\_\_  
Address \_\_\_\_\_  
City \_\_\_\_\_ State \_\_\_\_\_ ZIP code \_\_\_\_\_  
Work Phone \_\_\_\_\_ Home Phone \_\_\_\_\_ Fax \_\_\_\_\_  
Guest/Spouse Name (Last) \_\_\_\_\_ (First) \_\_\_\_\_  
City \_\_\_\_\_ State/Country \_\_\_\_\_

Membership Affiliation A: ☐ GSA Member No. \_\_\_\_\_ B: ☐ PS C: ☐ Check here for consideration for Student Paper Award

	(Registration required for participation in all events.)	(PLEASE CHECK ONE):			Qty	Amount
		Full Meeting	or	1 Day		
PREREGISTRATION FEES	Professional Member .....	( 1 ) \$45 <input type="checkbox"/>		( 2 ) \$30 <input type="checkbox"/>	1	\$ _____
	Professional Nonmember .....	( 3 ) \$60 <input type="checkbox"/>		( 4 ) \$30 <input type="checkbox"/>	1	\$ _____
	Student Member .....	( 5 ) \$25 <input type="checkbox"/>		N/A	1	\$ _____
	Student Nonmember .....	( 7 ) \$30 <input type="checkbox"/>		N/A	1	\$ _____
	Guest (fill in name above for badge) .....	( 9 ) \$20 <input type="checkbox"/>		N/A	1	\$ _____
	Secondary School Teacher .....	(42) \$10 <input type="checkbox"/>		N/A	1	\$ _____
SPECIAL EVENTS	For field trips only—Nonregistrant fee .....	(98) \$15 <input type="checkbox"/>		N/A	1	\$ _____
	Annual Banquet .....	May 14	( 40 ) \$ 14			\$ _____
	GSA Rocky Mountain Section Business Luncheon .....	May 14	( 60 ) \$ 7			\$ _____
FIELD TRIPS	GSA Rocky Mountain Section Management Board Breakfast .....	May 15	( 61 ) \$ 6			\$ _____
	1. Quaternary Volcanism, Tectonics, & Sedimentation in the Idaho Natl. Eng. Lab. ....	May 11-12	(100) \$110	1		\$ _____
	2. Structure and Fabric of Metamorphic Terrains in E. Great Basin .....	May 9-12	(101) \$230	1		\$ _____
	3. Extraordinary Synorogenic and Anoxic Deposits, Utah .....	May 11-12	(102) \$125	1		\$ _____
	4. Quaternary Geology and Geologic Hazards of Tooele & Northern Rush Valleys, Utah .....	May 12	(103) \$ 55	1		\$ _____
	5a. Geologic Evolution of Antelope Island, Utah (1 day, Monday) .....	May 11	(104) \$ 45	1		\$ _____
	5b. Geologic Evolution of Antelope Island, Utah (1 day, Tuesday) .....	May 12	(105) \$ 45	1		\$ _____
	5c. Geologic Evolution of Antelope Island, Utah (both days) .....	May 11, 12	(106) \$ 70	1		\$ _____
	6. Geologic Hazards of the Ogden Area .....	May 11	(107) \$ 55	1		\$ _____
	7. Geology, Geochemistry, and Mineral Deposits of the Oquirrh Mts., Utah .....	May 12	(108) \$ 45	1		\$ _____
	8. Mesozoic & Early Tertiary Paleontology & Paleoenvironments, NE Utah .....	May 11-12	(109) \$120	1		\$ _____
	9. General Geology of the Ogden Area .....	May 15	(110) \$ 17	1		\$ _____
	10. Miocene Monzonitic Intrusions & Associated Megabreccias, Iron Axis Region, SW Utah .....	May 16-17	(111) \$ 48	1		\$ _____
WORK SHOPS	11. Geologic Processes and Principles Along the Wasatch Front .....	May 16	(112) \$ 18	1		\$ _____
	12. Mesozoic Tectonics of the Northern Wasatch Range, Utah .....	May 16	(113) \$ 45	1		\$ _____
	13. Late Proterozoic Stratigraphy and Tectonics, N Utah & SE Idaho .....	May 16	(114) \$ 55	1		\$ _____
	1. GSA Rocky Mountain Section Education Committee .....	May 13	(150) \$ N/C	1		\$ _____
	2. Partnering for Excellence Workshop—GSA SAGE Program .....	May 15	(151) \$ N/C	1		\$ _____

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arranged at table height. Poster sessions will be scheduled adjacent to the exhibits and hospitality center in the ballroom and will be available for viewing for one-half day.

## PROJECTION EQUIPMENT

All slides must be 2" x 2" and fit a standard 35 mm carousel tray. If possible, speakers should bring their own loaded carousel tray identified with their name, session, and speaker number. A speaker ready room equipped with projectors will be available for review and practice. Two projectors and two screens will be provided for each meeting room.

## EXHIBITS AND VENDORS

Exhibits and vendors representing education, research, and industry will be displayed in the ballroom. For further information, contact: Exhibits Coordinator, GSA Rocky Mountain Section Meeting, Dept. of Geology, Weber State University, Ogden, UT 84408-2507.

## STUDENT SUPPORT

The GSA Rocky Mountain section has funds available for grants to GSA Student Associates who are presenting a paper at the meeting and are attending or have graduated from a college or university within the boundaries of the section no later than one month prior to the meeting. Students are strongly encouraged to apply for these grants, because most students who qualify will be funded to some degree. Additional funds are available to support car pools that include one or more students who will be presenting papers. Send applications to Kenneth E. Kolm, Rocky Mountain Section Secretary, Dept. of Geology and Geological Sciences, Colorado School of Mines, Golden, CO 80401, (303) 273-3651. Applications must be submitted by *March 1, 1992*. They should include the student's GSA membership number, the title of his or her paper or poster, and a budget.

The Paleontological Society will award a prize to the presenter of the best student paper on a paleontological topic. Papers can be co-written with a nonstudent, but the student must be both the presenter and the senior (primary) author. To be eligible, the speaker must either be currently enrolled in a graduate or undergraduate program or have completed such a program no longer than one month prior to the meeting. Candidates must indicate on the registration form that they are students and wish to be considered for the prize.

## EARTH SCIENCE EDUCATION PROGRAMS

Several special programs designed for earth science teachers (K-12) and

interested professionals will be presented during the meeting. These programs are designed to support GSA's interest in furthering education in earth science.

### 1. Partnering for Excellence

**Workshop**—GSA SAGE program. This workshop will be held from 8:00 to 9:00 a.m. on Friday, May 15, and will be hosted by W. D. Nesse, chairman of the Rocky Mountain Section Education Committee.

### 2. Earth Science Teacher (K-12)

**Workshop.** This workshop, consisting of exhibits and demonstrations, will be held in the ballroom of the Radisson Hotel from 9:00 a.m. to 12:00 noon on Friday, May 15. It will be coordinated by D. D. O'Brien, Utah Museum of Natural History, Salt Lake City, and Marie Wilcox, earth science teacher, Roy High School, Utah.

**3. Field Trips.** Two of the field trips held in conjunction with the meeting are specifically designed for teachers, students, and interested professional registrants. General Geology of the Ogden Area (Field Trip 9) is a Friday afternoon event designed primarily for those who wish to have a brief overview of the geologic features of the Ogden area. Geologic Processes and Principles along the Wasatch Front (Field Trip 11) is sponsored by Utah State University and will be an all-day Saturday trip. Teachers are welcome on other field trips and particularly are invited to consider Field Trips 4, 6, and 13. See the Field Trip section in this issue.

Registration for workshops is free. Please indicate on the preregistration form if you *do* plan to attend.

## ENTERTAINMENT

The Ogden Union Station at the foot of Historic 25th Street contains several specialized museums and art galleries. Of particular interest is the Browning Firearms Museum, which contains many prototypes and production models of weapons designed by J. M. Browning, one of the world's greatest gun inventors and an Ogden native. The station also contains railroad, old car, and natural history museums. All participants will receive a complementary pass to the Union Station and its museums for use during the convention in their meeting packets.

## GENERAL INFORMATION

Inquiries, additional information, special requests, or suggestions should be addressed to the general chair, Sidney Ash, Dept. of Geology, Weber State University, Ogden, UT 84408-2507, (801) 626-6908. ■

## Penrose Conference

# Precambrian Tectonics and the Dawn of the Phanerozoic

A GSA Penrose Conference on Precambrian Tectonics and the Dawn of the Phanerozoic will be held October 18-23, 1992, at Furnace Creek Ranch in Death Valley, California. The timing will allow overseas scientists to combine their participation in the Penrose Conference with attendance at the GSA 1992 Annual Meeting to be held in Cincinnati, Ohio, October 26-29, 1992.

Conveners are Ian W.D. Dalziel, Institute for Geophysics, University of Texas at Austin, 8701 Mopac Boulevard, Austin, TX 78759; Andrew H. Knoll, Botanical Museum, Harvard University, 26 Oxford Street, Cambridge, MA 02138; and Eldridge M. Moores, Department of Geology, University of California, Davis, CA 95616.

Some 800 million years ago Earth entered a period of major environmental and biogeochemical change that led to the emergence of macroscopic invertebrates and hence marked the dawn of the Phanerozoic Eon. It has long been suspected that the underlying cause of these changes was tectonic. The widespread occurrence of late Precambrian rift deposits and related volcanics transgressed by shallow marine Cambrian strata strongly suggests the existence of a supercontinent that fragmented during the Neoproterozoic. In the absence of pre-Mesozoic ocean floor, the configuration of this supercontinent has proved elusive. Even the counterparts of the extensive and well-established late Precambrian rifted margins of ancestral North America have not been identified with certainty. In most late Precambrian and Cambrian reconstructions Laurentia is portrayed as a single continent isolated within Panthalassa. Polar wander paths for the period between 1.0 Ga and 500 Ma are not well established.

During the past year, evidence has been published for the juxtaposition of the Pacific margins of North America and East Antarctica-Australia in the late Precambrian. Coupled with the idea, put forward during the 1980s, that eastern North America may have been juxtaposed with the pre-Andean margin of South America at that time, this has led to the hypothesis that Laurentia broke out of a Neoproterozoic supercontinent to form the Pacific and Iapetus ocean basins during the final amalgamation of Gondwana.

Regardless of the validity of this particular hypothesis, these ideas open up many unexplored avenues for research. Perhaps their most valuable aspect is the opportunity they afford to reexamine the possible link between tectonic changes in the late Precambrian and the environmental and biogeochemical changes that led to the emergence of animals and thereby initiated the Phanerozoic Eon. The purpose of this Penrose Conference is to bring together a broad interdisciplinary group of earth scientists to consider the problem of Precambrian tectonics in the light of the new ideas on the configuration of a Neoproterozoic supercontinent and the wealth of new data on the terminal Proterozoic and Early Cambrian environment that has accumulated in recent years. Death Valley, situated on the late Precambrian margin of North America with classic exposures of Neoproterozoic and Lower Cambrian strata, makes an ideal setting for the meeting.

Participation in the conference will be limited to 65 persons. Attendance by graduate students may be subsidized, and scientists in this category are encouraged to apply. Applications may be sent to any convener. **The application deadline is May 1, 1992.** The registration fee will be approximately \$700 and will include transport from the airport at Las Vegas, Nevada, to Death Valley and back; field trip expenses; all meals and lodgings. Formal invitations will be mailed by mid-May 1992. The addresses of the conveners are given above. Their fax numbers are: Ian Dalziel, 512-471-8844; Andy Knoll (on sabbatical in Cambridge, England), 44-223-333450; Eldridge Moores, 916-752-0951. ■

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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.

**Antonio Almela Samper**  
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and George A. Thompson*

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*Wallace W. Hagan*

## GSA Penrose Conferences

## March 1992

**Continental Tectonics and Magmatism of the Jurassic North American Cordillera**, March 28–April 3, 1992, Lake Havasu City, Arizona. Information: David M. Miller, U.S. Geological Survey, 345 Middlefield Road, MS-975, Menlo Park, CA 94025; (415) 329-4923; fax 415-329-4936; or Richard M. Tosdal (same address); (415) 329-5423.

## 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; or 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); and Eldridge M. Moores, Dept. of Geology, University of California, Davis,

CA 95616, (916) 752-0352 or 752-0350, fax 916-752-6363.

## 1992 Meetings

## February

■ **American Association for the Advancement of Science Annual Meeting**, February 6–11, 1992, Chicago, Illinois. Information: AAAS Meetings Office, 1333 H Street, NW, Washington, DC 20005.

**6th International Symposium on Landslides**, February 10–14, 1992, Christchurch, New Zealand. Information: ISL 1992 Secretariat, c/o Guthreys Pacific Ltd., P.O. Box 22-255, Christchurch, New Zealand; fax 643-790-175; telex: NZ4243 Guthreys.

**U.S. Geological Survey 8th Annual McKelvey Forum on Energy Resources**, February 18–20, 1992, Houston, Texas. Information: Christine Turner, USGS, Box 25046 MS 939, Federal Center, Denver, CO 80225; (303) 236-1561.

**First South Asia Geological Congress—GEOSAS-I**, February 23–27, 1992, Islamabad, Pakistan. Information: Hilal A. Raza, GEOSAS-I Secretary General, Hydrocarbon Development Institute of Pakistan, P.O. Box 1308, Islamabad, Pakistan; phone 9251-823690 or 821417; telex 5516 HDIP PK; fax 9251-828773.

**GSA South-Central Section Meeting**, February 24–25, 1992, Houston, Texas. Information: Hans G. Avé Lallemant, Dept. of Geology and Geophysics, P.O. Box 1892, Rice University, Houston, TX 77251; (713) 527-4889.

**Society for Mining, Metallurgy, and Exploration Annual Meeting**, February 24–27, 1992, Phoenix, Arizona. Information: Meetings Department, SME, P.O. Box 625002, Littleton, CO 80162; (303) 973-9550; fax 303-979-3461.

**American Society of Photogrammetry and Remote Sensing—American Congress of Surveying and Mapping Annual Meeting**, February 29–March 5, 1992, Albuquerque, New Mexico. Information: Registration Coordinator, ASPRS/ACSM, 5410 Grosvenor Lane, Suite 100, Bethesda, MD 20814-2122; fax 301-493-8245.

## March

**21st Computer Simulated Mineral Exploration Workshop**, March 3–30, 1992, Fontainebleau, France. Information: L. Zanone, Ecole des Mines de Paris, CCGM-IGM, 35, rue Saint-Honoré, 77305 Fontainebleau Cédex, France; phone (33 1) 64 69 49 30; telex 694 736 F; fax (33 1) 64 69 47 01.

**Circum-Pacific Council for Energy and Mineral Resources Symposium**, Sustainable Development: Energy and Mineral Resources and the Environmental Impact of Their Utilization in the Circum-Pacific Region, March 9–12, 1992, Bangkok, Thailand. Information: Mary Stewart, Circum-Pacific Council, 5100 Westheimer, Suite 500, Houston, TX 77056; fax 713-622-5360.

**Hydrocarbon Contaminated Soils and Groundwater: Analysis, Fate, Environmental and Public Health Effects and Remediation**, March 9–12, 1992, Long Beach, California.

Information: Martha Barrett, P.O. Box 312, Amherst, Massachusetts 01004; (413) 549-5561.

**11th Annual Symposium on Caribbean Geology: Caribbean Volcanoes—Past and Present**, March 11–15, 1992, Mayagüez, Puerto Rico. Information: Alan Smith, Dept. of Geology, University of Puerto Rico, P.O. Box 5000, Mayagüez, Puerto Rico 00709-5000; (809) 265-3845; fax 809-265-2880.

**GSA Southeastern Section Meeting**, March 18–20, 1992, Winston-Salem, North Carolina. Information: Paul D. Fullagar, Dept. of Geology, CB 3315 Mitchell Hall, University of North Carolina, Chapel Hill, NC 27599-3315; (919) 962-0677.

**AGU Chapman Conference on Climate, Volcanism, and Global Change**, March 23–27, 1992, Hilo, Hawaii. Information: Stephen Self, Dept. of Geology and Geophysics, University of Hawaii at Manoa, Honolulu, HI 96822; or Richard P. Turco, Dept. of Atmospheric Sciences, University of California, Los Angeles, CA 90024-1565.

**Second Conference on Earthquake Hazards in the Eastern San Francisco Bay Area**, March 25–28, 1992, Hayward, California. Information: Sue Ellen Hirschfeld, Dept. of Geological Sciences, California State University, Hayward, CA 94542; (415) 881-3486.

**GSA Northeastern Section Meeting**, March 26–28, 1992, Harrisburg, Pennsylvania. Information: Donald M. Hoskins, Pennsylvania Geological Survey, Dept. of Environmental Resources, P.O. Box 2357, Harrisburg, PA 17105; (717) 787-2169.

**40th National Science Teachers Association Meeting**, March 26–29, 1992, Boston, Massachusetts. Information: NSTA, 1742 Connecticut Ave., NW, Washington, DC 20009-1171; (202) 328-5800.

**Structural Styles in the Southern Midcontinent**, March 31–April 1, 1992, 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

**XVII General Assembly of the European Geophysical Society**, April 6–10, 1992, Edinburgh, Scotland. Information: EGS Office, Postfach 49, 3411 Katlenburg-Lindau, Germany; phone (49) 5556-1440; fax 49-5556-4709; telex 965564 zil d; E-mail SPAN: LINMPI::EGS; EARN: U0085@DGOGWDG5.

**1992 SEPM Permian Basin Section Annual Fieldtrip**, Paleokarst, Karst-related Diagenesis, and Reservoir Development: Examples from Ordovician-Devonian Age Strata of West Texas and the Mid-Continent, April 9–11, 1992. Information: Magell Candelaria, Arco Oil & Gas Co., P.O. Box 1610, Midland, TX 79702; (915) 688-5254; fax 915-688-5756.

**American Association of Petroleum Geologists Southwest Section**, April 12–14, 1992, Midland, Texas. Information: West Texas Geological Society, P.O. Box 1595, Midland, TX 79702; (915) 683-1573.

**1992 International High-Level Radioactive Waste Management**

**Conference**, April 12–16, 1992, Las Vegas, Nevada. Information: James Tulenko, Attn: TRANSACTIONS Office, American Nuclear Society, 555 N. Kensington Avenue, La Grange Park, IL 60525.

**Fifth Annual Symposium on the Application of Geophysics to Engineering and Environmental Problems (SAGEEP)**, April 26–29, 1992, Oakbrook, Illinois. Information: Mark Cramer, 11100 E. Dartmouth Ave., Suite 190, Aurora, CO 80014; (303) 752-4951.

**GSA North-Central Section Meeting**, April 30–May 1, 1992, Iowa City, Iowa. Information: Raymond R. Anderson, Iowa DNR, Geological Survey, University of Iowa, 123 N. Capital St., Iowa City, IA 52242; (319) 335-1575.

## 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 Geológicas, 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.

**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. (Abstract deadline: January 29, 1992.)

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

**Pan-American Current Research on Fluid Inclusions (PACROFI IV)**, May 22–24, 1992, Lake Arrowhead, California. Information: Michael A. McKibben, Department of Earth Scien-

ces, University of California, Riverside, CA 92521-0423; (714) 787-3444; fax 714-787-4324. (Abstract deadline: March 1, 1992.)

**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; or Martin R. Gibling, Dept. of Geology, Dalhousie University, Halifax, Nova Scotia B3H 3J5, Canada; (902) 494-2355.

**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.

**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: WVFILL92@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, & 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.

■ **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; or 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

**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**, University Park, Pennsylvania, July 23-24, 1992. 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.

**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.

**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. (Abstract deadline: March 31, 1992.)

**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.

**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@geol-

ogy.wisc.edu; or Mark Harris, Dept. Geosciences, University of Wisconsin, P.O. Box 413, Milwaukee, WI 53201; (414) 229-5452; or 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. (Abstract deadline: February 1, 1992.)

**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; or A. G. Green, Geological 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. (Abstracts deadline: March 1, 1992.)

**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.

**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.

**4th International Conference on Paleocceanography**, 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, or Jonathan Phillips, Dept. of Geography, East Carolina University, Greenville, NC 27858; (919) 757-6082; E-mail: GEPHILLI@ECUVM1.BITNET.

**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.

**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.

**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.

**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.)

**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, Minneapolis, Minnesota. Information: Jerry Bigham, Dept. of Agronomy, Ohio State University, Columbus, OH 43210; (614) 292-2001.

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

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## GSA ANNUAL MEETINGS

### ■ 1992

**GSA Annual Meeting, Cincinnati, Ohio**  
**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**  
**Radisson Suite Hotel, October 25-28**

Chairman: James W. Skehan, S. J.

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

John T. Cheney  
Dept. of Geology  
Amherst College  
Amherst, MA 01002  
(413) 542-2233 (Dept.)

J. Christopher Hepburn  
Dept. of Geology and Geophysics  
Boston College  
Chestnut Hill, MA 02193  
(617) 552-3640 (Dept.)

## GSA SECTION MEETINGS

### ■ 1992

**South-Central, Houston, Texas**  
**Rice University, February 24-25**

Hans G. Avé Lallemant, Dept. of Geology and Geophysics, P.O. Box 1892,  
Rice University, Houston, TX 77251; (713) 527-4889

**Southeastern, Winston-Salem, North Carolina**  
**Stouffer-Winston Plaza, March 18-20**

Paul D. Fullagar, Dept. of Geology, CB 3315 Mitchell Hall, University of North  
Carolina, Chapel Hill, NC 27599-3315; (919) 962-0677

**Northeastern, Harrisburg, Pennsylvania**  
**Harrisburg Hilton, March 26-28**

Donald M. Hoskins, Pennsylvania Geological Survey, Dept. of Environmental  
Resources, P.O. Box 2357, Harrisburg, PA 17105; (717) 787-2169

**North-Central, Iowa City, Iowa**  
**University of Iowa, April 30-May 1**

Raymond R. Anderson, Iowa DNR, Geological Survey, University of Iowa,  
123 N. Capital St., Iowa City, IA 52242; (319) 335-1575

**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

# Springer for Geology

## Radiocarbon After Four Decades

**An Interdisciplinary Perspective**

Edited by **R. E. Taylor**, University of California, Riverside, CA, **A. Long** and **R. S. Kra**, University of Arizona, Tucson, AZ

**Radiocarbon After Four Decades: An Interdisciplinary Perspective** commemorates the 40th anniversary of radiocarbon dating. The volume presents all aspects of this dating technique from the history of its development to future research trends. All of the 53 authors were instrumental in the establishment of or major contributors to the use of this revolutionary scientific tool. The thirty-five chapters provide a solid foundation in the essential topics of radiocarbon dating: The Natural Carbon Cycle; Instrumentation and Sample Preparation; Hydrology; Old World Archaeology; New World Archaeology; Earth Sciences; Biomedical Applications; and Historical Perspectives.  
**1992/approx. 616 pp., 208 illus./Hardcover \$89.00**  
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## Biochronological Correlations

By **J. Guex**, Institut de Géologie, Lausanne, Switzerland

Due to the discontinuous nature of fossil records, it is often difficult to use biostratigraphic data to establish biochronological correlations and produce a relative time scale. In **Biochronological Correlations**, the author creates a deterministic mathematical model to resolve the multiple contradictions inherent to stratigraphic recording of fossil species. The book begins with theoretical interpretations of highly complex biostratigraphic data followed by presentations of computer-aided Unitary Association Method. Geologists and structural geologists, as well as micropaleontologists, will benefit from this new tool in stratigraphy.  
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By **A. E. Scheidegger**, Technische Universität, Wien, Austria

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## Cycles and Events in Stratigraphy

Edited by **G. Einsele**, **W. Ricken**, and **A. Seilacher**, University of Tübingen, Germany

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## Volcanoes of the Central Andes

By **S. L. de Silva**, Indiana State University, Terre Haute, IN and **P. W. Francis**, Lunar and Planetary Institute, Houston, TX

This richly illustrated book, the first of its kind to catalog the volcanoes of the Central Andes, draws from a variety of sources to present a reference work for this remarkable volcanic province. It contains selected information about the geochemical properties of subducted crust, resulting from the specific geodynamic setting of subduction. Each of the major 44 registered volcanoes is characterized by location, type synonymy, summit elevation, edifice height, and category. Further details are provided on structure, evolution, most recent activities, geochemistry, and relevant references, making this a truly comprehensive study of Central Andes volcanoes.  
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By **D. Bahat**, Ben Gurion University of the Negev, Beer Sheva, Israel

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# DNAG NEWS

Allison R. (Pete) Palmer

## Progress Continues

DNAG is just about wrapped up, and I'm down to less than one day a week at GSA most weeks. Progress continues to be steady but slow; only three books remain to be finished of the 30 planned for production by GSA. At long last the final chapter for *The Cordilleran Orogen: U.S.* has been received and was sent to copy-editing. The editors are now reviewing the galleys for the entire book; you can expect it in your hands by June or July. This leaves the Precambrian volume and the Alaskan volume to complete GSA's part of *The Geology of North America*. The only other book still out there is the volume to accompany the transects, and that should have all of its missing chapters at least written and in review or revision by early 1992.

Meanwhile, books keep moving along. Volume K-2, *Quaternary Non-glacial Geology: Conterminous U.S.* was printed, and advance copies were received in November. Blueines for *Neotectonics of North America* have been checked and returned to the printer, and this book, which is the companion volume for the three completed neotectonic maps (Stress, Seismicity, Thermal Aspects), should be available by the time you read this. Right behind that is Volume J, *The Gulf of Mexico Basin*, which went to the printer in November, and should be available in March (with a 1991 date).

## More Kudos

The patient contributors to Volume G-3, *The Cordilleran Orogen: U.S.*, some of whose submissions date back

to 1986—when everybody had promised to have their chapters finished (40% didn't arrive until 1990 or later)—are listed below. They bring the total number of contributors to completed DNAG volumes to 1933. Many thanks to all for their part in making this a potentially exciting volume. All of the early contributors have been given a chance to prepare "Notes Added in Proof" to bring readers up to date on any significant developments related to their chapters since they were type-set, so the book (600+ pages) will be as current as possible. ■

## Contributors to Volume G-3, The Cordilleran Orogen: U.S.

J. P. Albers	E. L. Miller
R. W. Allmendinger	M. M. Miller
M. E. Beck, Jr.	A. R. Niem
W. L. Bilodeau	W. A. Niem
R. L. Bruhn	T. H. Nilsen
B. C. Burchfiel	J. S. Oldow
C. Busby-Spera	A. R. Palmer
R. L. Christiansen	F. G. Poole
D. S. Cowan	R. J. Ross, Jr.
J. C. Crowell	J. B. Saleeby
G. A. Davis	C. A. Sandberg
W. R. Dickinson	P. D. Snavely, Jr.
G. C. Dunne	C. H. Stevens
W. G. Ernst	J. H. Stewart
S. A. Graham	N. W. Walker
L. F. Hintze	B. Wernicke
R. W. Hutchinson	J. E. Wright
P. W. Lipman	C. T. Wrucke
R. J. Madrid	R. S. Yeats
D. M. Miller	M. L. Zoback

## Reminders

# CALL FOR NOMINATIONS

## Officers and Councilors

The GSA Committee on Nominations requests your help in compiling a list of GSA members qualified for service as officers and councilors of the Society. The committee requests that each nomination be accompanied by basic data and a description of the qualifications of the individual for the position recommended (vice-president, treasurer, councilor).

Nominations for 1993 officers and councilors must be received at GSA headquarters no later than **FEBRUARY 15, 1992**. Please send nominations and backup material to the Administrative Department, Geological Society of America, P.O. Box 9140, Boulder, CO 80301.

## Distinguished Service Award

The GSA Distinguished Service Award was established by Council in 1988 to recognize individuals for their exceptional service to the Society. GSA Members, Fellows, Student Associates, or, in exceptional circumstances, GSA employees may be nominated for consideration. Any GSA member or employee may make a nomination for the award. Awardees will be selected by the Executive Committee, and all selections must be ratified by the Council. Awards may be made annually, or less frequently, at the discretion of Council. This award will be presented during the Annual Meeting of the Society. Nominations and any supporting information may be addressed to Executive Director, Geological Society of America, P.O. Box 9140, Boulder, CO 80301.

Deadline for nominations for 1992 is **MARCH 1, 1992**.

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Interested applicants should submit a vita, letter of application describing yourself and letters from three references by March 1, 1992, to: PRI Search Committee, c/o James Sorauf, Department of Geological Sciences, S.U.N.Y.-Binghamton, Binghamton, New York, 13902-6000.

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hours per week, 8:00 a.m. to 5:00 p.m., Monday through Friday. Salary: \$28,118 per year. Interested persons should submit a resume to Columbia Job Service, P.O. Box 567, Columbia, SC 29202, Attn: Ms. Vicki Fagg. Please reference Job Order Number SC0979218.

### VISITING FACULTY MEMBER, GEOLOGY

Visiting Faculty Member/Miami University/Department of Geology. Applications are invited for a full-time, visiting faculty member to teach introductory-level courses in Physical Geology and Geology of the U.S. National Parks during the 9-month 1992-1993 academic year. The successful candidate must have prior experience in effective teaching of lecture courses in a university setting. The anticipated teaching load is 3-4 courses per semester; the position carries no service or research responsibilities.

A Master's degree (for appointment as a Visiting Instructor) or a Ph.D. (for appointment as a Visiting Assistant Professor) in Geology or Geophysics is required. Review of applications will begin in November, 1991 and will continue until the position is filled. Candidates should submit a letter of application that discusses teaching interests, a resume, transcripts of all college work, and three letters of recommendation to: Dr. Maryellen Cameron, Department of Geology, Miami University, Oxford, Ohio 45056. Women and minority candidates are encouraged to apply. Miami University offers equal opportunity in employment and education (M/F/H).

The Swiss Federal Institute of Technology and the University of Zurich are accepting applications for a joint faculty position of

### PROFESSOR OF GEOLOGY

We are seeking an internationally recognized creative scientist to lead a geodynamics-tectonics-structural geology group. Applications are encouraged from candidates with interests in physical processes of rock deformation, rheology and kinematics studied by field as well as experimental or theoretical means. Research should be directed towards developing models for the evolution of mountain ranges such as the European Alps and of extensional terrains.

Emphasis is placed on skill and enthusiasm in field work. Collaboration with research groups in petrology, geophysics, and sedimentology is expected. Teaching responsibilities include graduate courses as well as basic courses in tectonics, structural geology and field courses.

Applicants should submit a detailed curriculum, publication list and a statement of research interests by March 31, 1992 to the president of ETH Zürich, Prof. Dr. J. Nüesch, ETH Zentrum, CH-8092 Zürich. Applications from female scientists are specifically encouraged.

### BOWLING GREEN STATE UNIVERSITY

The Department of Geology requests applications to fill a position in environmental geology that will add to existing faculty strengths in one of the areas listed below. The opening is a tenure-track, Assistant Professor position that begins August 20, 1992. A Ph.D. is required. Responsibilities will include supervision of M.S. theses, graduate and undergraduate teaching, and research.

(1) HYDROGEOLOGY, including groundwater geology, contaminant transport, and/or engineering hydrogeology. Teaching responsibilities would include courses in groundwater hydrogeology.

(2) LOW TEMPERATURE GEOCHEMISTRY, including aqueous, environmental and/or groundwater geochemistry. Teaching responsibilities would include courses in geochemistry and groundwater hydrogeology.

(3) REMOTE SENSING/GEOPHYSICS, including image analysis, GIS, engineering geophysics, and/or environmental geophysics. Teaching responsibilities would include courses in remote sensing and geophysics.

The department has just moved into a large, newly renovated building. Extensive facilities include: Sun 4/470 SPARCserver, TERRAMAR image analysis workstation, ARC/INFO GIS system, P&E 5100 AAS, Rigaku 3070 XRF, Phillips 3520 APD XRD, JEOL T100 SEM, GeoMetrics gradiometer, GeoMetrics 12-channel seismograph, Worden gravimeter, DC resistivity, complete rock/sample preparation facilities, field vehicles, and specialized laboratories in geochemistry, sedimentology, image analysis, GIS, and computer graphics.

Letters of application should include a statement of research interests, vita, and the names of at least three references. The closing date for applications is March 1, 1992. Applications should be sent to Chair, Search Committee, Department of Geology, Bowling Green State University, Bowling Green, Ohio 43403. Women and minority candidates are encouraged to apply. BGSU is an affirmative-action/equal opportunity employer.

### PETROLOGY/MINERALOGY COLORADO STATE UNIVERSITY

The Department of Earth Resources in the College of Natural Resources at Colorado State University invites applications for a full-time, tenure-track, assistant professor-level faculty position in Petrology/Mineralogy beginning August 20, 1992. Candidates should have a Ph.D. degree in Geology. The appointee is expected to teach Optical Mineralogy, Petrology, Introductory Geology and appropriate graduate-level courses, supervise M.S. and Ph.D. students, and develop an active research program enhancing the Department's emphasis on field-oriented research in non-renewable resources and surficial processes. Expertise in one or more of the following disciplines is of interest: clay mineralogy, economic geology, engineering geology, geochemistry, geophysics, soils, and tectonics.

The department has 14 full-time faculty members in geology, geography, and watershed science. Applicants should send a vita, a statement of research and teaching interests, and three letters of reference to Eric A. Erslev, Dept. of Earth Resources, Colorado State Univ., Fort Collins, CO 80523. Deadline for applications is March 15, 1992. Colorado State University is an EO/AA employer.

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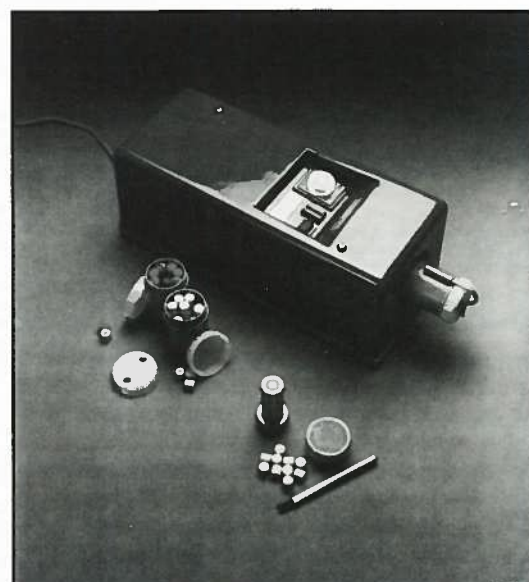
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The Wisconsin Geological and Natural History Survey, a division of University of Wisconsin Cooperative Extension, studies and maintains records on the geology, mineral resources, water resources, soils, climate, and—to a lesser degree—botanical and zoological resources of Wisconsin. The Survey's research and inventory programs enable the Survey to provide timely and objective responses to public policy questions concerning the state's natural resources and environment.

The State Geologist/Director establishes policy, directs planning, and has general supervisory and budgetary responsibilities for all Survey functions. Qualifications include: (1) Earned doctorate in geology or closely related field; established scientific record acceptable for a tenured faculty appointment on the University of Wisconsin-Madison campus; (2) Proven capabilities in leadership and administration, including program development and evaluation, budget, and personnel; (3) Strong communication and interpersonal skills.

Applications must be received no later than March 1, 1992. Submit a letter of application (statement of interest and summary of qualifications and relevant experience), a resume, and names, addresses, and phone numbers of three references to: Professor Stephen Born, Chair, Search and Screen Committee, University of Wisconsin-Extension, c/o 619 Extension Building, 432 N. Lake Street, Madison, WI 53706. An alphabetical list of all nominees and applicants, without differentiation, may be released following the closing date. For more information, please call (608) 263-1945.

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**POSTDOCTORAL FELLOWSHIPS IN  
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Two postdoctoral positions in structural geology will be available for combined pure and applied structural geology research, commencing on or about 1 June, 1992. These positions will be offered as one-year appointments, potentially renewable for a second year. They will involve approximately half-time grant-funded research and half-time petroleum/minerals industry contract research. Both positions will involve field mapping and mesoscale structural analysis, and substantial field experience is required. One position will address topics in the foothills and front ranges of the western Canadian Cordillera; the second will involve studies of medium-to high-grade deformation in Newfoundland & Labrador. Applicants should submit cover letter, curriculum vitae, and addresses of three references. Applications and requests for additional information should be sent to: W. Jamison, Centre for Earth Resources Research, Department of Earth Sciences, Memorial University of Newfoundland, St. John's, Newfoundland, Canada, A1B 3X5.

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**Opportunities for Students**

**Summer Research Program for Undergraduates at Columbia University's Lamont-Doherty Geological Observatory.** Eight students will be selected to participate in 10-week long research program using Ocean Drilling Program (ODP) cores, well-logs and seismic profiles. Current sophomore and junior science majors who are citizens or permanent residents of the U.S. are eligible. Students will receive \$2,200 stipend and housing. Some money is available to defray cost of travel between home institution and Lamont. Program is sponsored by JOI-U.S. Science Support Program associated with ODP. Application deadline is March 1, 1992. For further information contact: Dr. Suzanne O'Connell, Program Coordinator, Dept. of Earth and Environmental Sciences, Wesleyan University, Middletown, CT 06457, Tel. (203) 347-9411 ext. 2044, Fax (203) 343-3903.

**Ocean Drilling Summer Research Program for Undergraduates at the University of Hawaii.** The School of Ocean and Earth Science and Technology (SOEST) at the University of Hawaii is accepting applications for its 1992 Ocean Drilling Summer

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This special issue of the journal **Modern Geology** includes papers by the world's leading experts, including Jim Farlow, Martin Lockley, Adrian Hunt, Spencer Lucas, Greg Paul, Peter Dodson, James Spotila, Emily Giffin and Tony Thurlborn. Hot and cold running dinosaurs, footprints, eggs, skin, teeth and the myths of dinosaurology are some of the topics covered.

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Research Program. SOEST will host this program at the University of Hawaii's Manoa campus in Honolulu, Hawaii where the undergraduate participants will be in residence. During the program, undergraduates from around the U.S. and its territories will participate in research, lectures and field trips relating to the science of the Ocean Drilling Program. The aim of the ODP summer Research Program at SOEST is to introduce bright and energetic undergraduates to the science of the Ocean Drilling Program and to help prepare them to become research scholars. The program is designed to stimulate serious consideration of graduate studies and to increasing the number of women and minority students in this field. Students with a 3.0 or better grade point average will spend eight weeks engaged in research with a faculty mentor at SOEST. A faculty mentor is assigned to each student based on the student's educational background and interests. In addition, the applicants will participate in weekly lectures and in several field trips on the islands of Oahu and Hawaii. Successful applicants will receive a travel award to cover expenses to and from Hawaii, room and board for the duration of the program, and a student stipend of \$2,000. Applications must be post marked by March 1, 1992. REVISED DATES: THIS PROGRAM WILL NOW EXTEND FROM JUNE 22 - AUGUST 15.

For applications contact: Craig R. Glenn, Program Coordinator, Ocean Drilling Summer Research Program, University of Hawaii, Department of Geology & Geophysics, 2525 Correa Road, Honolulu, HI 96822, Tel. 808-956-2200. Fax. 808-956-2538.

**Research Grants Available.** The Colorado Scientific Society invites graduate students to apply for research monetary grants to be awarded by the Society in early May 1992. Applicants must be currently enrolled in a Masters or Ph.D. program at a private or state college or university. Four to six grants rang-

ing from \$800 to \$1300 each will be awarded for field-oriented earth-science thesis projects in Colorado and the Rocky Mountain region. Also, a grant of about \$950 will be awarded for an engineering geology thesis project (with no areal restriction). Interested students can obtain research grant applications from the Chairman of the Memorial Funds Committee, G. S. Holden, Colorado Scientific Society, P.O. Box 150495, Lakewood, CO 80215. Deadline for applications is April 10, 1992.

**Projected Deep Borehole Opportunity  
in the Albany Basin of New York**

*Open Working Session in Conjunction with the  
Meeting of the Northeastern Section of GSA*

Wednesday afternoon March 25, an open working session in conjunction with the meeting of the Northeastern Section of GSA will discuss the scientific and economic objectives of a projected deep borehole in the Albany Basin in New York. The purpose of the borehole is to probe the tectonic-, sea-level-, and climate-history of the early Paleozoic as well as Precambrian events. Downhole measurements and coring targets will be part of the emphasis of the working session. All those interested are invited to attend. For further information contact Gerald M. Friedman, Brooklyn College of the City University of New York, c/o Northeastern Science Foundation affiliated with Brooklyn College, P.O. Box 746, Troy, NY 12181-0746. Telephone (518) 273-3247, Fax (518) 273-3249.

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## Call for Nominations

### 1992 John C. Frye Environmental Geology Award

In cooperation with the American Association of State Geologists, GSA makes an annual award for the best paper on environmental geology published either by GSA or by one of the state geological surveys. The award is a \$500 cash prize from the endowment income of the GSA Foundation's John C. Frye Memorial Fund.

The 1992 award will be presented at the autumn AASG meeting to be held during the GSA Annual Meeting in Cincinnati. Members of the selection committee are Chairman Earl H. Bennett II, Idaho Geological Survey; John P. Kempton, Illinois Geological Survey; and Frank E. Kottowski, New Mexico Bureau of Mines and Mineral Resources.

### Criteria for Nomination

Nominations can be made by anyone, based on the following criteria: (1) paper must be selected from GSA or state geological survey publications, (2) paper must be selected from those published during the preceding three full calendar years, (3) nomination must include a paragraph stating the pertinence of the paper, (4) **nominations must be received by the Executive Director of GSA no later than March 30, 1992.**

### Basis for Selection

Each nominated paper will be judged on the uniqueness or significance as a model of its type of work and report and its overall worthiness for the award. In addition, nominated papers must establish an environmental problem or need, provide substantive information on the basic geology or geologic process pertinent to the problem, relate the geology to the problem or need, suggest solutions or provide appropriate land use recommendations based on the geology, present the information in a manner that is understandable and directly usable by geologists, and address the environmental need or resolve the problem. It is preferred that the paper be directly applicable by informed laypersons (e.g., planners, engineers).

### 1991 Recipients Announced

Recipients of the 1991 award presented at the GSA Annual Meeting in San Diego are Richard C. Berg, Illinois State Geological Survey, and H. Allen Wehrmann and John M. Shafer, Illinois State Water Survey, for their paper "Geological and hydrological factors for siting hazardous or low-level radioactive waste disposal facilities," Circular 546 (1989), Department of Energy and Natural Resources, Illinois State Geological Survey.



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