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## It's Only Topography: Part 2

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### Editor's Note

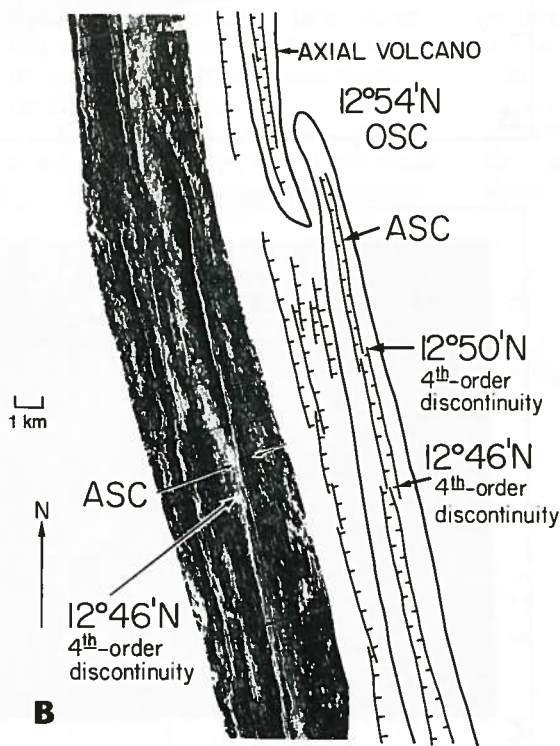
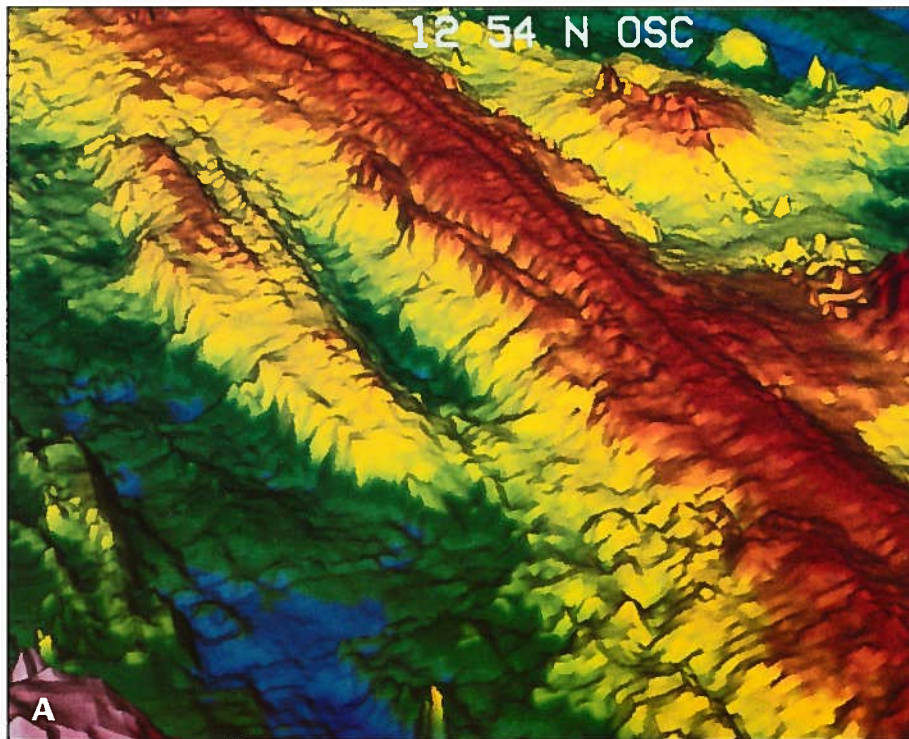
The science article in this issue is the second of two parts, the first part of which was published in January. The article summarizes much recent work on mapping the ocean floor. Because this article represents a major synthesis of a great deal of new information, and because of space limitations in *GSA Today*, we elected to publish the paper in two parts. We do not plan to make a habit of having articles appear in two installments, however. Accordingly, the space limitations on articles for *GSA Today* will remain as they have been.

—Eldridge M. Moores

### VOLCANISM ON MID-OCEAN RIDGES

The narrow ribbon of active volcanism along spreading axes is called the neovolcanic zone (e.g., Macdonald, 1982). The neovolcanic zone is characterized by elongate axial highs tens of kilometres long at fast-spreading centers (Searle, 1984); generally shorter (depending on local magmatic budget), discontinuous volcanoes at intermediate-rate spreading centers (Luyendyk and Macdonald, 1985); and a coalesced patchwork of hundreds of small conical to slightly elongate volcanic constructions at slow-spreading centers (Smith and Cann, 1992). The zone is so narrow (~1–3 km) that axial volcanoes are occasionally split in two and rafted away as the plates separate (Macdonald et al., 1980, 1983; Kappel and Ryan, 1986). Yet the most extensive high-resolution study of a fast-spreading ridge to date shows that there are very few structures on the flanks of the East Pacific Rise which resemble the 300–400 m axial high or split halves of it. The axial elevation of the rise seems to disappear completely off-axis (Fig. 4). How can this be? The answer to this question becomes clear when one considers how the neovolcanic zone varies with spreading rate and magma supply.

The axial high on fast-spreading centers indicates that the supply of magma is steady and robust and is able to keep up with the rate of plate separation (Fig. 4). The shape and cross-section area of the axial high are sensitive indicators of the local magma supply. The reduction in cross-section area and change in shape to a narrow,



**Figure 6.** A: Enlarged shaded relief image (location in Fig. 3A) of the fast-spreading East Pacific Rise, 12°35'–13°N. The 12°37'N overlapping spreading centers (OSC) is in the foreground; 12°54'N OSC is in the background. The axial summit caldera is large enough here (~500 m wide x 50 m deep) to show up as a small axis-parallel trough at the crest of the East Pacific Rise (image produced at University of California, Santa Barbara by S. P. Miller based on data from Macdonald et al. [1992]). B: Sidescan sonar image and tectonic sketch of East Pacific Rise, 12°40'–13°N showing axial summit caldera (ASC) and examples of third-order (12°54'N OSC) and fourth-order (12°50'N, 12°46'N) discontinuities.

triangular cross section near many discontinuities indicates a reduction in magma supply near the ends of ridge segments; conversely, magma supply is generally greater along the midsections of segments (Macdonald and Fox, 1988; Scheirer and Macdonald, 1993). Active volcanism is dominated by linear fissure eruptions along the crest of the rise and extensive outpourings of sheet flows (e.g., Choukroune et al., 1984; Macdonald et al., 1989). These lavas erupt from a long, linear trough that lies along the crest of the axial high (Figs. 4, 6A, 6B, 7). This trough is referred to as an axial summit caldera,

because it is produced by collapse of the frozen volcanic carapace when underlying magma drains away, rather than by block faulting (Haymon et al., 1991a). The caldera is tens of kilometres long and typically ~50–500 m wide (Macdonald et al., 1984; Searle, 1984). Presence of the axial summit caldera (Macdonald and Fox, 1988) coincides almost perfectly with a bright, phase-reversed seismic reflector (e.g., Detrick et al., 1987; Harding et al., 1993), which is interpreted to be the roof of a crustal magma chamber beneath the rise. The caldera is also restricted to 60% of the rise where the shape and

cross-section area indicate a robust magmatic budget—i.e., not near discontinuities of orders 1–3.

The axial high on fast-spreading centers has been compared to terrestrial shield volcanoes (e.g., Lonsdale, 1977). While this is a fruitful analogy for understanding the structure and morphology of many submarine volcanic products, it can be misleading, because the axial high is not a volcanic construction clear down to the Moho as is Hawaii, for example. Rather, as outlined above, the elevation of the axial high is created primarily by the buoyancy of hot rock and magma which upwell beneath the rise. For example, if the magma supply to Hawaii were cut off, the island would sink beneath the waters of the Pacific because of subsidence of the lithosphere on which it rides; however, it would not disappear if it follows the evolutionary path of its predecessors along the Hawaii-Emperor seamount chain. In contrast, the axial high at fast-spreading centers will disappear if cut off from its magma supply (Macdonald, 1990). The thickness of the accumulated volcanics is actually thinnest along the axis where the elevation is greatest (Christeson et al., 1992). Thus, while the axial high looks like a shield volcano, it is actually more akin to a long, skinny, magma-filled balloon whose diameter is a sensitive measure of magma supply. This is why we see little vestige of the axial “volcano,” split or whole, on the flanks of the East Pacific Rise. As it splits in two, moves off axis and cools, most of it disappears. Only a muted representation of the axial neovolcanic zone survives off-axis (Figs. 3A, 4) (Tighe and Fox, 1991), most commonly within the discordant zones of second-order discontinuities where tips of abandoned ridges may be supported by thicker lithosphere (Fig. 4).

In contrast, significant volcanic constructional edifices may develop on the ridge axis at intermediate-rate spreading centers (40–90 mm/yr.). A more episodic magma supply (Macdonald, 1982), combined with thicker zero-age lithosphere (Purdy et al., 1992), allows axial volcanoes to be constructed and supported along the spreading axis. This thicker zero-age lithosphere also provides sufficient overburden so that normal faulting may occur right along the spreading axis (as opposed to tensional failure and collapse along the axes of most fast-spreading centers where the lithosphere is not sufficiently thick for normal faulting to occur until it has moved 2–5 km off-axis [e.g., Carbotte and Macdonald, 1990]). Thus, as spreading continues, the episodically forming axial volcano on intermediate-rate spreading centers splits by normal faulting, and the two halves of the volcano are rafted away and preserved on the flanks (Fig. 8), creating the “bow forms” found by Kappel and Ryan (1986). A direct test of this split-volcano hypothesis is that the volcanic section (layer 2A) of the oceanic crust should be thicker beneath abyssal hills than the intervening valleys at intermediate-rate spreading centers but

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Note: Figure 1 (in Part I of this article, *GSA Today*, January 1993, p. 1) is from National Geophysical Data Center data announcement 91-mgg-07, relief globe slides (1991).

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should have a relatively uniform thickness independent of abyssal hills on fast-spreading centers. Seismic data at fast-spreading centers (Kappus et al., 1992; Harding et al., 1993) and at intermediate-rate spreading centers (Rohr et al., 1992) support this hypothesis. These data also support topographic observations that some of the abyssal hill topography flanking intermediate-rate spreading centers may have a volcanic constructional component, whereas the relief associated with lined hills flanking the fast-spreading East Pacific Rise developed primarily because of faulting (Lonsdale, 1977; Bicknell et al., 1988; Carbotte and Macdonald, 1990).

In contrast to magmatically robust fast- and intermediate-rate spreading centers, magmatically starved intermediate- and slow-spreading centers are characterized by a rift valley and an axial neovolcanic zone that are discontinuous (Figs. 5A, 5B) (e.g., Macdonald, 1986). Some have argued that the rift valley disappears episodically on slow-spreading ridges, so we included one of the touted examples of this disappearance in Figure 5A. The rift valley does not disappear along the entire segment; it is more than 400 m deep along 80% of its length. Near mid-segment, however, the valley shoals to a 200-m-deep half-graben, but even there it does not

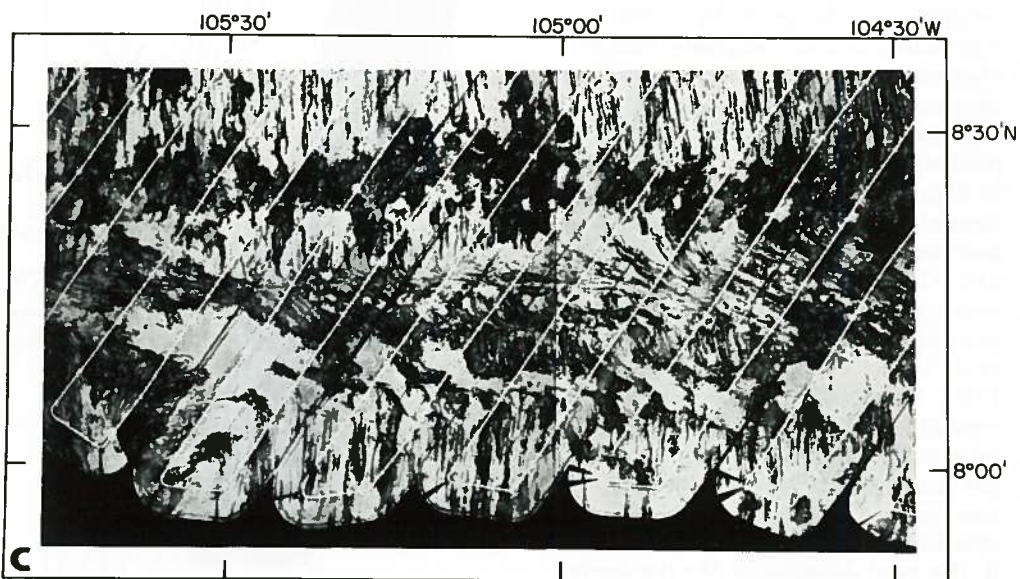
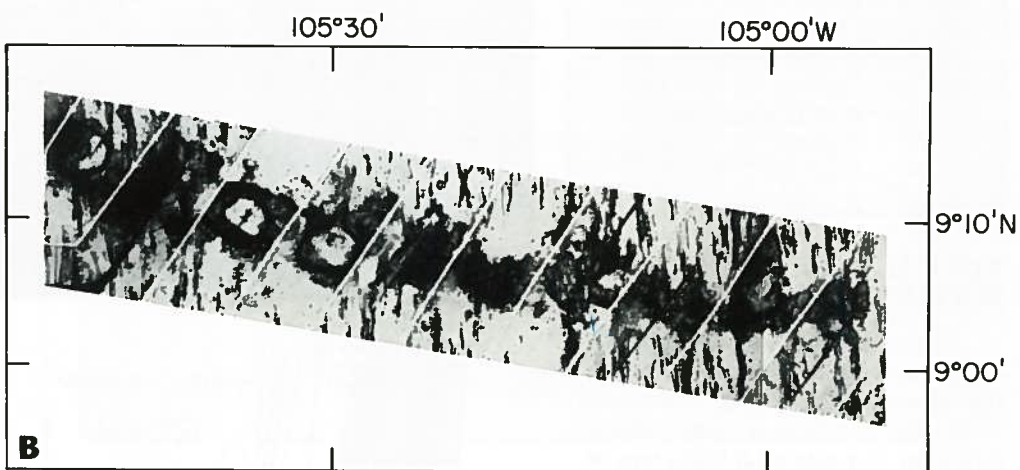
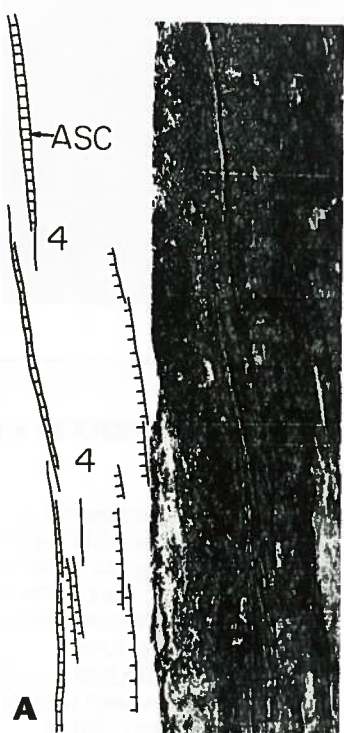
vanish. At slow-spreading ridges, the axial rift valley disappears along entire segments only near hot spots (e.g., Azores and Iceland) and where rare occurrences of seamount volcanism along the axis overprint the rift valley (e.g., near lat 26°S; Grindlay et al., 1991).

Sea Beam charts show that the neovolcanic zone within the rift valley inner floor is dotted by numerous small, conical volcanoes averaging 60 m in height (Fig. 5C) (Kong et al., 1988; Smith and Cann, 1992), and less commonly by long, linear volcanic ridges (Pockalny et al., 1988). In contrast to the buoyantly supported axial high at fast-spreading centers, these edifices are true volcanic constructions whose elevations are produced entirely by lava flows, primarily pillow flows (Bryan and Moore, 1977). These discontinuous conical volcanoes suggest point-source volcanism from many isolated pockets of magma, in contrast to the remarkably continuous magma reservoir beneath fast-spreading centers. Smith and Cann (1992) suggested that hundreds of these volcanoes coalesce to create the volcanic layer on slow-spreading ridges. If so, then the crust created at slow-spreading centers is a heterogeneous patchwork of lozenge-shaped volcanic units, in contrast to the more continuous "conveyor-belt" style of volcanism at fast-spreading centers. As at intermediate-rate spread-

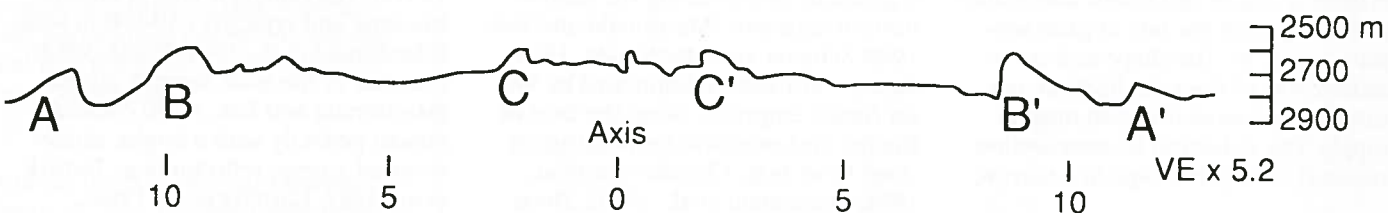
ing centers, some of these volcanoes split in two (Atwater, 1979), but more commonly they are dismembered, only parts of the volcanoes being preserved as "lips" at the edges of large fault blocks (Macdonald and Luyendyk, 1977; Ballard and van Andel, 1977).

**USING TOPOGRAPHY TO FORECAST SEAFLOOR VOLCANIC ERUPTIONS AND AXIAL MAGMA CHAMBERS**

On the basis of Sea Beam maps of the East Pacific Rise between lat 9° and 13°N, we suggested that the shape and cross-section area of a fast-spreading rise is an indirect measure of its magma supply (Macdonald et al., 1984). A narrow "triangular" cross section indicates a starved magma supply, whereas a broad dome- or rectangular-shape cross section indicates a robust supply of magma. In 1987, Detrick et al. published multichannel seismic results that were consistent with this hypothesis. A bright, phase-reversed reflector, interpreted to be the roof of a narrow crustal magma chamber, was observed 1.2–2.0 km beneath the seafloor where the rise axis is domed or rectangular in cross section, but this reflector was absent where the profile is triangular. Furthermore, we found an excellent correlation between the presence of an axial summit caldera (then called an "axial summit graben") and the magma



**Figure 7.** Side-scan sonar close-ups and interpretations from Figure 4 (in Part 1). The dark areas have a high acoustic reflectivity; the white lines show the ship track. A: The axial summit caldera (ASC) at 9°30'–40'N (see text for discussion). The 4s show the locations of two fourth-order discontinuities that offset the axial seamount caldera less than 1 km; hachured lines indicate faults; the hachures are on the down-dropped side. B: OCP seamount chain; the highly reflective hollows around the seamounts indicate lava flows that are younger than the crust they lie upon. C: The west flank of the Siqueiros Fracture Zone showing history of intratransform spreading and southward propagation of East Pacific Rise cutting across the transform, consuming one of the intratransform spreading centers (near 8°15'N, 104°40'W). Also shown is the 8°20'N seamount chain.

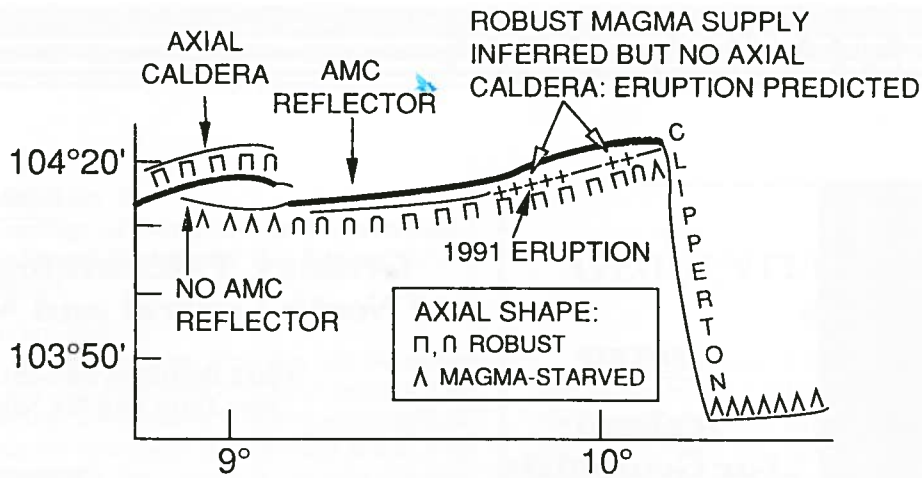


**Figure 8.** Deep-tow profile of the intermediate spreading rate East Pacific Rise near 21°N (Normark, 1976). A–A', B–B', C–C' represent possible split volcanic edifices, common at intermediate-rate spreading centers but rare at fast-spreading centers (see Fig. 4 and text for discussion).

chamber reflector (Macdonald and Fox, 1988). In only two locations between 9° and 13°N (9°42'–55'N and near 10°00'N) did we observe a magmatically robust, domed ridge cross section, underlain by a bright magma-chamber reflection, that was lacking a summit caldera (Fig. 9). We reasoned that these two anomalous locations were in a magmatically robust phase, swollen with underlying magma and smoothed by fresh lavas that had not yet collapsed to form a caldera. Such a location seemed to be a good candidate for a ridge that is in an active eruptive phase of its evolution (Macdonald and Fox, 1988).

In 1989, Haymon et al. (1991a) conducted a detailed ARGO visual survey of the East Pacific Rise from 9°09' to 54°N for an Ocean Drilling Program site survey. Where we had noted the absence of an axial summit caldera in 1987, there existed in 1989 a narrow caldera (40–70 m wide). Our SeaMARC II survey in 1987 did not detect the feature, indicating either that it was too small to detect with SeaMARC II (unlikely) or that caldera collapse had occurred between 1987 and 1989. During a return to the same area in April 1991, divers in the submersible *Alvin* witnessed many indications that an eruption was occurring beneath and around them (Haymon et al., 1991b and unpublished). Thriving colonies of tube worms documented during the 1989 ARGO survey were mostly buried in fresh glassy lava, but a few scorched corpses were scattered about. Crabs and other mobile predators were absent in April 1991 but were voraciously feasting on broiled tube worms in May (Haymon et al., 1991c). Large (~100 m<sup>2</sup>) white bacterial mats grew around new hydrothermal vents. High-temperature fluids issued directly from cracks in the fresh lava flows; there had been no time for fast-growing sulfate-sulfide edifices to form. On the basis of <sup>210</sup>Po/<sup>210</sup>Pb dating, the basalt samples collected at 9°50.6'N from *Alvin* during April 1–14, 1991, must have erupted during March 26–April 6, 1991 (Rubin and Macdougall, 1991). Evidence of eruption was found at several sites extending throughout the 9°42'–55' interval forecasted in 1988 (Haymon et al., 1991c), and appeared to have propagated along an eruptive fissure north to at least 9°54'N.

Buoyed by this one apparent forecast success, we inspected our southern East Pacific Rise SeaMARC II data and found two more sites where we believe eruptions are occurring or will occur very soon: near 14°30'S and between 17°20' and 30°S (Macdonald, 1991). The significant maximum in cross-sectional area (Fig. 10) and a stretch of ~20 km where the axial summit caldera is filled and not yet collapsed convinced us that the case for 17°20'–30°S was particularly compelling, so that area was presented as our next forecast at the December 1991 American Geophysical Union meeting. In the same AGU session, Detrick and Harding presented the first multichannel results for the very fast spreading East Pacific Rise at 13°–20°S (Detrick et al., 1991; Harding et al., 1991). They showed that the magma-chamber reflection is bright and narrow, and present along approximately 60% of the rise, very similar to the East Pacific Rise 9°–13°N observations. However, the reflector is shallower than the one at 9°–13°N (~1 km) and at 17°20'S, the reflector almost reaches the seafloor! When we presented the analysis of our first forecast for 9°42'–55°N and the reasoning behind our next forecast for 17°20'–30°S, Vince Renard, who had conducted three reconnaissance dives with the



**Figure 9.** Enlargement of Macdonald and Fox's (1988) Figure 2 showing basis for forecast of 1991 eruption. The thick line shows the location of the axial magma chamber seismic reflector (from Detrick et al., 1987), the axial shape indicative of robust or starved magma supply as shown; the thin line parallel to the axis shows where an axial caldera is present, the plus symbol shows the regions where a cross-sectional shape indicates a robust magma supply but absence of an axial summit caldera, presumably due to recent flooding by lavas. There are only two plus regions on the East Pacific Rise between 9° and 13°N; these are the locations where volcanic eruptions were forecast (Macdonald and Fox, 1988). Most of the 9°42'–55'N region has undergone post-1989 volcanism (Haymon et al., 1991c), and a documented eruption occurred in late March–early April 1991 near 9°51'N (Haymon et al., 1991b). *Alvin* dives near 10°N in March 1992 document evidence for very recent volcanic activity here as well.

French submersible *Cyana* in 1984 near 17°25'–27°S (Renard et al., 1985), related how they had seen large areas of fresh glassy lava, the same mysterious white bacterial mats blowing out of fissures in the lava carapace, and hydrothermal fluids venting straight out of cracks in the lava flow, but no sulfide edifices developed yet; most of these were the same indicators of active eruption observed near 9°50'N (Haymon et al., 1991b). The sulfate-sulfide edifices grow in height at a rate of about 10 cm/day (Hekinian et al., 1984), so this limits the age of the eruption to being very recent or ongoing. We think this is a second successful forecast (of sorts) of a deep-seafloor volcanic eruption. Subsequently, a preliminary analysis of March 1992 *Alvin* dive observations near 10°N indicates that dike injection and minor volcanism may have occurred since 1991 in the 10°–10°02'N area (Macdonald, unpub. cruise report).

Recent seismic results also provided an opportunity to test our prediction of where axial magma chambers

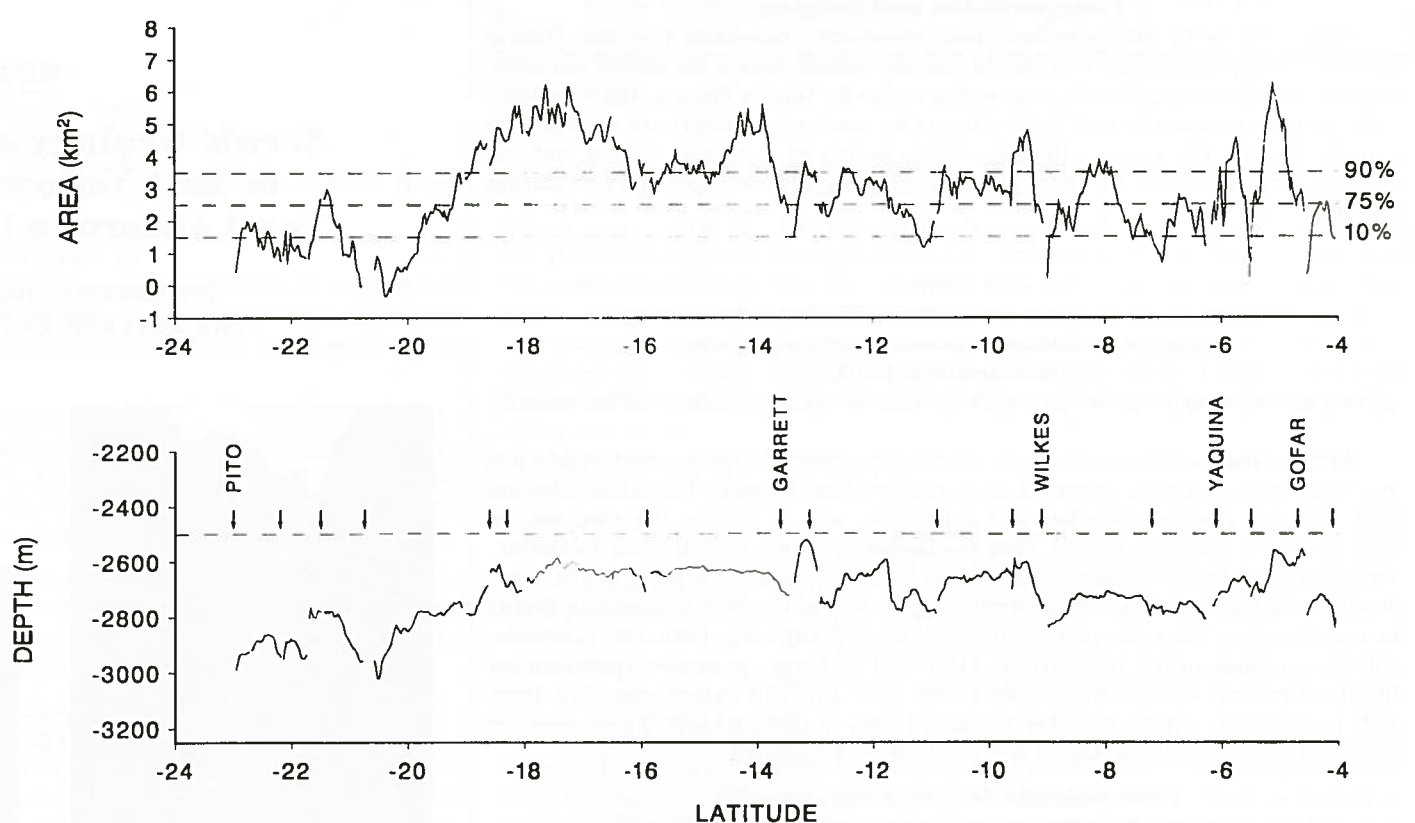
should be found between 3° and 23°S on the East Pacific Rise (Fig. 10) (Macdonald and Fox, 1988). We refined this prediction by making a sequence of cross-section area calculations for the rise crest at 1 km intervals along strike using our digital bathymetric data base (Scheirer and Macdonald, 1991). At the December 1991 AGU meeting, Detrick showed where the magma chamber had been imaged between 13° and 20°S (Detrick et al., 1991). In Scheirer's talk, immediately following Detrick's, the predicted magma-chamber locations, based on excessive or maximum cross-section area and shape, had a better than 80% agreement with seismic detection of a magma-chamber reflector (we had only predicted presence, not depth or width of the magma chamber). Our earlier magma-chamber prediction, based solely on shape of the axial high and presence of an axial summit caldera, was almost as successful, and the predicted locations were published in Macdonald and Fox (1988) for comparison with the seismic results. Some of the axial relief we measure may

be caused by variations in the thickness of the volcanic carapace (especially at ridges that spread at an intermediate rate), reflecting a longer term average of the magma supply than is measured seismically (Harding et al., 1993). This is the most likely explanation for the 10%–20% of the ridge where our prediction method fails. In general, our forecasting method for axial magma chambers and volcanic eruptions will not work for intermediate-rate- and slow-spreading ridges, but it should work for most fast-spreading cases.

Although it is exciting to forecast submarine eruptions and the locations of magma chambers on the basis of such a simple analysis of seafloor topography, the real scientific importance is not in the forecast itself but in the successful test of two important hypotheses: (1) a distinctive morphology of the ridge axis is linked to the local magma supply, and (2) the fine-scale structure of the axial summit caldera on fast-spreading ridges is linked to the recent eruption history.

In summary, precise mapping of the shape of the seafloor near mid-ocean ridges, in concert with other studies, has revealed a great deal about the creation and tectonic processes responsible for the creation and evolution of oceanic crust. The mid-ocean ridge is segmented in a pattern that reflects magma supply. There is a hierarchy of segmentation such that short segments (~10 km) tend to be short-lived (10<sup>2</sup>–10<sup>5</sup> yr), whereas long segments may last for millions of years. Presumably, the longer the segment, the deeper the source (i.e., 1000-km-long hot-spot centers tap the lower mantle, intermediate-wavelength expressions of segmentation several tens to hundreds of kilometres long tap sources in the upper mantle ~50–60 km deep). The axial high at fast-spreading centers is characterized by an axial summit caldera along its crest. The 300–400 m elevation of the high is produced by the buoyancy of hot rock and magma beneath the newly created edges of the spreading plates. The elevation is not a volcanic construction, so there is little vestige of it off-axis. At intermediate spreading rates, there is

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**Figure 10.** Axial cross-sectional area (top) and depth (bottom) profiles of the East Pacific Rise between 3° and 23°S from SeaMARC II and Sea Beam records; measurements were taken every 1 km along strike (after Scheirer and Macdonald, 1993). The arrows indicate first- and second-order ridge axis discontinuities. On the basis of the documented relation between the presence of an axial magma chamber vs. cross-sectional area for 8.8°–13°N, parts of the ridge whose cross-sectional areas fall above the 90% line (3.5 km<sup>2</sup>) have a 90% probability of having an axial magma chamber; the same applies to the 75% and 10% lines. The prediction agrees very well with recent multichannel seismic results from the 13°–20°S area (Detrick et al., 1991).

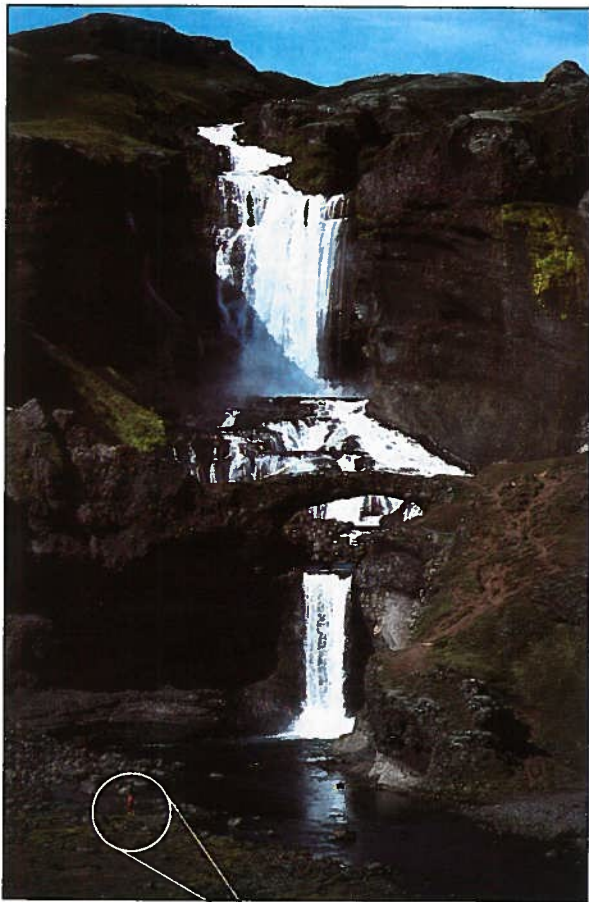


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Diane Bellis, U.S. Department of Agriculture, Forest Service*

#### **Daily Itinerary**

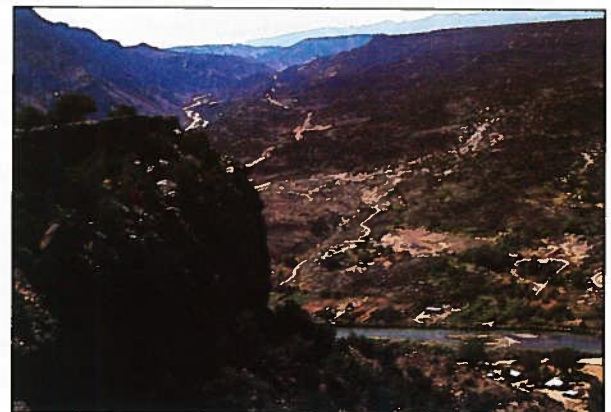
All trips begin and end in Santa Fe.

Day One—Saturday, May 29

6:00 to 8:00 p.m.—**Arrive in Santa Fe.** Welcoming Reception and Orientation, Plaza Resolana en Santa Fe.



St. Francis Cathedral, Santa Fe.  
Photo by Jack Parsons.



Near Taos; Pilar  
looking down the Rio Grande.

## GEOHOSTEL

### **Scenic Geology and Natural History of East Yellowstone, Beartooth, and Absaroka Country, Wyoming**

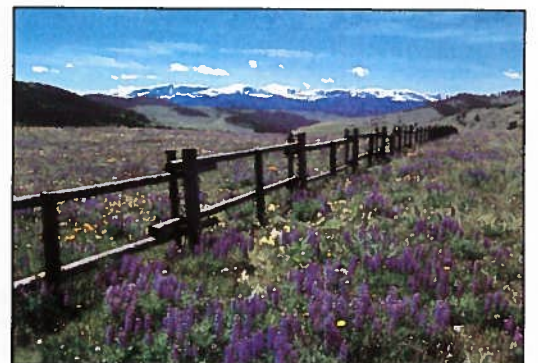
Northwest College, Powell, Wyoming  
Five Days and Six Nights: July 17–22, 1993

#### **Scientific Leaders**

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



Fall Creek Falls—Clarks Fork.  
Courtesy of Wyoming Travel Commission.



Mountain wild flowers.  
Courtesy of Wyoming Division of Tourism.



**Day Two—Sunday, May 30**

8:30 to 12:00 noon—**Classroom lecture: Geology of Northern and Northwestern New Mexico; Introduction to the Cultural History of the Region.** Afternoon is free for touring Santa Fe, the City Different.

**Day Three—Monday, May 31**

8:00 a.m. to 5:00 p.m.—**Taos and the Rio Grande Gorge.** This trip will be dominated by the development of the Rio Grande Rift and associated structural geology. The route will include the Tertiary Tesuque Formation of the Santa Fe Group and unusual geomorphic features such as Camel Rock, eroded from soft sedimentary strata. The spectacular Rio Grande Gorge is approximately 650 ft deep, and has cut into volcanic flows 4.5–3.6 million years old. Afternoon is free for touring Taos.

**Day Four—Tuesday, June 1**

8:00 a.m. to 5:00 p.m.—**Albuquerque and Tramway to Sandia Peak.** Albuquerque is situated on several river terraces of the Tertiary Santa Fe Group and Pleistocene and Holocene deposits, beneath the Sandia Mountains. The tram provides exciting views of 1.4-billion-year-old Precambrian granite cliffs of the Sandia Granite, which forms the core of the Sandias. Afternoon is free for touring Albuquerque.

**Day Five—Wednesday, June 2**

7:00 a.m. to 6:00 p.m.—**San Juan Basin, Geology of the Southern Part of the Basin, and Tour of the Ruins at Chaco Canyon.** This trip will skirt the eastern edge of the San Juan Basin, initially crossing the sharply uplifted Precambrian and Paleozoic Nacimiento uplift. Farther northward, the San Juan Basin provides an excellent record of Late Cretaceous marine transgressions and regressions. Chaco Canyon is a spectacular archaeological area. Between 1050 A.D. and 1300 A.D. large stone masonry apartment complexes were built to house substantial populations.

**Day Six—Thursday, June 3**

8:00 a.m. to 2:00 p.m.—**Madrid.** This trip will include a traverse of the Espanola Basin, part of the Sangre de Cristo uplift, and part of the Jemez volcanic field and the Hagen embayment. The rock units will include basement Precambrian rocks, Paleozoic and Mesozoic sedimentary rocks, and Tertiary-Quaternary sedimentary and volcanic units.

The Farewell Party begins at 6:00 p.m.

**Fee and Deposit**

Cost: \$550 for GSA members. Nonmembers \$595.

\$125 deposit, due with your reservation, is refundable through March 30, less \$20 processing fee.

**Total balance due: April 1**

Minimum age: 21 years. Limit: 28 persons.

**Fee includes** classroom programs and materials, field trip transportation, lodging for 6 nights (double occupancy, dormitory rooms), breakfast and lunch daily through Thursday, and welcoming and farewell events. **Not included** are transportation to and from New Mexico, transportation during non-class and field trip hours, meals or other expenses not specifically included.

**Daily Itinerary**

All trips begin and end in Powell.

**Day One—Saturday, July 17**

6:00 to 8:00 p.m.—**Arrive in Powell.** Welcoming Reception and Orientation, Home-steader's Park.

**Day Two—Sunday, July 18**

8:00 a.m. to 12:00 noon—**Dead Indian Hill.** A short drive and walk to a spectacular overview of the region. We will review northwestern Wyoming geology, specifically local stratigraphy, Laramide tectonics, the Heart Mountain thrust, local geomorphology, and plant communities.

**Day Three—Monday, July 19**

8:00 a.m. to 5:00 p.m.—**Yellowstone.** We will drive up the Wapiti Valley to Yellowstone Park, stopping at Rattlesnake Mountain, Holy City Hoodoos, Yellowstone Lake, and Yellowstone Falls. Emphasis will be on the Absaroka volcanic suite and the development of the Yellowstone caldera and surrounding plateau.

**Day Four—Tuesday, July 20**

8:00 a.m. to 12:00 noon—**Bighorn Basin.** We will traverse the Big Horn Basin and examine the famous Sheep Mountain anticline. Emphasis will be on stratigraphy, Laramide structures, petroleum resources, and basin hydrogeology.

**Day Five—Wednesday, July 21**

8:00 a.m. to 4:00 p.m.—**Daisy Pass—Cooke City.** This trip will take us to the upper Clark Fork of the Yellowstone River. We will start with a look at the spectacular Sunlight Basin, then drive above Cooke City to Daisy Pass near timberline. Highlights will be complex geology, an old mining area with good mineral collecting, and beautiful flowers.

**GEOVENTURES REGISTRATION FORM**  
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GeoVentures are a special benefit created for members, but are open also to guests and friends. GeoVentures is the overall name for adult educational and adventure experiences of two kinds: GeoTrips and GeoHostels. Both are known for expert scientific leadership. Fees for both are low to moderate (relative to the length of time and destination) and include lodging and meals as designated. The venues, however, are quite different.

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**Day Six—Thursday, July 22**

8:00 a.m. to 5:30 p.m.—**Beartooth Highway Loop.** This trip will take us over the Beartooth Highway through Red Lodge, Montana. This highway, often called the most scenic in America, earns the title with spectacular geology as well. Highlights will be Laramide structures on the north scarp of the Beartooth Plateau and vast-scale alpine and ice-cap glacial features on a road that is above timberline for 30 miles. Precambrian rocks of the plateau are more than 3 billion years old. Culmination of the trip is the Beartooth Butte, the favorite spot on Earth of trip leader Ken Kolm.

The Farewell Party begins at 7:00 p.m.

**Fee and Deposit**

Cost: \$425 for GSA members. Nonmembers \$475.

\$100 deposit, due with your reservation, is refundable through April 30, less \$20 processing fee.

**Total balance due: May 1**

Minimum age: 21 years. Limit: 28 persons

**Fee includes** classroom programs and materials, field trip transportation, lodging for 6 nights (single-occupancy, dormitory rooms), breakfast and lunch daily through Thursday, and welcoming and farewell events. **Not included** are transportation to and from Wyoming, transportation during nonclass and field trip hours, meals, or other expenses not specifically included.

sufficient cooling for a volcanic edifice to develop and sufficient thickening of the lithosphere on-axis for accumulation of strain and true normal faulting to occur. Splitting of axial volcanoes and axial grabens occurs under these circumstances. Half-volcanoes, with their steep fault-bounded sides facing the spreading axis, are preserved on the flanks of the ridge. Where axial rift valleys occur, at slow-spreading centers and magma-deficient intermediate-rate spreading centers, the neovolcanic zone lies within the inner floor of the rift valley. Numerous small conical volcanoes, which may coalesce into larger edifices, and elongate ridges created by fissure eruptions contribute to volcanic constructional terrain. On fast-spreading ridges, the morphology and fine-scale structure of the ridge are sufficiently sensitive to magma supply to permit forecasts of magma-chamber locations and even eruptions.

These are only a few examples, taken mostly from our own research, of how useful precise measurements of seafloor topography can be. Many other examples could be cited; determining the history of and changes in plate motion; determining the relative importance of faulting, volcanism, sedimentation, and mass wasting in shaping the ocean floor; exploring the causes of linear seamount chains, and so on (e.g., Searle, 1992). Satellite measurements have also provided low-resolution glimpses of large uncharted areas of the seafloor (Marks et al., 1991). While we have emphasized the importance of topographic measurements, marine geology-geophysics is very much an interdisciplinary area of research, and the charts and structural maps reviewed here provide a common base that draws together geochemists, seismologists, structural geologists, and even biologists and chemists. We hope to catch up, before the end of the millennium, with the successful mission

to map the surface of Venus. The long-term goal is the construction of a global-scale-high resolution map of the seafloor that will define patterns of crustal evolution during the past 200 m.y. and provoke fundamental insights into processes that shape the planet in space and time.

#### ACKNOWLEDGMENTS

Swath-mapping and *Alvin* cruises, which have made these observations possible, have been supported by the Office of Naval Research and the National Science Foundation. We thank R. Haymon and an anonymous critic for helpful reviews. This paper is the primary reference for our forecast of volcanic eruptions; Scheirer and Macdonald (1993) is the primary reference for prediction of axial magma chambers based on cross-sectional area calculations, and the case for split volcanoes at some intermediate rate spreading centers vs. horst and graben relief at

fast-spreading centers is developed more fully in Carbotte and Macdonald (unpublished).

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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 1994 officers and councilors must be received at GSA headquarters no later than **FEBRUARY 15, 1993**. Please send nominations and back-up material to the Administrative Department, Geological Society of America, P.O. Box 9140, Boulder, CO 80301.

### Penrose and Day Medals, and Honorary Fellowship

Nominations for GSA's Penrose and Day Medals and for Honorary Fellowship in the Society are due at headquarters by **FEBRUARY 1, 1993**.

For procedures and additional information, please refer to the October 1992 issue of *GSA Today*, or call headquarters at (303) 447-2020.

Send your nominations and required back-up material to the Administrative Department, Geological Society of America, P.O. Box 9140, Boulder, CO 80301.

### Young Scientist Award (Donath Medal)

The Young Scientist Award was established in 1988 to be awarded to a young scientist (35 or younger during the year in which the award is to be presented) for outstanding achievement in contributing to geologic knowledge through original research that marks a major advance in

the earth sciences. The award, consisting of a gold medal called the Donath Medal and a cash prize of \$10,000, was endowed by Dr. and Mrs. Fred A. Donath.

For the year 1993, only those candidates born on or after January 1, 1958, are eligible for consideration. In choosing candidates for the Young Scientist Award, scientific achievement and age will be the sole criteria. Nominations for the 1993 award must include

- biographical information,
- a summary of the candidate's scientific contributions to geology (200 words or less),
- a selected bibliography (no more than 10 titles),
- supporting letters from five scientists.

Nominations for the 1993 Young Scientist Award must be received at GSA headquarters by **FEBRUARY 1, 1993**. For procedures and additional information, please refer to the October 1992 issue of *GSA Today*, or call headquarters at (303) 447-2020.

### 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 1993 is **MARCH 1, 1993**.

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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.

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Bruce F. Molnia

Washington Report provides the GSA membership with a 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.

## Walter Massey and the Foundation for the 21st Century

Because the National Science Foundation (NSF) is the largest source of earth science research grant funding in the nation, any attempt at redefinition or redirection of NSF should be of great interest to the earth science community. Therefore, a summary of the recent activities of the National Science Board Commission on the Future of the National Science Foundation is the basis of this month's Washington Report.

A little more than two years ago, Walter Massey became director of the NSF, replacing Eric Bloch, who had served for the previous six years. As described in last month's Washington Report, the political climate that Massey found upon his arrival in Washington was one in which questions were being raised by Congress and others about the ability of the federal research community to contribute to the health and welfare of the nation through the creation and dissemination of new knowledge resulting from federal support of research and education.

On December 6, 1991, Massey addressed this issue head-on, in a memorandum to his staff titled "Statement

In August 1992, Massey took the next step. In a presentation to the National Science Board (NSB), the policy-making arm of NSF, Massey stated, "I think it is imperative that NSF determine its place in this new order." Massey described "three broad options for the future" of the NSF. First, NSF "could revert to its historical roots as a small agency predominantly dedicated to the support of individual investigators and small groups at universities." Second, NSF "could continue on its present path, where the agency builds on its mission as a supporter of academic researchers with marginal and exploratory ventures in other areas, such as centers, initiatives in high-performance computing and advanced manufacturing, and programs linking universities and industry." Third, NSF could "build on our traditional mission and exercise new leadership across a broader spectrum of research areas. NSF would adopt an expanded portfolio of programs that would be integrated with ongoing activities and closely aligned with industry and other government agencies." Massey dismissed the first option, stating that this option would

directions of NSF." William Danforth, chancellor of Washington University, St. Louis, and Robert Galvin, chairman of the Executive Committee of Motorola, were named as cochairmen. No earth scientists were named to the panel. Twelve of the 15 panel members were not members of the NSB.

To accomplish its task, the panel held three open meetings, all at NSF headquarters in Washington, D.C. The first, held on September 17, focused on academic- and industry-based research. The second, held October 16, focused on various models of research excellence. The third, held November 7, 13 days before the release of the report, focused on NSF and its role in funding research. In addition to public meetings, the commission also solicited and received more than 800 written comments. Two specific questions were offered for comment: (1) NSF support plays an important role in the health of the nation's academic system, which is the source of new ideas and human resources in science and engineering. How can NSF best maintain and enhance the health of this vital national resource? and (2) In light of the many changes in both science and world affairs (such as the increasing inseparability of science and technology, the rise of the global economy, and the end of the cold war), should NSF build on its traditional mission by pursuing a broader array of educational objectives and doing more to link academia and industry? If so, what strategies could the agency adopt to move in this direction?

The commission's short report, "A Foundation for the 21st Century: A Progressive Framework for the National Science Foundation" was released on November 20. In general, the report endorses the importance of fundamental and strategic research and affirms NSF's role in math, science, and engineering education. The report repeatedly addresses the changing nature of science and the national agenda. The report consists of a 2 1/3 page Background section, a 4 2/3 page Findings and Recommendations section with 20 recommendations (divided into five general recommendations [GR], ten research recommendations [RR], three education recommendations [ER], and two structural recommendations [SR]), and a concluding 2 2/3 page section, The Stronger National Policy.

The Background section concludes "Success requires: an enlightened federal science and technology policy that touches all relevant agencies, a determination by industry to reach out for talent and knowledge, and the development of appropriate links. The universities and the NSF should complement rather than replace the roles of those engaged in technology development. Redirecting the NSF's activities from research and education would have little or no effect on the U.S. competitive position in the near term, but would severely restrict prospects for the long term. Research and education activities offer ample opportunity to increase the potential contribution of scientists and engineers to society."

Earlier in the Background section, the commission went head-to-head with Congressman Brown's task force report on the nonlinear relation between advances in knowledge and advances in science. The commission report states, "Failures in the marketplace have not been the result of slow transfer of academic science to industry. In fact, American firms have been the first to commercialize virtually all innovative products, but have lost market share to competitors with shorter product cycles, lower costs, and superior quality. All manner of other more

prominent factors, including the stewardship by American business, far outweigh whatever could be traced to the technology itself or the technologists."

The Findings and Recommendations section begins with the statement, "Change is part of the national agenda. NSF, and the colleges and universities it supports, are in a position to help create a new vision of and value from the role of science and engineering for society." Rather than reproducing all 20 recommendations, I present several of what I consider to be the more important ones: GR1—"The US should have a stronger and more coherent policy wherein science and engineering can contribute more fully to America's strength." GR2—"Society's voice is welcome and needed." GR3—"The Commission strongly supports the initiation of proposals by investigators and selection of those to be funded by merit review carried out by experts." RR1—"The Board and the Foundation's key role in the support of research in science and engineering should be reaffirmed." RR2—"The NSB and the NSF should encourage interdisciplinary work and cooperation among sectors." RR4—"It is urged that the size of NSF grants be examined. Many believe that on average, NSF individual research grants are too small." RR7—"The Foundation should more aggressively lead in communicating the 'case' for science and engineering, which deserves a high priority in the mind of public officials and citizens alike." RR9—"Undergraduate education is enriched by faculty participation in research. Research is essential to preparing graduate students for scientific careers in academia, government, and industry." EE1—"A major priority for the NSB and the NSF should continue to be education in science and education." EE3—"The Foundation is chartered to support improved education in mathematics and science throughout all the school years, from kindergarten through graduate and post-doctoral studies. The two most critical areas needing improvement are K-12 education and undergraduate education.... The Commission urges the NSF to persuade the scientific community to expand its commitments to improving the quality of undergraduate education in mathematics, science and engineering. Introductory courses, especially, need improvement." SR2—"NSF should continue to support shared, common use facilities that cannot be built and maintained by individual institutions."

The report concludes, "Finally, the Commission returns to the role of the Board in influencing a stronger science and engineering and technology policy for the Nation. The Board and the NSF are today the lead organizations representing the interests of broad science and engineering in the United States. The Board must work with its peers in the private and public sectors so that the nation might formulate a much needed science and technology roadmap. We are convinced that students, scientists, engineers, industry, and the public would join together to build and build on that roadway."

"It is a journey that we must begin."

Speaking of journeys, on January 8, 1993, NSF reluctantly agreed to relocate from downtown Washington, D.C., near the White House, to a new facility located at Ballston, about five miles away in suburban Arlington, Virginia. For almost two years, NSF had battled to remain in its cramped Washington, D.C., headquarters. Only when it became clear that the incoming Clinton Administration also supported the NSF relocation did Director Massey and his staff give in. ■

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***"The [NSF] Foundation should more aggressively lead in communicating the 'case' for science and engineering, which deserves a high priority in the mind of public officials and citizens alike."***

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of Goals and Priorities," in which he wrote that his highest priority was to use the resources of NSF to "maintain and enhance the health and vitality of our nation's research and education enterprise." Massey wrote, "This priority also includes the promotion of excellence in science, engineering, mathematics and technology education at all levels." He included in this priority "increasing the development and representation of all citizens, particularly underrepresented groups, in all aspects of the research and education enterprise."

Massey's memo defined three goals: (1) "increasing support to individual investigators through budget allocations and larger grant size and extended award duration"; (2) "NSF must be responsive to current critical national needs, particularly in education and in human resources and economic development"; and (3) "having the Foundation's staff, our management practices and all our activities reflect and exemplify the excellence we strive for through our external mission." Massey noted that the implementation of these directives "will require strong commitment from the entire foundation." Apparently this was still not sufficient.

"almost certainly mean discontinuing the programs that have sought to connect basic research with the user community." He also dismissed the second option, stating that "it is very likely that this would be a path of unstable equilibrium." He stated that the third option is the one that he prefers. To provide a more far-reaching consideration of the future course of NSF, Massey also recommended to the NSB that a special commission be established "to help us in our examination of the role and direction of NSF in light of the changes in science and technology and the markedly changed external environment."

On September 9, J. J. Duderstadt, president of the University of Michigan and chairman of the NSB, named the 15-member panel to evaluate the future of the NSF. Duderstadt said that the "commission report [due in late November] will incorporate the views of scientists, industry leaders, university administrators, and educators to provide the NSB with a broad range of external advice for future planning. Once the commission's recommendations are received, the Board will continue to seek extensive and constructive participation from the scientific community in determining future



Robert L. Fuchs

## Haydn H. Murray Appointed Trustee



Haydn Murray

At the annual meeting of the Foundation's Board of Trustees in Cincinnati in October, Haydn H. Murray of Indiana University was appointed a Trustee of the Foundation. Haydn Murray replaces Beach Leighton, who chose to retire from the board at the conclusion of his five-year term. The terms of Charles Mankin and Phil LaMoreaux also ended, and both were appointed by the board to second terms.

Haydn Murray was born in 1924 in Illinois. He attended the University of Illinois, receiving B.S., M.S., and Ph.D. degrees in geology from that institution, the last in 1951. From 1951

to 1957 he taught geology at Indiana University and was also a clay mineralogist with the Indiana Geological Survey. In 1957 he joined Georgia Kaolin Company as director of research, and over the next 16 years rose to the position of executive vice-president. In 1973 Haydn Murray returned to Indiana University as chairman of the geology department; he continues there today as professor of geology.

Murray is a well-known figure in clay mineralogy and the industrial minerals. He has received numerous honors and awards such as the Hal Williams Hardinge Award in industrial minerals from the American Institute of Mining Engineers (AIME) and the New Jersey Ceramic Association Man of the Year Award in 1971. He was the chair of the industrial minerals division of the Society of Mining Engineers (SME) in 1982 and a member of its board of directors from 1982 to 1985. He has been president of both the Society of Mining Engineers and the American Institute of Professional Geologists. He is a Distinguished Member of the Clay Minerals Society and AIME, and holds memberships in several other scientific and professional organizations.

Haydn Murray has been involved in GSA activities for more than 40 years. He is a Fellow of the Society and served on the Council from 1982 through 1984.

The Trustees were unanimous and enthusiastic in appointing Murray to the board. Trustee Paul Bailly commented that Haydn Murray's long service to geology and to GSA, plus his broad experience in mining and industrial minerals, is an important complement to the backgrounds and expertise of the other Trustees.

## Cady Award—Coal Geology

The Gilbert H. Cady Memorial Fund was established 21 years ago to recognize meritorious work in coal geology. Under the auspices of GSA's Coal Geology Division, the Cady Award is presented annually for outstanding contributions to coal geology in North America. The award consists of a certificate and an engraved sterling silver tray. Since inception there have been 11 recipients of the award.

Gilbert Cady died in 1970 at the age of 88. Almost all of his career was spent in the heartland of the United States. Born in Chicago, he studied at Northwestern University, the University of Illinois, Yale University, and the University of Chicago, where he received his doctorate. He was one of the early appointees to the Illinois State Geological Survey in 1906, and his

work there continued until 1919. After a brief stint working as a consultant in China, he became head of the Department of Geology at the University of Arkansas and State Geologist. In 1926 Gilbert Cady returned to the Illinois Geological Survey as Head of the Coal Division, a position he held until his retirement in 1951.

After retirement, Cady worked as a coal consultant to various state surveys and many coal and oil companies. His daily office routine continued until only a few days before his death.

Gilbert Cady had a wide influence on coal geologists and a profound effect on coal geology. In addition, he was held in high professional regard by the coal-mining industry. His contributions to the field of coal geology were manifold, including use of spores for correlation of coal seams, contributions to the basic classification system for coal, studies on mineral matter in coal, and much coal petrology research. His geologic work extended beyond coal into structural mapping and industrial minerals.

Gilbert Cady was instrumental in the formation of GSA's Coal Geology Division, and it was fitting that the Cady Memorial Fund and Award was established by the Division shortly after his death to honor the pioneering work of this leader in the field of coal geology. Contributions to the Cady Fund can be sent to the GSA Foundation, using the accompanying coupon. ■

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George C. Soronen  
James B. Stevens  
John E. Szatai  
Bennie W. Troxel  
Victor Vacquier  
William G. Wahl  
Roger M. Waller  
G. Frederick Warn  
Ray E. Wells  
Sherman A. Wengender\*  
Peter Werner  
Brian P. Wernicke\*  
Frank C. Whitmore, Jr.  
William B. Whiteford  
John H. Whitmer\*  
Paul A. Witherspoon, Jr.  
Kenn-Ming Yang  
Frederick P. Zoerner


### Women in Science

Helen L. Cannon  
Susan Garcia\*  
Amy M. Loomis  
Helen L. Nace  
(in memory of Annabel B. Olson)  
Daniel B. Sass  
Ruth A.M. Schmidt\*

\*Second Century Club members (gifts of \$100 or more).



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## Origin and Emplacement of Low-K Silicic Magmas in Subduction Settings

### Conveners

James S. Beard, Virginia Museum of Natural History, Martinsville, VA 24112

George W. Bergantz, Department of Geological Sciences, University of Washington, Seattle, WA 98195

Marc J. Defant, Department of Geology, University of South Florida, Tampa, FL 33620

Mark S. Drummond, Department of Geology, University of Alabama, Birmingham, AL 35294

A Penrose Conference, "The Origin and Emplacement of Low-K Silicic Magmas in Subduction Settings," was held September 25-30, 1992, in Chelan, Washington. The conference had 60 participants, including six graduate students. Participants came from 26 states and five countries and included petrologists (experimental and otherwise), field geologists, magma physicists, geochemists, and geophysicists. The diversity of opinion and perspective among the attendees was, in large part, responsible for the large success of the conference. The conference was cosponsored by the Virginia Museum of Natural History.

The conference included four days devoted to meetings and discussion and a one-day field trip to the Chelan migmatite complex. The first day was largely devoted to discussions of experimental petrology, day two to geochemistry, day three to field studies, geophysics, and magma physics, day four a field trip, and day five, the Archean. Each morning and afternoon session began with one or more talks designed to present an overview of the main topic for the day and to highlight specific issues. Posters were presented every afternoon. Most of the time was devoted to discussion.

The origin of adakites (aluminous, heavy REE-depleted, Sr-enriched, tonalitic-dacitic magmas) was a topic of great interest to most conference participants and the subject of spirited debate throughout the conference. It has been proposed that adakites form by melting of subducted oceanic crust. Melting of the deep crust has been proposed as an alternative explanation. The first presentations in the experimental petrology sessions demonstrated that it is the stability of amphibole in the subducted slab that dictates the conditions under which adakites may form by slab melting. Where the downgoing slab is hot, amphibole may undergo dehydration melting before it reaches its upper pressure-stability limit and slab melting will occur. New thermal models presented at the meeting confirm that slab melting can occur where very young, very hot, oceanic crust is being subducted, the tectonic setting common to many adakite occurrences. Where the downgoing slab is cold, amphibole will remain stable until its upper pressure-stability limit, where it will break down to anhydrous minerals plus a water-rich fluid phase. In this scenario, which pertains to most subduction zones, slab melting will not occur. It was generally agreed that slab melts should show some evidence of equilibration (or, at least, reaction) with mantle peridotite during ascent. Adakite-like volcanic rocks are also found in areas of over-thickened continental crust, such as the Andean high plateaus. These rocks appear to have formed by melting of crust at depths where garnet is stable. In the end, most participants agreed that adakite-type melts can and do form both by slab melting and by

melting in thickened crust. The task now is to distinguish between the two processes. This will require the recognition and chemical quantification of proposed interactions between slab melts and peridotite, an understanding of plagioclase stability (and its effects on Sr behavior) during vapor-absent melting of amphibolite at 10-30 kilobars, and an improved understanding of the low-pressure stability limits of garnet during vapor-absent melting of amphibolite. The interpretation of any given adakite as a slab melt will also hinge on the recognition of slab-derived chemical characteristics (e.g., detectable  $^{10}\text{Be}$ ). It was also pointed out that melts of the subducted slab are likely to be depleted in B relative to typical arc magmas.

The issue of the origin of Archean trondhjemite-tonalite-granodiorite (TTG) suites and the relevance (or lack thereof) of adakite for Archean petrogenetic models was discussed at length. It appears that mantle peridotite is involved in the genesis of some Archean TTG. This was shown in particularly striking fashion when the compositions of dehydration melts compiled from all available experimental studies were compared with Archean TTG compositions. This comparison clearly showed that Archean TTG are uniformly higher in Mg than the experimental melts, even those of high-Mg basaltic amphibolites. One alternative to a role for the mantle in Archean TTG petrogenesis might be the melting of komatiite. Experimental work is needed to test this possibility, as well as to examine a potential role for basalt-tonalite mixing in TTG petrogenesis. A testable model for the origin of Archean TTG now exists.

Other potential sources of low-K magmas in arcs were discussed. It was pointed out that boninites are the lowest of the low-K and are parental to some tonalites and dacites. Field studies in the Catalina Schist have documented the formation of trondhjemite melts by relatively low pressure, water-saturated melting of basaltic rocks in a subduction zone at the onset of subduction. As with boninites, the mantle wedge presumably provides the heat for this process, and a relatively cold slab provides the water. Experimental and geochemical work shows that low-K silicic magmas also form during dehydration melting of metabasites in the crust of the arc. Garnet and amphibole may or may not be stable during partial melting, depending on pressure, water content, degree of melting, and bulk composition. Under typical conditions of low water activity, garnet and amphibole will be stable only at mid-crustal pressures and above.

The role of fluids, especially water, during subduction and crustal melting also came under scrutiny. A lengthy discussion concluded with a consensus that little is known about the composition or physical characteristics of fluids generated by the descending slab, and this was suggested as an obvious area

for further work. Dehydration-melting experiments suggest temperatures for tonalite-dacite genesis in the crust of 800 °C or above, while metamorphic thermometry of migmatite terranes typically indicates temperatures below 800 °C. Naturally, experimentalists blamed the geothermometers while metamorphic petrologists suggested that involvement of free water in melting reactions might account for the low observed temperatures. It is likely that small amounts of water occur as fluid inclusions in even the most determinedly vapor-absent melting experiments. Experimentalists need to develop techniques to detect and analyze very low melt fractions during experiments and need to determine exactly what mechanisms are responsible for the formation of the first melt fraction. Metamorphic petrologists need to devise techniques to determine whether or not geothermometers are recording peak temperatures.

Several experimental and geochemical studies documented complex behavior during melting. It is becoming apparent that "fertility" of melt sources in the crust is a complex function of bulk composition, mineral composition, modal composition, and the interaction among different rock types that are in contact during melting. One striking study documented the mutual fluxing of juxtaposed tonalite and pelite. Experiments are beginning to quantify the effects of mineral composition on partition coefficients, while other work documented both equilibrium and nonequilibrium control of trace-element chemistry by accessory phases.

The mechanisms by which the heat necessary for partial melting is transferred to the crust during the underplating of basalt were discussed. Convective models for heat transfer are attractive because they tend to produce large-scale melting in the crust; one model produces a volume of silicic melt roughly equivalent to the amount of underplating basalt. It was argued, however, that this model requires superheating in the underplating basalt and that in nonsuperheated systems, heat transfer will evolve on conductive time scales, even if convection is occurring in the basaltic magma chamber.

The discussion above focuses attention on the question of the fraction of melt that can be effectively extracted from a system undergoing partial melting. Much of the experimental data presented indicated that geologically realistic silicic melts form at low degrees of partial melting. Likewise, some thermal models for crustal melting suggest relatively low melt fractions. A mathematical analysis of melt extraction suggests that the physically defined critical melt fraction (CMF) may not control melt extraction. Rather, once interconnectivity is established, at melt fractions far below the CMF, melt might be free to move about. In this model, melt pocket formation is controlled by crystallo-

graphy, and melt-crystal angles consistently are greater than 60°. This result suggests that the dihedral angles determined in experiments on rock powders may have limited applicability to natural systems. This analysis is supported by the observation that very low percentage melts formed during dehydration-melting experiments tend to pond or even to migrate through the charge. Deformation and diking will also facilitate the extraction of small melt fractions from partially melted systems.

Field studies presented throughout the conference pointed out the complexities involved in the generation and emplacement of silicic magmas within and beneath the crust. They served as sobering reminders that elegant experimental, physical, and geochemical models for low-K magma genesis must ultimately explain ground truth, which is generally not so clean and simple. The field trip to the Chelan migmatite complex illustrated the bewildering variety of mixing unmixing processes that occur in crustal MASH zones, and a study of melting in the Catalina Schist did the same for subduction complexes. Several participants noted that given these complexities, it is remarkable that the products of arc magmatism are so uniform.

The conveners thank all of the participants for their generosity in sharing new ideas and information and for generating the lively and uninhibited, yet collegial, discussion that made this conference a success. Particular thanks go to Cliff Hopson and Jim Mattinson for putting together and leading the field trip (and, coincidentally, dictating the choice of Chelan as a meeting site) and to Lois Elms and Mandy Brewer for an excellent job coordinating the myriad logistical details. Bob Kay's "sanukaphone" was instrumental in calling the proceedings to order. ■

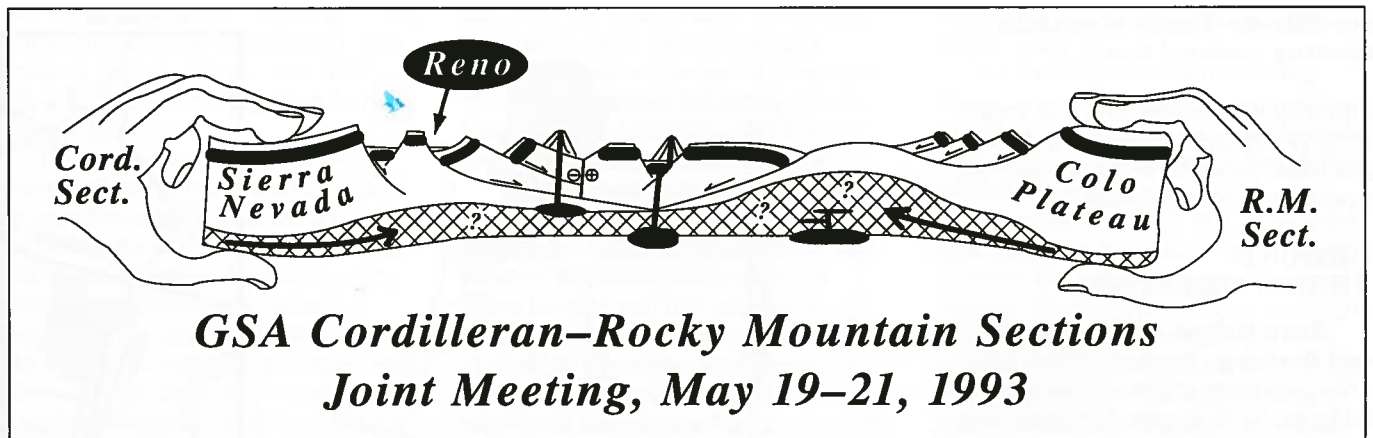
### Penrose Conference Participants

Fred Barker	Robert Kay
Calvin Barnes	Suzanne Kay
Andrew Barth	Peter Kelemen
James Beard	William Leeman
Paul Bedard	Herve Martin
George Bergantz	James Mattinson
Mark Bordelon	Calvin Miller
Alan Brandon	David Mogk
Michael D. Brown	Roger Nielsen
J. D. Clemens	Alberto Patino-Douce
Jon Davidson	Julian Pearce
William Davis	Robert Rapp
Ralph Dawes	Tracy Rushmer
Marc Defant	Edward Sawyer
Thomas Donnelly	Cuneyet Sen
Mark Drummond	Steven Silva
Frank Dudas	Krishna Sinha
Michael Dungan	Virginia Sisson
Owen Evans	Kjell Skjerlie
Mark Feigenson	Sorena Sorensen
Arthur Ford	Leeann Srogi
David Fountain	Jeffrey Tepper
Nathan Green	Alan Thompson
Anita Grunder	J. L. Vigneresse
Gilbert Hansen	Peter Weigand
Wes Hildreth	Joseph Whalen
Clifford Hopson	Donna Whitney
Donald Hyndman	Robert Wiebe
Kenneth Johnson	Michael Wolf
Dana Johnston	Peter Wyllie

**Final Announcement**

**CORDILLERAN  
and ROCKY  
MOUNTAIN  
SECTIONS, GSA  
Joint Meeting**

**Reno, Nevada  
May 19-21, 1993**



The Cordilleran and Rocky Mountain Sections of the Geological Society of America will meet jointly, together with the Pacific Coast and Rocky Mountain Sections of the Paleontological Society of America, at the Reno Hilton in Reno. The meeting is being hosted by the Department of Geological Sciences, University of Nevada, Reno, and the Department of Geosciences, Boise State University.

**RENO**

The meeting will be held at the Reno Hilton (formerly Bally's and the MGM Hotel), centrally located in Reno, with easy access to numerous restaurants and many casinos and resorts. Reno is situated in the Truckee Meadows, a Basin and Range valley between the Carson Range, a Sierra Nevada spur, on the west, and the Virginia Range to the east. Lake Tahoe, the largest freshwater alpine lake in North America, is a 45-minute drive to the southwest, and Donner Pass, on the Sierra crest, is 45 minutes west. Reno is close to a great variety of geologic features ranging in age from early Paleozoic to Holocene, including rocks of Paleozoic island-arc terranes and their basement, an early Mesozoic magmatic arc, the Cretaceous Sierra Nevada batholith, Tertiary volcanic and sedimentary rocks, Basin and Range structures, pluvial Lake Lahontan sediments, glacial deposits, and Holocene faults. Many of these features will be examined on field trips.

The weather in mid-May should be warm and springlike, with average daily temperatures in the upper 70s and overnight lows in the 40s. The area receives an average of about one inch of rain during the month of May. Travel to Reno is easy; Interstate 80 passes east-west through Reno and Sparks, just north of the Reno Hilton, and U.S. 395 runs north-south, immediately adjacent to the hotel. The Reno-Cannon International Airport is serviced by America West, American, Continental, Delta, Northwest, Reno Air, Skywest, Southwest, USAir, and United airlines.

**REGISTRATION**

**Preregister Today! Preregistration Deadline: April 7, 1993.**

1. Considerable savings in registration fees accompany preregistration. Advance registration is strongly suggested for special events and all field trips because of the limited

space available. Use the preregistration form included 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.

**Cancellations, Changes, Refunds.** All requests for registration **additions, changes, and cancellations** must be made in writing (faxes accepted) and received by April 14. **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—Reno Hilton Hotel**  
 Tues., May 18 2:00 p.m. to 8:00 p.m.  
 Wed., May 19 7:30 a.m. to 5:00 p.m.  
 Thurs., May 20 7:30 a.m. to 5:00 p.m.  
 Fri., May 21 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.

**REGISTRATION FEES**

	Advance*	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
Elementary and Secondary Teachers	\$10	N/A	\$10	N/A
Field Trip Nonregistrant	\$15	N/A	\$15	N/A

\*By 4/7/93

**ACCOMMODATIONS**

A block of rooms at the Reno Hilton, site of the meeting, has been reserved for attendees. A special reduced rate of \$75 (single or double occupancy) has been arranged. The Reno Hilton, which has recently been redecorated, is northern Nevada's largest convention facility and casino. It has dining and entertainment galore: Seven restaurants, two entertainment lounges, extensive gaming facilities, two movie theaters, a 2000-seat showroom with headliner entertainment, a 40-shop mall, health spas, indoor and outdoor tennis courts, and a 50-lane bowling center. **Reservations can be made by calling the Reno Hilton direct at 1-800-648-5080 or by filling out the Reno Hilton reservation form (below).**

For other accommodations call the Reno-Sparks Convention & Visitors Authority at 1-800-FOR-RENO or (702) 789-2129.

**STUDENT HOUSING**

A limited number of rooms at the Reno Hilton will be available to students, four persons to a room, at a rate of \$75 per room night. Students must make reservations through Berry Lyons, Department of Geological Sciences, University of Nevada, Reno, (702) 784-6465. Students must submit verification of student status (e.g., letter from Department Chairman) for all

four occupants of each room. First come, first served. GSA student members will be given preference.

**AIR TRAVEL**

GSA's official travel agent, Cain Travel Group, has negotiated excellent discounts with the major Reno carriers. Cain offers discounts of up to 40% on select airlines; some of these fares do not require staying through Saturday. Cain can also assist you with the special discounts and coupon offerings in your area. Book early; availability is limited.

**To make a reservation, call Cain Travel and identify yourself as a GSA traveler.** Tickets may be paid for by check (payable to Cain Travel), or by major credit card, or invoiced to your company. Final payment must reach Cain Travel no later than 10 days prior to departure to allow for mailing time. All tickets will be mailed unless requested otherwise. After tickets are issued, you are protected from fare increases; if a fare decreases, call Cain Travel for an adjustment, 1-800-346-4747 toll-free, (303) 443-2246 collect from outside U.S., fax 303-443-4485.

As with all airline reservations, please use caution regarding change and cancellation penalties that accompany low-fare tickets. This especially applies to field trip participants whose

**Cordilleran-Rocky Mountain Meeting continued on p. 40**

**Reno Hilton Housing Form  
GSA Cordilleran-Rocky Mountain Meeting**

May 19-21, 1993 • Q Name: GEO93

Please make reservations for \_\_\_\_\_ persons King bed  \$75.00

Name(s) \_\_\_\_\_ Room—2 double beds  \$75.00

Address \_\_\_\_\_ King—round bed  \$130.00

City/State \_\_\_\_\_ ZIP \_\_\_\_\_ One-bedroom suite  \$195-220

Telephone ( ) \_\_\_\_\_ Two-bedroom suite  \$290-315

Arrival Date \_\_\_\_\_ Arrival Time \_\_\_\_\_  Non-smoking room preferred.  
All requests subject to availability.

Departure Date \_\_\_\_\_ Credit Card # \_\_\_\_\_

Deposit Amount\* \$ \_\_\_\_\_ Expiration Date \_\_\_\_\_

(All rates subject to 9% Washoe Co. room tax, subject to change.) Name of card holder \_\_\_\_\_

\*One night's deposit or credit card is required to guarantee accommodations. Deposit is refundable if reservation is canceled 24 hours prior to ARRIVAL. Please send reservation and deposit at least 30 days prior to arrival.

Reservation requests received after **April 18, 1993** will be confirmed subject to room availability. Please note your estimated check-in time to ease your check-in procedure on arrival.

1. Check-out time is 12:00 noon; therefore, guest room may not be available until 3:00 p.m.
2. Please telephone changes to the Reservations Department at **1-800-648-5080.**
3. \$10.00 additional for 3rd person in room.
4. Confirmation of your reservation can be obtained by calling **1-800-648-5080.**

**Mail to: Reno Hilton  
2500 E. Second St.  
Reno, NV 89595  
1-800-648-5080  
(702) 789-2129**

**Cordilleran-Rocky Mountain Meeting** continued from p. 39

trips may be canceled after the April 7, 1993, preregistration deadline. Be sure you understand the restrictions on the type of ticket you purchase.

**GROUND TRANSPORTATION**

**Reno Hilton Airport Shuttle and Parking.** The Reno Hilton has a free airport shuttle that runs from 6:15 a.m. to 11:45 p.m. Unlimited free parking is available at the Reno Hilton.

**Rental Cars.** Rent your own car to tour Reno, Virginia City, Lake Tahoe, or Pyramid Lake (see map)! Rental cars will be provided at special convention rates (from \$31 to \$59 daily) by Avis, and these rates will be available from one week before to one week after the dates of the meeting. Should a lower qualifying rate become available, Avis will present a 5% discount on that rate. The attendee must use the assigned Meeting Avis Worldwide Discount (AWD) Number and meet Avis rate requirements to receive the discount. The Avis Worldwide Discount (AWD) number for our group is B571304. Reservations may be made by calling 1-800-331-1600.

**SPECIAL EVENTS AND ENTERTAINMENT**

Special Events requiring purchase will be available for purchase on the pre-registration form and, if space is still available, in the registration area at the meeting.

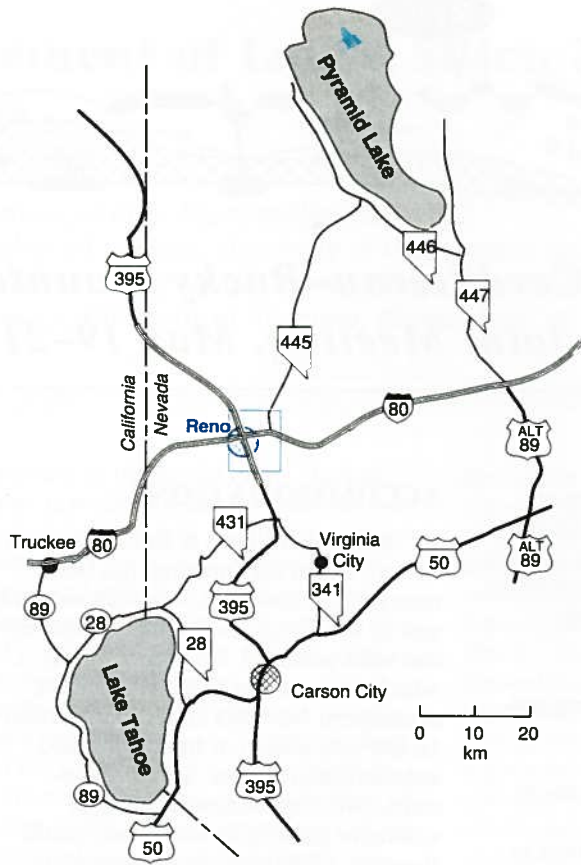
**Welcoming Party.** A welcoming party for all registrants will be held on Tuesday evening, May 18, from 7:30 to 9:00 p.m. in the Exhibits area in Goldwyn Ballroom. Hors d'oeuvres will be available with an accompanying cash bar. Registration for the meeting is required.

**Lake Tahoe Sunset Dinner Dance Cruise on the MS Dixie.** Wednesday, May 19; bus leaves at 5:15 p.m. from the Reno Hilton. Enjoy a magnificent Tahoe sunset, a cruise to Emerald Bay, and an evening of dining and sightseeing on Tahoe's original paddlewheeler. The *Dixie*, built in 1927, now features two enclosed heated decks, an open promenade deck for panoramic sightseeing and photography, a glass-bottom viewing window, two full-service bars, dance area, dining room, and a galley. Dinner includes New York steak or broiled Alaskan halibut served with all the trimmings and unlimited California wine throughout the meal. No tank tops or shorts are allowed, although dress is not strictly formal (coats and ties are not required). The cost includes the bus trip to Lake Tahoe. **An added attraction on the cruise: Guest speaker Dr. Marty Rose, Desert Research Institute, "Climatic, tectonic, and geomorphological significance of submerged 5 to 6,000-year-old forests in Lake Tahoe."** Cost: \$40. Limit: 125—Preregister early for this one!

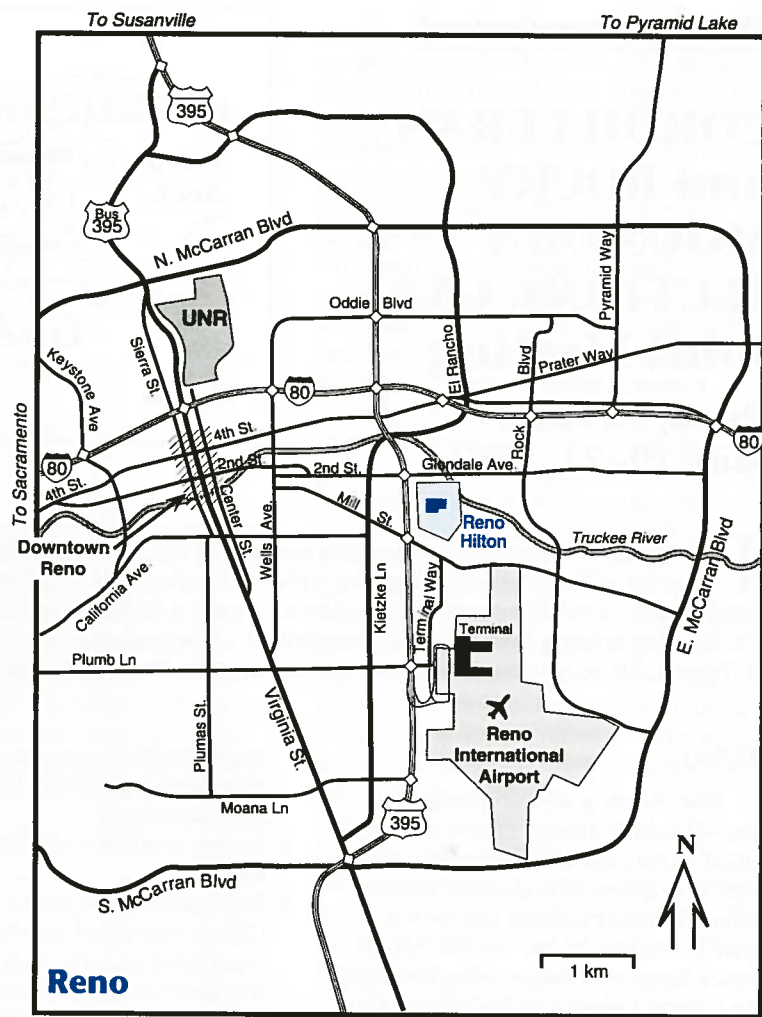
**Unwind and plan your evening at our cash bars.** Reno Hilton, 5:00 to 6:30 p.m., Wednesday and Thursday.

**Reno Hilton Buffet.** Join your friends at the Open Buffet, Wednesday evening, May 19, 6:30 to 8:30 p.m. Includes salads, hot entrees, dessert bar, coffee, tea, and milk. Cost: \$18.

**Open House at Mackay School of Mines, University of Nevada, Reno.** Thursday, May 20, 5:30 to 7:30 p.m., free wine, beer, hors d'oeuvres, and finger foods. Transportation to and from Reno Hilton beginning at 4:30.



Western Nevada



Reno

**Education Program Social Hour.** Reno Hilton, Thursday, May 20, 5:00 to 6:30 p.m., cash bar.

**Meeting: Friends of the Ordovician.** Reno Hilton, Thursday, May 20, 7:00 to 9:00 p.m.

**Ticketed Meal Functions. National Association of Geology Teachers Luncheon,** 12:00 noon, Wednesday, May 19. Cost: \$15.

**GSA Cordilleran Section Management Board Luncheon,** 12:00 noon, Wednesday, May 19. Cost: \$15.

**GSA Rocky Mountain Section Management Board Luncheon,** 12:00 noon, Wednesday, May 19. Cost: \$15.

**Cordilleran and Rocky Mountain Sections, Paleontological Society, Luncheon,** 12:00 noon, Thursday, May 20. Cost: \$15.

**GSA Rocky Mountain Section Business Meeting and Luncheon,** 12:00 noon, Thursday, May 20. Cost: \$15.

**Association for Women Geoscientists Luncheon,** 12:00 noon, Friday, May 21. Cost: \$15.

**GSA Cordilleran Section Business Meeting and Luncheon,** 12:00 noon, Friday, May 21. Cost: \$15.

**Coffee, Snacks, and Lunch.** Coffee, soft drinks, snacks, and a selection of sandwiches will be available at moderate cost in the Exhibits and Poster Display areas of the Goldwyn Ballroom. Free coffee will be provided at various times through the generosity of corporate donors. The Reno Hilton also houses several restaurants where lunch is available.

**FIELD TRIPS**

Field trips will be offered before, during, and after the meeting. Note that several one-day excursions are planned. Unless otherwise noted, all field trips will begin and end at the Reno Hilton. For further details about the trips, please contact the field trip leader listed first in the trip description. General questions should be addressed to Jim Trexler or Mary Lahren, Field Trip Coordinators, Department of Geolog-

ical Sciences, University of Nevada, Reno, NV 89557, (702) 784-1504 and (702) 784-6610, fax 702-784-1766; or Claude Spinosa, Department of Geosciences, Boise State University, Boise, ID 83725, (208) 385-1581, fax 208-385-4061.

Preregistration for all field trips is required. Participants will be accepted on a first-come, first-served basis through GSA headquarters. **Preregistration deadline is April 7, 1993.** The pre-registration form is provided in this announcement. Participants preregistering for a field trip *only* must pay a \$15 non-registrant fee in addition to the field trip charge. Codes for items included in trips are: B—breakfast, L—lunch, D—dinner, and ON—overnight lodging.

The cancellation deadline is April 14, 1993. No refunds will be given if cancellation is received after this date. All cancellations must be in writing. If GSA must cancel a trip, that cancellation will be announced by April 22, 1993. Full refunds will be issued after the meeting. Be aware of cancellation deadlines and possible penalties imposed by airlines. Also note that some trips that begin or end in Las Vegas provide airline tickets to Reno as part of the package.

**Field Trip Guidebook.** An extensive guidebook containing articles and road logs for all the trips will be published by the Department of Geological Sciences, University of Nevada, Reno. This guidebook will be included in the cost of all the field trips except for the shorter excursions and the field trips for teachers. The guidebook will also be sold at the meeting.

**Premeeting**

**1. Tertiary Extensional Tectonics and Basin Evolution, Northeast Nevada.** Saturday, May 15 (12:30 p.m.) through Tuesday, May 18 (6:00 p.m.). Karl Mueller, Dept. of Geology, University of Montana, Missoula, MT 59812, (406) 243-4684; Arthur Snoko, University of Wyoming, Laramie. Cost: \$239 (3 B, 3 L, 1 D, 3 ON). Trip begins and ends in Reno. Limit: 27.

Participants on this trip will examine synextensional strata in Tertiary basins along the northern margin of the Ruby-East Humboldt metamorphic

complex. We will visit well-exposed sequences of Eocene to Miocene strata in the Mary's River basin, Toano basin, and other adjacent areas to develop the history of half-graben development and low-to high-angle normal faulting in the region. The trip will be focused on examining facies architecture in these extensional basins and its relation to normal fault geometry and evolution. We will also outline a new model of overprinted, oppositely rooted, extensional fault systems which accommodates episodic Eocene to Pleistocene exhumation of the metamorphic complex. In addition, new <sup>40</sup>Ar/<sup>39</sup>Ar and fission-track ages of Tertiary strata will be presented to define the timing of half-graben development.

**2. Cenozoic Production of Intermediate Rocks by Magmatic Mixing in the Colorado River Extensional Corridor.** Saturday, May 15 (afternoon) through Tuesday, May 18 (evening). Rodney V. Metcalf, Eugene I. Smith, and James G. Mills, Dept. of Geoscience and Center for Volcanic and Tectonic Studies, University of Nevada, Las Vegas, NV 89154-4010. Cost: \$226 (\$287 including airfare to Reno) (3 L, 3 ON). Trip begins and ends in Las Vegas, with optional transportation to Reno. Limit: 28.

This trip will focus on the role of felsic-mafic magma mixing in the production of intermediate calc-alkalic rocks during Miocene extension. On Sunday evening, trip leaders will give a brief lecture presenting data in support of the magma mixing model and an overview of what will be seen on the trip. Participants will spend three days in the field examining hybrid intermediate rocks and mantle-derived mafic and continental-derived felsic end-member mixing components in both volcanic and plutonic environments. Two independent magma systems will be examined: (1) the Wilson Ridge pluton and cogenetic volcanic rocks of the River Mountains stratovolcano and Hoover Dam caldera; and (2) the Mount Perkins pluton. Two days of the trip will be devoted to examining field evidence of magma mingling and magma mixing within the two plutons. Participants

should be prepared for strenuous hikes over rugged terrain.

**3. Mesozoic(?) Contraction in Central Nevada: The Central Nevada Thrust Belt.** Saturday, May 15 (7:00 p.m.) through Tuesday, May 18 (5:00 p.m.). Wanda Taylor, Dept. of Geosciences, University of Nevada, Las Vegas, NV, 89154, (702) 597-4615; John Bartley, University of Utah; Joan Fryxell, California State University, San Bernardino; James Schmitt, Montana State University; Dirk Vandervoort, Cornell University. Cost: \$283 (\$212 if camping) (4 B, 4 L, 3 D, 4 ON). Space in motel for 23 only, first come, first served. Trip begins in Las Vegas and ends in Reno. Limit: 35.

The Mesozoic(?) Central Nevada thrust belt will be inspected in seven ranges between Alamo and Eureka. Thrusts, a duplex, a back-thrust zone, numerous folds, and the relations constraining their age will be examined. One age constraint is provided by the syn- to post-tectonic sediments of the Cretaceous Newark Canyon Formation that will be examined near Eureka. Emphasis will be placed on structural geometries, thrust correlations, along-strike extent of the contractile belt, time of deformation, and stratigraphic record of syntectonic basin development. Structural geometries and timing of contraction will be used to consider the relation of the Central Nevada thrust belt to the Elko and Sevier orogenic belts and the East Sierran thrust system.

**4. Devonian and Jurassic Volcano-plutonic Associations in the Northern Sierra Terrane: Implications for Arc Evolution and Mesozoic Deformation.** Sunday, May 16 (4:00 p.m.) through Tuesday, May 18 (5:00 p.m.). Richard Hanson, Dept. of Geology, Texas Christian University, Fort Worth, TX 76129, (817) 921-7996; Gary Girty, San Diego

State University; David Harwood, USGS, Menlo Park; Richard Schweickert, University of Nevada, Reno. Cost: \$237 (2 B, 2 L, 2 D, 2 ON). Begins and ends in Reno. Limit: 30.

The Northern Sierra terrane contains a well-preserved record of Paleozoic and Mesozoic island-arc activity. The Devonian part of the arc provides a tilted, cross-sectional view of a complete volcano-plutonic association, comprising the composite Bowman Lake batholith, linked hypabyssal intrusions, and coeval extrusive rocks of the Sierra Buttes Formation. The Jurassic part of the arc records a major pulse of Early and Middle Jurassic volcanism, closely associated with intrusion of voluminous Middle Jurassic plutonic rocks ranging in composition from peridotite to granite. We will compare and contrast the evolution of the Devonian and Jurassic arc systems and will examine evidence for timing of events, pluton-emplacment mechanisms, and the petrologic evolution of the intrusive rocks. Depositional environments and interactions between hypabyssal intrusions and wet sediments will be examined in the Devonian and Jurassic sequences. Spectacular field evidence for mingling and mixing of tonalitic and trondhjemitic magmas will be seen in the Bowman Lake batholith. We will also examine highly strained, andalusite- and sillimanite-grade dynamothermal aureoles formed during forceful emplacement of Jurassic plutons, and we will discuss relations between Middle Jurassic plutonism and regional deformation and metamorphism. Some stops will involve short hikes on rocky slopes.

**5. Jurassic to Cretaceous Transpressional Deformation of the Mesozoic Marine Province of the Northwestern Great Basin.** Saturday, May 15 (afternoon) through Tues-

day, May 18. John Oldow and Joseph Satterfield, Dept. of Geology and Geophysics, Rice University, Houston, TX 77251; Norman Silberling, USGS., Denver. Cost: \$305 (3 L, 3 D, 3 ON). Begins and ends in Reno. Limit: 40.

Recent studies of the Mesozoic tectonic evolution of the western United States have called for substantial transcurrent displacement between the Sierra Nevada and the western Great Basin. The location, timing, and sense of shear of the transcurrent fault system(s) are controversial, and to a large degree the controversy has centered on the Pine Nut fault of western Nevada. This three-day field trip will focus on the Mesozoic stratigraphic and structural relations of western Nevada and their bearing on late Mesozoic tectonism. The emphasis of the trip will be to document the structural juxtaposition of coeval rocks on the early Mesozoic marine province by far-traveled thrust and transcurrent fault systems. Stratigraphic aspects of the trip will concentrate on the biostratigraphic age control, sequence stratigraphic correlations, and facies relations of the coeval succession throughout the region. The structural component of the trip will address superposition relations among poly-phase structures and their implications for the kinematics of contractional and transcurrent faults. Short hikes will require sturdy boots.

**6. Three-dimensional Aspects of the Neogene Strain Field, Nevada-Utah-Arizona Tricorner Area.** Saturday, May 15 (meet between 4:00 and 6:00 p.m. at Las Vegas airport for transport to Mesquite, Nevada) through Tuesday, May 18. R. E. Anderson, USGS, Box 25046, Denver Federal Center, MS 966, Denver, CO 80225, (303) 273-8578; Robert Bohannon, USGS, Denver. Cost: \$300 (3 B, 3 L, 2 D, 3 ON) or \$380 (includes air fare from Las

Vegas to Reno). Begins and ends in Las Vegas. Limit: 32.

On this trip we will review the Neogene tectonic development of the Nevada-Utah-Arizona tricorner area at the margin of the Basin and Range in light of extensive geologic mapping, seismic reflection data, and newly compiled potential-field data. The trip will focus on the tectonic processes responsible for the formation of the basins and ranges in the area. We will visit three mountain masses adjacent to the Virgin River depression—the east Mormons, Beaver Dams, and Virgins—as well as drive through the spectacular Virgin Gorge, which occupies the structural saddle separating two of the mountain ranges. Evidence will be shown indicating that most of the major, northward-striking faults have significant components of strike-slip displacement, and that open to overturned folds are genetically and mechanically related to the strike-slip faults. We will present direct and indirect evidence that many of the major extensional faults are convex upward and that uplift and tilting of their footwall blocks is a prime factor in shaping the tectonic development of the region. The lateral extent, magnitude of displacement, and tectonic role of detachment faults will be evaluated. Evidence will be presented that previous estimates of large-scale extension should be revised downward, and that large (>10 km) vertical displacements are more closely associated with material transfer normal to extension than with isostatic adjustments to tectonic unloading.

**7. Stratigraphy of the Roberts Mountains Allochthon, Roberts Mountains and Shoshone Range, Nevada.** Sunday, May 16 (7:00 a.m.)

**Cordilleran-Rocky Mountain Meeting continued on p. 42**

## Preregistration Form

Preregistration deadline is April 7, 1993. Cancellation deadline is April 14, 1993

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## GSA Cordilleran and Rocky Mountain Sections Reno, Nevada • May 19-21, 1993

				COLUMN B
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<b>SPECIAL EVENTS &amp; TICKETED MEAL FUNCTIONS</b>				
Lake Tahoe Dinner Dance Cruise on MS Dixie	May 19	(56) \$ 40	\$ _____	
Reno Hilton Open Buffet	May 19	(60) \$ 18	\$ _____	
NAGT Luncheon	May 19	(61) \$ 15	\$ _____	
GSA Cordilleran Section Management Board Luncheon	May 19	(62) \$ 15	\$ _____	
GSA Rocky Mountain Section Management Board Luncheon	May 19	(63) \$ 15	\$ _____	
Cordilleran/Rocky Mtn. Sections Paleontological Society Lunch	May 20	(64) \$ 15	\$ _____	
GSA Rocky Mountain Section Luncheon	May 20	(65) \$ 15	\$ _____	
GSA Cordilleran Section Luncheon	May 21	(66) \$ 15	\$ _____	
Association of Women Geoscientists Luncheon	May 21	(67) \$ 15	\$ _____	
<b>FIELD TRIPS</b>				
1 Tertiary Extensional Tectonics & Basin Evolution, NE Nevada	May 15-18	(100) \$239	1 \$ _____	
2a Cenozoic Production, Colorado River Corridor	May 15-18	(101) \$266	1 \$ _____	
2b Cenozoic Production, Colorado River Corridor (with airfare)	May 15-18	(102) \$287	1 \$ _____	
3a Mesozoic(?) Contraction: Central Nevada Thrust Belt	May 15-18	(103) \$283	1 \$ _____	
3b Mesozoic(?) Contraction: Central Nevada Thrust Belt (camping)	May 15-18	(104) \$212	1 \$ _____	
4 Devonian & Jurassic Volcano-plutonic, N Sierra Terrane	May 15-18	(105) \$237	1 \$ _____	
5 Jurassic/Cretaceous Transpres. Def., NW Great Basin	May 15-18	(106) \$305	1 \$ _____	
6a Three-dimensional Aspects, Neogene Strain Field	May 15-18	(107) \$300	1 \$ _____	
6b Three-dimensional Aspects, Neogene Strain Field (with airfare)	May 15-18	(108) \$380	1 \$ _____	
7 Stratigraphy of Roberts Mountains Allochthon	May 16-18	(109) \$220	1 \$ _____	
8 Papoose Flat Pluton, Inyo Mountains	May 16-18	(110) \$200	1 \$ _____	
9 Geology of Lake Tahoe	May 20	(111) \$ 20	1 \$ _____	
10 Dikes in Donner Summit Pluton	May 21	(112) \$ 25	1 \$ _____	
11 Oligocene-Miocene Caldera Complexes, Great Basin	May 21-24	(113) \$210	1 \$ _____	
12 Tectonics of East-Central Sierra Nevada	May 21-24	(114) \$285	1 \$ _____	
13 Neogene Tectonism, SW Nevada-White Mtns	May 21-23	(115) \$215	1 \$ _____	
14 Neotectonics of Walker Lane: Pyramid Lake to Tonopah	May 22-24	(116) \$190	1 \$ _____	
15 Cenozoic Magmatism and Tectonism across Walker Lane	May 22-24	(117) \$210	1 \$ _____	
16a Structural Constraints, S. Great Basin	May 21-24	(118) \$270	1 \$ _____	
16b Structural Constraints, S. Great Basin (with airfare)	May 21-24	(119) \$310	1 \$ _____	
17 Comstock Lode, Nevada	May 22	(120) \$ 20	1 \$ _____	
18a Reno's Geologic Environment ..... K-6 Elementary Teachers	May 22	(121) \$ 15	1 \$ _____	
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## Cordilleran-Rocky Mountain Meeting *continued from p. 41*

through Tuesday, May 18 (7:00 p.m.). Sponsored by the Paleontological Society, Pacific Coast Section. Stanley Finney and Bruce Perry, Dept. of Geological Sciences, California State University, Long Beach, CA 90840, (310) 985-8637; Raul Madrid, Conquistador Gold, Ltd., Reno; Paul Emsbo, Colorado School of Mines. Cost: \$220 (3 B, 3 D, 3 ON). Begins and ends in Reno. Limit: 28.

On this trip we will examine the stratigraphy of the Roberts Mountains allochthon, especially the Ordovician Vinini and Valmy formations in the Roberts Mountains and the Shoshone Range, respectively. There will also be opportunities to examine the Roberts Mountains thrust and structural stacking in the allochthon. The stratigraphy, biostratigraphy, and sedimentology of the Vinini Formation in the Roberts Mountains will be examined closely. It records the deposition of a major submarine fan adjacent to North America during the Middle Ordovician, when most of the craton was subaerially exposed and extensively eroded. The resulting unconformity on the craton marks the boundary between the Sauk and Tippecanoe sequences of Sloss. We will examine the sequence boundary in an area of continuous deposition. Evidence will be presented for a North American provenance of quartz sands within the RMA, and there will be opportunities to collect graptolites and conodonts that are unusually well preserved and of great stratigraphic importance. Exposures in the Shoshone Range will provide the opportunity to compare and contrast the stratigraphies of the Vinini and Valmy formations. Special attention will be given to feldspathic sandstones in the Valmy, which had a western provenance, and pillow basalts that issued from fissures rather than from seamounts.

**8. Deformation Associated with Emplacement of the Papoose Flat Pluton, Inyo Mountains, Eastern California.** Sunday, May 16 through Tuesday, May 18. Richard Law and Sven Morgan, Geological Sciences, Virginia Tech., Blacksburg, VA 24061 (703) 231-6685; Art Sylvester, University of California, Santa Barbara; Clem Nelson, University of California White Mountain Research Station, Bishop, California; Matt Nyman, Univ. of Calgary, Alberta. Cost: \$200 (2 B, 2 L, 2 D, 2 ON). Begins and ends in Reno. Limit: 35.

This field trip will focus on the contrasting styles of deformation and emplacement on the western and eastern margins of the Papoose Flat pluton. While intense crystal plastic deformation and extreme stratigraphic attenuation of the late Proterozoic and Early Cambrian metasedimentary wall rocks are concentrated around the western margin of the pluton, the eastern margin is characterized by low strain states and hornfels textures. The relative importance of models involving forceful emplacement and/or regional tectonism put forward to explain the observed deformation styles will be discussed in the light of recent structural, microstructural, petrofabric, and metamorphic studies. The first day will be spent traveling from Reno to Westgard Pass and examining the sedimentary section where it is unaffected by intrusion and deformation. The second day will be spent on Papoose Flat examining the equivalent intensely deformed metasedimentary section in the aureole together with the underlying gneissose plutonic rocks on the western margin of the plu-

ton. The third day will be spent at the eastern margin.

## During Meeting

**9. Geology of Lake Tahoe.** Thursday, May 20, all day. Joseph Lintz, Dept. of Geological Sciences, University of Nevada, Reno, NV 89557-0138, (702) 784-6994. Cost: \$20 (1 L). Field trip guidebook volume optional at cost. Limit: 30.

This trip includes a circuit of Lake Tahoe by way of Carson City, Zephyr Cove, South Lake Tahoe, Tahoe City, and Truckee. We will begin at the Steamboat Springs geothermal area, and continue to Washoe Valley, where the Carson Range rises 4000 feet to the top of Slide Mountain. The Sierra Nevada batholith is rapidly degrading into Washoe Valley here, where major slides and debris flows have recently come down Slide Mountain. On U.S. Highway 50 crossing Spooner Summit, we will inspect some of the granodiorite bedrock in the Carson Range. The afternoon will be spent on glacial geology of the Tahoe basin, with discussions of the processes that formed Lake Tahoe. The trip returns to Reno via North Lake Tahoe, Truckee, and Verdi. The steep Truckee River canyon walls preserve thick sections of Neogene and Pleistocene volcanic rocks. Cost includes a copy of the section in the field trip guidebook pertaining to this trip. Spouses are welcome.

**10. Dikes in the Donner Summit Pluton.** Friday morning, May 21 (half day). Richard Schultz, Malcolm Hibbard, and Kathleen Ward, Dept. of Geological Sciences, University of Nevada, Reno, NV 89557-0138, (702) 784-4318. Cost: \$25 (coffee and donuts). Field trip guidebook volume optional at cost. Limit: 25.

Multiple generations of igneous dikes were injected into the partially molten Donner Summit pluton in northeastern California. These dikes record a complex sequence of both dilation and shear and document a mechanism of magma mingling that occurred in this pluton. Dikes consistently crosscut mafic igneous inclusions, or enclaves, that apparently were deformed before the episodes of dike emplacement into the granodiorite. Although numerous studies have documented geochemical and isotopic systematics associated with similar dikes in the Sierra Nevada Range and around the world, comparatively little is known about the kinematics, mechanics, and significance of the deformation recorded by these structures.

This half-day field trip will highlight some of the salient characteristics of the dikes and touch on their implications for late-stage igneous processes within the pluton. Exceptional exposures of both dikes and mafic inclusions occur between a frontage road and the South Yuba River at 6400' elevation. Outcrops are easily accessible. The field trip area is located near Donner Summit, about 1 hour's drive west of Reno. Cost includes a copy of the section in the field trip guidebook pertaining to this trip.

## Postmeeting

**11. Oligocene-Miocene Caldera Complexes, Ash-Flow Sheets, and Extensional Tectonism in the Great Basin.** Friday, May 21 (5:00 p.m.) through Monday, May 24. Myron Best and Eric Christiansen, Dept. of Geology, Brigham Young University, Provo, UT 84602, (801) 378-2340; Peter Rowley, Robert Scott, Sherman Grommé, and Ernie Anderson, USGS; Anne Harding, University of Colorado; Alan Deino, Berkeley Geochronology Center. Cost: \$210 (3 L, 3 ON). Begins in Reno, alternate end at Las Vegas or Reno. Limit: 24.

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Participants will see outflow tuff sheets and topographic walls, associated megabreccia deposits, and intracaldera tuff in Oligocene calderas in south-central Nevada and in early Miocene and middle Miocene calderas in southeastern Nevada. Some Miocene caldera formation was synchronous with major extensional and strike-slip faulting, and caldera margins are regional faults; one middle Miocene caldera has been offset several kilometres by a strike-slip fault. Participants can debate petrologic evolution of long-lived, compositionally zoned, crustal magma systems represented in very large (thousands of km<sup>3</sup>) deposits of intracaldera and extracaldera tuffs that have been correlated by precise <sup>40</sup>Ar/<sup>39</sup>Ar chronology, paleomagnetism, and petrographic and compositional properties. Participants will see the compositional transition in explosive Great Basin volcanism from rhyolite (>31 Ma) to dominantly dacite (31-27 Ma) to trachydacite (27-23 Ma) to dominantly rhyolite (<24 Ma) and peralkalic trachyte and rhyolite (middle Miocene).

**12. Tectonics of the East-Central Sierra Nevada—Saddlebag Lake and Northern Ritter Range**

**Pendants.** Friday, May 21 (5:00 p.m.) through Monday, May 24. Richard Schweickert and Mary Lahren, Dept. of Geological Sciences, University of Nevada, Reno, NV 89557, (702) 784-6901. Cost: \$285 (3 B, 3 L, 2 D, 3 ON). Begins and ends in Reno. Limit: 30.

Saddlebag Lake pendant, which lies along the eastern edge of the Sierra Nevada batholith, occupies a key tectonic position between the Antler and Sonoma orogenic belts in Nevada and the Western Metamorphic belt of the Sierra Nevada. Spectacular, glaciated exposures provide critical information on the extent and truncation of the Antler and Sonoma orogenic belts, the Triassic and Jurassic structural development of the region, the location of the Mojave-Snow Lake fault, implications for intrabatholithic breaks, and arc crustal evolution. On this field trip we will visit important localities near Tioga

Pass, and in Lundy, Virginia, and Robinson canyons, relating to Paleozoic and Mesozoic stratigraphy and structure, the Golconda thrust, the Lundy Canyon thrust, the Triassic Tioga Pass caldera, and Late Triassic plutons. At two stops we will examine rare outcrops of metaperidotite interpreted to be part of the Golconda allochthon. Various scenarios for eastern Sierra Nevada tectonics and models for the crustal evolution of the Mesozoic Sierran magmatic arc will be discussed. Be prepared for moderate hikes, some near 10,000 feet elevation, and probable partial snow cover. Viability of trip depends on 1993 Sierra Nevada snow-pack conditions.

**13. Neogene Tectonism from the Southwestern Nevada Volcanic Field to the White Mountains, California.** Friday, May 21 (5:00 p.m.) through Sunday, May 23 (9:00 p.m.). Edwin H. McKee, USGS, 345 Middlefield Road, Menlo Park, CA 94025, (415) 329-5477; Donald Noble and Steven Weiss, University of Nevada, Reno; Marith Reheis, USGS, Denver. Cost: \$215 (2 L, 2 ON double occupancy). Begins and ends in Reno. Limit: 22.

The first day will focus on the Miocene volcano-tectonic evolution of Gold Mountain-Slate Ridge and adjacent areas of southwestern Nevada. We will emphasize the use of marked variations in thickness and attitude of ash-flow sheets and of syntectonic erosion and intercalated clastic wedges to elucidate episodes of Northwest-directed Neogene extensional faulting and block uplift between Pahute Mesa and northernmost Death Valley. The second day will focus on late Cenozoic tectonics along the northern part of the Furnace Creek fault zone in southern Fish Lake Valley, California. We will examine upper Miocene-lower Pliocene sedimentary and interbedded volcanic rocks that predate and mark the onset of motion on the Furnace Creek fault zone, study a syntectonic Pliocene to middle Pleistocene wind gap and drainage system dismembered by motion on the fault zone and, time permit-

ting, see evidence for late Cenozoic low-angle normal faults.

**14. Neotectonics of the Walker Lane: Pyramid Lake to Tonopah, Nevada.** Saturday, May 22 (8:00 a.m.) through Monday, May 24 (7:00 p.m.). James Yount, USGS, Reno Field Office, Reno, NV 89557 (702) 784-5565; John Bell, Craig DePolo, Alan Ramelli, Nevada Bureau of Mines and Geology. Cost: \$190 (3 L, 2 D, 2 ON). Begins and ends in Reno. Limit: 30.

The Walker Lane is well known as a major northwest-trending topographic lineament that coincides with a broad zone of right-slip faults that deform Tertiary rocks from Honey Lake, California, to, perhaps, the vicinity of Las Vegas, Nevada. Less well known is that abundant historic and geologic evidence exists for continuing tectonic activity within the Walker Lane from the close of the Tertiary to the present day. This field trip will focus on morphologic and stratigraphic studies from specific fault systems within the central Walker Lane that best illustrate this recent tectonic activity. Stops will be made in some classic areas of young deformation, including the Pyramid Lake fault zone, the Olinghouse fault zone (a possible source for a magnitude 6.7 earthquake in 1869) and faults near Cedar Mountain (responsible for a magnitude 7.2 earthquake in 1932). Other areas to be examined include important north- and northeast-trending zones of Quaternary deformation that intersect the Walker Lane such as the Carson lineament and the Wabuska lineament east of Carson City, the Excelsior Mountain fault and the Benton Springs fault near Mina, and the faults along the northwest side of Lone Mountain, near Tonopah.

**15. Cenozoic Magmatism and Tectonism across the Walker Lane, Nevada.** Saturday, May 22 (7:00 a.m.) through Monday, May 24 (8:00 p.m.). David John, USGS, MS-901, Menlo Park, CA 94025, (415) 329-5424; John Dilles, Oregon State University; Richard Hardyman, USGS, Reno. Cost: \$210 (2 B, 3 L, 1 D, 2 ON). Begins and ends in Reno. Limit: 40.

This trip focuses on recently mapped late Cenozoic (late Oligocene to Holocene) igneous and structural features in the central Walker Lane and in the southern Stillwater Range, emphasizing the temporal relations between magmatism and faulting. For the first 1½ days, we will examine structural and stratigraphic features of the Stillwater caldera complex and the evidence for multiple periods of late Cenozoic extension in the southern Stillwater Range. The Stillwater caldera complex consists of three partly overlapping late Oligocene calderas and their subjacent granitic plutons that were tilted 40°–90° by early Miocene extensional faulting, thereby exposing cross sections of the upper crust as thick as 10 km. We will also see the scarp from the 1954 Dixie Valley earthquake. The afternoon of the second day will be spent on the east side of the Walker Lane in the Terrill Mountains looking at (1) a detachment fault probably related to northwest-striking Walker Lane-type strike-slip faults, and (2) an intrusive ash-flow tuff fissure vent. The third day will be spent in the northern Wassuk Range examining temporal relations between late Cenozoic strike-slip faults, normal faults, stratal tilting, and dike emplacement in this part of the central Walker Lane. Exposures document the evolution of fault styles temporally associated with Oligocene ignimbrites, Miocene andesites, the late Miocene Wassuk Group sedimentary rocks, and Quaternary sediments.

**16. Structural Constraints on Neogene Tectonism in the South-**

**ern Great Basin.** Friday, May 21 (5:00 p.m.) through Monday, May 24 (5:00 p.m.). Brian Wernicke, J. Kent Snow, Division of Geological and Planetary Sciences, Mail Code 170-25, California Institute of Technology, Pasadena, CA 91125, (818) 356-6192; Kip V. Hodges, Massachusetts Institute of Technology; J. Douglas Walker, University of Kansas. Cost: \$270 (\$310 including airfare to Las Vegas from Reno) (3 B, 3 L, 2 D, 3 ON). Trip begins and ends in Las Vegas. Limit: 33.

We will examine field relations critical to the amount and style of Neogene extensional and strike-slip faulting in the southern Great Basin. Day 1: Transect through crustal section exposed at Tucki Mountain, including deep exposures of the Panamint thrust-nappe complex and contrasting facies of Kingston Peak and Noonday formations. Day 2: Offset features along the Northern Death Valley–Furnace Creek fault zone, and components of the Last Chance allochthon exposed in the Racetrack Valley area. Day 3: Chicago Pass and Baxter thrusts in the Nopah and Resting Spring ranges, and discussion of correlation with the Panamint thrust. There will be two moderate to strenuous hikes.

**17. The Comstock Lode, Nevada.** Saturday, May 22 (all day). Donald Hudson, Consultant, 1540 Van Petten St., Reno, NV 89503, (702) 747-6027. Cost: \$20 (1 L). Begins and ends in Reno. Field trip guidebook volume optional at cost. Limit: 36.

This trip will focus on the geologic setting of the fabulous Comstock District, in and around Virginia City, Nevada. The emphasis will be on recent research on the three-dimensional zonation of hydrothermal alteration and mode of mineralization as well as the geochemical, structural, and stratigraphic setting of the district. Planned stops include surface exposures of the lodes and various zones of the hydrothermal alteration assemblage. Cost includes a copy of the section in the field trip guidebook pertaining to this trip.

**18. Reno's Geologic Environment: A Trip for K–6 Elementary School Teachers.** Saturday, May 22 (all day). Becky Weimer Purkey, Nevada Bureau of Mines and Geology, University of Nevada, Mailstop 178, Reno, NV 89557-0088, (702) 784-6691. Cost: \$15 for teachers; \$30 for professionals (1 L, materials). Begins and ends in Reno. Limit: 80.

Elementary school teachers and scout leaders are invited to participate in an all-day field trip featuring a variety of exciting geologic sites in the Reno area which can be incorporated into elementary school science field trip curricula and scout badge requirements. The field trip stops will feature Basin and Range faulting, geothermal energy, volcanic rocks, glacial deposits, landslides, and industrial and precious mineral deposits. Specific elementary exercises in rock and mineral identification and collection, use of topographic and geologic maps and aerial photos, and observation and data-collecting methods will be conducted at the stops. Related topics addressed during the day will include local geologic hazards, soil types, life zones, local mining history and the opening of the American West, and uses of local rocks and minerals in society. Bring cameras; wear sturdy walking shoes and appropriate attire for the out-of-doors. Low-cost daycare will be available at the University of Nevada, Reno campus; advance reservations are necessary.

**19. Western Nevada Geology for Secondary and Postsecondary Earth Science Teachers.** Saturday,

May 22 (all day). Thomas P. Lugaski, Mackay School of Mines, University of Nevada, Reno, NV 89557, (702) 784-6052, fax 702-784-1766; and Maureen Leshendok, University of Nevada, Reno. Cost: \$15 for teachers; \$30 for professionals (1 L, includes field guide for this trip, sample bags). Begins and ends in Reno. Limit: 40.

This field trip will highlight the late Tertiary and Quaternary geology of western Nevada in the vicinity of Reno. Participants will visit the remnants of both a Pliocene lake and Pleistocene Lake Lahontan, where they will have the opportunity to collect fossil fish, freshwater mollusc fossils, volcanic rocks, and assorted sedimentary rocks, including diatomite, oolites, oncolites, and tufa, as well as to examine the limnology and paleolimnology of the area. The trip will weave around the boundary of the Basin and Range and the Walker Lane, observing the tectonics, especially ancient and modern faults, their topographic expression, modern seismic hazard, and related mineralization. At issue throughout the day will be the effects of both irrigation and the current drought on this arid landscape. Bring cameras; wear sturdy walking shoes and appropriate attire for the out-of-doors. Low-cost daycare will be available at the University of Nevada, Reno campus; advance reservations are necessary.

## SYMPOSIA

Scheduled symposia and their conveners are:

**1. Stratigraphic Paleobiology: Analyzing Significant Biotic Trends in the Phanerozoic.** Mary Droser, University of California, Riverside, (714) 787-3797, fax 714-787-4324; Claude Spinosa, Boise State University.

**2. Basin and Range Seismic Hazard.** James Brune, University of Nevada, Reno, (702) 784-4975, fax 702-784-1766; John Anderson, University of Nevada, Reno.

**3. Influence of Magmatic and Tectonic Processes on the Formation of Hydrothermal Mineral Deposits (sponsored jointly by the Geological Society of Nevada).** Donald C. Noble, University of Nevada, Reno, (702) 784-6928, fax 702-784-1766; Eric Seedorff, Magma Copper, Ely, Nevada.

**4. Reconstruction of Pre-Cenozoic Sedimentary Basins, Western Colorado Plateau across the Great Basin.** John E. Marzolf, Southern Illinois University, (618) 453-3351, fax 618-453-7393.

**5. Cenozoic Magmatism in the Colorado River Extensional Corridor and Adjacent Areas.** Rodney V. Metcalf, University of Nevada, Las Vegas, (702) 739-3262, fax 702-597-4064; Eugene I. Smith and James Mills, University of Nevada, Las Vegas.

**6. Neogene Tectonism from the Southwestern Nevada Volcanic Field to the White Mountains, California.** Edwin H. McKee, USGS, Menlo Park, (415) 329-5477, fax 415-329-5490; Donald C. Noble and Steven I. Weiss, University of Nevada, Reno; Marith Reheis, USGS, Denver.

**7. Origin and Timing of Cenozoic Normal and Strike-slip Faulting in the Walker Lane and Adjacent Areas, Western Nevada.** John H. Dilles, Oregon State University, (503) 737-1245, fax 503-737-1200; David A. John, USGS, Menlo Park, and John S. Oldow, Rice University.

**Cordilleran–Rocky Mountain Meeting continued on p. 44**

## JOI/USSAC Distinguished Lecturer Series

The JOI/U.S. Science Support Program associated with the international Ocean Drilling Program is very pleased to announce the third annual JOI/USSAC Distinguished Lecturer Series. The speakers for the 1993–1994 season are:

**Sherman Bloomer, Boston University**

Early arc volcanism and the ophiolite problem: Evidence from ocean drilling in Western Pacific arcs and fore-arcs.

**Kathryn Gillis, WHOI**

Hydrothermal systems at mid-ocean ridges: A view of the crustal component by deep sea drilling.

**Roger Larson, University of Rhode Island**

The Mid-Cretaceous superplume episode and its geological consequences.

**David Rea, University of Michigan**

Terrigenous sediment delivery to the deep sea - A record of mountain uplift, climate change, or sea level?

**Brian Taylor, University of Hawaii**

The tectonic evolution of volcanic systems in island arcs and back-arc basins.

**James Zachos, UC Santa Cruz**

The early Cenozoic transition from a greenhouse to an icehouse world: A deep sea perspective.

JOI/USSSP funding will cover the speakers' travel expenses. The deadline for applications is April 2, 1993. For more information contact:

Mary Reagan  
Joint Oceanographic Institutions, Inc.  
1755 Massachusetts Ave., NW, Suite 800  
Washington, DC 20036  
phone (202) 232-3900, fax (202) 232-8203

## Cordilleran-Rocky Mountain Meeting continued from p. 43

### 8. Cenozoic Crustal Extension North of Snake River Plain.

David R. Lageson, Montana State University, (406) 994-3331, fax 406-994-6923; and David Rodgers, Idaho State University.

### 9. Latest Pleistocene and Holocene Surface Faulting, Basin and Range Province.

Craig DePolo and Alan Ramelli, Nevada Bureau of Mines and Geology, (702) 784-6691.

### 10. Magmatic Constraints on Basin and Range Evolution.

Allen F. Glazner, University of North Carolina, (919) 962-0689, fax 919-966-4519; Drew S. Coleman, University of Kansas, and William P. Leeman, Rice University.

### 11. Stratigraphy of the Roberts Mountains Allochthon.

Stanley C. Finney, California State University, Long Beach, (310) 494-8637, or 310-498-4809.

### 12. Reconstructing the Structural History of Basin and Range Extension Using Sedimentology and Stratigraphy.

Kathi Beratan, University of Pittsburgh, (412) 624-1408, fax 412-624-3914; and James Schmitt, Montana State University.

### 13. Constraints on Relative Motion between Mesozoic Batholiths and Cratonic North America in Cenozoic Time.

Brian P. Wernicke, California Institute of Technology, (818) 356-6192, fax 818-568-0935.

### 14. The Neogene of West-central Nevada.

James R. Firby, University of Nevada, Reno, (702) 784-6696, fax 702-784-1766; Howard E. Schorn, University of California, Berkeley.

### 15. National Association of Geology Teachers Symposium: The Importance of Geology to People.

Greg Wheeler, Sacramento State University, (916) 278-6337.

### 16. Geology Division of the Council on Undergraduate Research Poster Session for Undergraduate Research.

will be available for viewing for one-half day.

### 1. Tectonic Evolution of Northern California—Cape Mendocino to the Basin and Range.

David S. Harwood, USGS, Menlo Park, (415) 329-4932, fax 415-329-4936.

### 2. Undergraduate Research.

The Geology Division of the Council on Undergraduate Research will sponsor this special poster session. Posters must be written by student(s) only, although their preparation may be facilitated by professionals. Topic emphasis will focus on undergraduate research in any discipline of geology or such related fields as water resources, hydrology, or environmental science. General questions and comments should be addressed to Jill Schneiderman, Dept. of Geology, Pomona College, Claremont, CA 91711-6339, (714) 621-8555.

### 3. Techniques for Teaching Earth Science.

Bob Lawson, Washoe County School District, Reno, (702) 851-5640; Pat Cashman, University of Nevada, Reno, (702) 784-6924.

### 4. Alaskan Potpourri.

Dave Brew, USGS, Menlo Park, (415) 329-5726.

## THEME SESSIONS

### 1. Crustal Structure and Evolution of the Sierra Nevada

### 2. Block Tectonics and the Relation between Normal and Strike-slip Faulting in the Western United States

### 3. Paleomagnetism of the Great Basin

### 4. Geology of Yucca Mountain and Vicinity, Southern Nevada

### 5. Pennsylvanian-Permian Tectonics and Stratigraphy of Western North America; a Reassessment of the Continental Collision Model

### 6. Ultramafic and Mafic Rocks of Northern Alaska

### 7. Engineering Geology: Case Histories

## 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 trays 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 will be located in the Goldwyn Ballroom and will be open early, at 3:00 p.m., Tuesday, May 18, and will close at 8:00 p.m., Thursday, May 20. The cost of standard booths will be \$300 for commercial exhibitors and \$150 for educational and nonprofit institutions. For further information and space reservations, please contact Richard Schultz, Exhibits Coordinator, Dept. of Geological Sciences, University of Nevada, Reno, NV 89557, (702) 784-4318, fax 702-784-1766.

## STUDENT SUPPORT

The GSA Cordilleran and Rocky Mountain Sections have funds available for grants to support GSA Student Associates of the respective sections 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. Cordilleran Section Student Associates should send applications to Cordilleran Section Secretary Bruce A. Blackerby, Dept. of Geol-

ogy, California State University, Fresno, CA 93740, (209) 278-2955 (direct) or 278-3086 (department). Rocky Mountain Section Student Associates should send applications to Rocky Mountain Section Secretary Kenneth E. Kolm, Dept. of Geology and Geological Engineering, Colorado School of Mines, Golden, CO 80401, (303) 273-3800. Applications should include certification that the student is presenting a paper and is a GSA Student Associate of the Cordilleran Section or the Rocky Mountain Section. All letters must be received by March 15, 1993.

## EARTH SCIENCE EDUCATION PROGRAMS

Several special programs designed for teachers (K-12) and interested professionals are scheduled on Thursday afternoon and evening (May 20) during the meeting. The \$10 registration fee for teachers will be refunded when they attend the meeting. Two field trips specifically designed for teachers—one for teachers of grades K-6, and the other for teachers of grades 7-12—will be run on Saturday, May 22. Teachers will be able to go on the field trips at minimal cost because of a generous grant from the U.S. Geological Survey. For information on any of the earth science education programs, contact Patricia H. Cashman, Dept. of Geological Sciences, University of Nevada, Reno, NV 89557-0138, (702) 784-6924.

**A limited number of scholarships are available to enable out-of-state K-12 teachers to attend the meeting and a field trip.** These are funded by the GSA Cordilleran and Rocky Mountain sections, and by participating Earth Science Departments; for information, contact Michael Cummings, Dept. of Geology, Portland State University, Portland, OR 97207, (503) 725-3022, fax 503-725-3025, or Bill Nesse, Dept. of Earth Sciences, University of Northern Colorado, Greeley, (303) 351-2830, fax 303-351-1269.

**1. Workshop: Techniques for Teaching Earth Science.** This workshop, consisting of posters and demonstrations, will be presented by Master Teachers from the Washoe County School District and by earth science professionals. It will be held from 3:00 to 8:00 p.m. on Thursday, May 20, Reno Hilton, with the other poster sessions and exhibits. Coordinators: Bob Lawson, Science Coordinator, Washoe County School District, Reno, (702) 851-5640, and Patricia Cashman, University of Nevada, Reno, (702) 784-6924.

**2. Earth Science Theater.** Earth science teaching videos will be shown continuously from 8:00 a.m. to 10:00 p.m. on Thursday, May 20, Reno Hilton, in a room adjacent to the posters and exhibits. Handouts with information on the videos (including where to borrow or rent them for classroom use) will be available for teachers. Coordinator: Sue Marcus, USGS, Reno Field Office, (702) 784-5590.

**3. Workshop: Partners for Excellence.** This workshop on GSA's Partners for Excellence program will be held from 4:00 to 5:30 p.m. on Thursday, May 20, Reno Hilton. All interested teachers and professionals (whether or not they are currently participating in the Partners program) are invited to attend. The workshop will be hosted by Bill Nesse, University of Northern Colorado, (303) 351-2830, chairman of the Rocky Mountain Section Education Committee.

**4. Social Hour for Teachers and Professionals.** A social hour to encourage interaction between teachers and professional earth scientists attending the meeting will be held from 5:00

to 6:30 p.m. on Thursday, May 20, Reno Hilton. Everyone is invited; Partners for Excellence are particularly welcome!

**5. Open House, Mackay School of Mines, University of Nevada, Reno,** including tour of Mackay School of Mines Library, Thursday, May 20, 5:00 to 7:00 p.m.; teachers and educators welcome. Free refreshments and hors d'oeuvres. Transportation provided to and from Reno Hilton beginning at 4:30.

**6. National Association of Geology Teachers Symposium: The Importance of Geology to People,** 7:00 to 10:00 p.m., Thursday, May 20. Coordinator is Greg Wheeler, Sacramento State University, (916) 278-6337.

**7. Field Trips.** Two field trips specifically designed for teachers—one for teachers of grades K-6, and the other for teachers of grades 7-12—will be run on Saturday, May 22. Academic or in-service credit for the field trips is available for an additional fee. Teachers will be able to go on the field trips at minimal cost because of a generous grant from the U.S. Geological Survey. For more information about the field trips, see field trip descriptions 18 and 19 in the field trip section.

## GUEST PROGRAM

**Behind-the-Scenes Tour of Nevada Museum of Art, Arlington Gardens, and Reno Hilton.** Is there life beyond casinos? Come see the "other side" of Reno. The Truckee Meadows is a beautiful and diverse valley. Take this opportunity to take the pulse of this thriving locale from behind the scenes at the Hilton, lunch and shopping at the charming Arlington Gardens, and a docent-guided tour of the Nevada Museum of Art. Wednesday, May 19, 10:00 a.m. to 4:00 p.m. Cost: \$40, includes lunch.

**Historical Tour of Virginia City, Gold Hill Hotel, and Governor's Mansion.** You can't leave Nevada without seeing a real ghost town! Here's your chance. We'll start with a whirlwind tour of Virginia City (immortalized by Mark Twain in *Roughing It*) with an entertaining historical narrator, continue on to a gourmet lunch at the historic Gold Hill Hotel (which has a top-class French restaurant), then finish our day with a tour of the Governor's Mansion in Carson City. Can you really put a price on history? You bet your life! \$50, and that's no gamble. Thursday, May 20, 9:00 a.m. to 4:00 p.m.

**Spa Day at Walley's Hot Springs, Carson Valley.** At the end of an exciting week, take some time to rejuvenate. Come to elegant Walley's Hot Springs near historic Genoa, Nevada, and relax in the sauna, steam room mineral baths, and natural hot springs. While nourishing your soul, you can cleanse your body with a fresh, crisp, healthy salad from the extensive salad and juice bar. Bring a towel and your most comfortable swim suit. For an additional charge, you can have a professional full-body massage. All this and transportation too, for \$55. Friday, May 21, 9:00 a.m. to 4:00 p.m.

## GENERAL INFORMATION

Inquiries, additional information, special requests, and suggestions should be addressed to Richard A. Schweickert or Walter S. Snyder, meeting co-chairmen, Dept. of Geological Sciences, University of Nevada, Reno, NV 89557 (702) 784-6901, fax 702-784-1766 (Schweickert), and Dept. of Geosciences, Boise State University, Boise, ID 83725, (208) 385-3645, fax 208-385-4061 (Snyder). ■

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## GSA ANNUAL MEETINGS

### ■ 1993

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



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

Abstract Deadline: July 7

Preregistration Deadline: September 24

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

### ■ 1994

GSA Annual Meeting  
Seattle, Washington  
Washington State Convention and Trade Center  
October 24-27

Chairman: Darrel S. Cowan, University of Washington

**Call for Field Trip Proposals:** Please contact the field trip chairman—Donald A. Swanson, Department of Geosciences, University of Washington, Seattle, WA 98195, (206) 543-1190.

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

### ■ FUTURE

Boston	October 25-28	1993
Seattle	October 24-27	1994
New Orleans	November 6-9	1995
Denver	October 28-31	1996
Salt Lake City	October 20-23	1997

For general information on technical program participation (1993 or beyond) contact Sue Beggs, Meetings Manager, GSA headquarters.

## GSA SECTION MEETINGS

**South-Central Section, Texas Christian University, Fort Worth, Texas, March 15-16, 1993.** John A. Breyer, Department of Geology, P.O. Box 30798, Sid Richardson Building, Corner of Bowie and Cockrell, Texas Christian University, Ft. Worth, TX 76129-0001, (817) 921-7270. *Preregistration Deadline: February 19, 1993. Abstract deadline was November 20, 1992.*

**Northeastern Section, Sheraton Inn Conference Center, Burlington, Vermont, March 22-24, 1993.** Barry L. Doolan or Rolfe S. Stanley, Department of Geology, Perkins Geology Hall, University of Vermont, Burlington, VT 05405-0122, (802) 656-0247. *Preregistration Deadline: February 22, 1993. Abstract deadline was November 24, 1992.*

**North-Central Section, University of Missouri, Rolla, Missouri, March 29-30, 1993.** Richard D. Hagni, Department of Geology & Geophysics, 125 McNutt Hall, University of Missouri-Rolla, Rolla, MO 65401-0249, (314) 341-4616. *Preregistration Deadline: March 5, 1993. Abstract deadline was December 2, 1992.*

**Southeastern Section, Florida State Conference Center, Tallahassee, Florida, April 1-2, 1993.** James F. Tull, Department of Geology, B-160, Florida State University, Tallahassee, FL 32306-3026, (904) 644-1448. *Preregistration Deadline: March 5, 1993. Abstract deadline was December 7, 1992.*

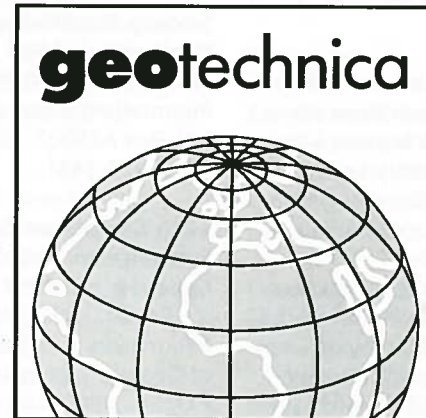
**Cordilleran and Rocky Mountain Sections, Reno Hilton (formerly Bally's Hotel), Reno, Nevada, May 19-21, 1993.** Richard A. Schweickert, Department of Geological Sciences, Mackay School of Mines, University of Nevada-Reno, Reno, NV 89557-0138, (702) 784-6050; or Walter S. Snyder, Department of Geosciences, Boise State University, Boise, ID 83725, (208) 385-3645, fax 208-385-4061. *Preregistration Deadline: April 23, 1993. Abstract deadline was January 26, 1993.*

### Student Travel Grants for Section Meetings

The GSA Foundation will award matching grants up to a total of \$3500 each to the six GSA Sections. The money, when combined with equal funds from the Sections, will be used to assist students traveling to the 1993 GSA Annual Meeting in Boston in October and to the 1993 Section meetings. Contact your Section secretary for application procedures.

Cordilleran	Bruce A. Blackerby	(209) 278-3086
Rocky Mountain	Kenneth E. Kolm	(303) 273-3800
North-Central	George R. Hallberg	(319) 335-1575
South-Central	Rena M. Bonem	(817) 755-2361
Northeastern	Kenneth N. Weaver	(410) 554-5503
Southeastern	Michael J. Neilson	(205) 934-2439

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## GSA Penrose Conferences

### February 1993

**Continental Tectonics and Magmatism of the Jurassic North American Cordillera**, February 27–March 4, 1993, Havasu City, Arizona. Information: Dave Miller, (415) 329-4923, and Dick Tosdal, (415) 329-5423, U.S. Geological Survey, 345 Middlefield Road, Menlo Park, CA 94025; or Bob Anderson, (604) 666-2693, Geological Survey of Canada, 100 West Pender Street, Vancouver, B.C. V6B 1R8, Canada.

### March 1994

**From the Inside and the Outside: Interdisciplinary Perspectives on the History of Earth Sciences**, March 1994, California. Information: Leo F. Laporte, Dept. of Earth Sciences, University of California, Santa Cruz, CA 95064, (408) 459-2248, fax 408-459-3074; Naomi Oreskes, Dept. of Earth Sciences, Dartmouth College, Hanover, NH 03755, (603) 646-2373; Kenneth L. Taylor, Dept. of the History of Science, University of Oklahoma, Norman, OK 73019-0315, (405) 325-2213.

## 1993 Meetings

### February

**Geologic Remote Sensing, 9th Thematic Conference**, Exploration,

Environment, and Engineering, February 8–11, 1993, Pasadena, California. Information: ERIM/Thematic Conferences, Nancy J. Wallman, P.O. Box 134001, Ann Arbor, MI 48113-4001, (313) 994-1200, ext. 3234, fax 313-994-5123.

**Earthquake Engineering Research Institute 45th Annual Meeting**, February 11–13, 1993, Seattle, Washington. Information: EERI, 499 14th St., Suite 320, Oakland, CA 94612-1902, (510) 451-0905, fax 510-451-5411.

**Society for Mining, Metallurgy, and Exploration 1993 Annual Meeting**, February 15–18, 1993, Reno, Nevada. Information: Meetings Department, SME, P.O. Box 625002, Littleton, CO 80162, (303) 973-3461.

**12th Caribbean Geology Annual Symposium**, Geology of Puerto Rico, Genesis of an island arc terrane, February 24–28, 1993, Mayagüez, Puerto Rico. Information: J. H. Schellekens, Department of Geology, University of Puerto Rico, P.O. Box 5000, Mayagüez, Puerto Rico 00681-5000; phone/fax (809) 265-3845.

### March

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

**Lunar and Planetary Science 24th Annual Conference**, March 15–19, 1993, Houston, Texas. Information: 24th LPSC, Lunar and Planetary Institute, 3600 Bay Area Blvd., Houston, TX 77058-1113, (713) 486-2166.

**Michigan Geological Survey Division Symposium**, Michigan: Its Geology and Geologic Resources, March 18–19, 1993, East Lansing, Michigan. Information: Carol L. Skillings, Dept. of Natural Resources, Geological Survey Division, Box 30028, Lansing, MI 48909-7258, (517) 334-6976.

**GSA Northeastern Section Meeting**, March 22–24, 1993, Burlington, Vermont. Information: Barry L. Doolan or Rolfe S. Stanley, Dept. of Geology, University of Vermont, Burlington, VT 05405-0122, (802) 656-0247.

**Society for Industrial and Applied Mathematics**, Sixth Conference on Parallel Processing for Scientific Computing, March 22–24, 1993, Norfolk, Virginia. Information: SIAM Conference Coordinator, 3600 University City Science Center, Philadelphia, PA 19104-2688, (215) 382-9800, fax 215-386-7999, E-mail: meetings@siam.org.

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

**Prospectors and Developers Association of Canada International Convention**, March 28–31, 1993, Toronto, Ontario, Canada. Information: Rita Plaskett, Prospectors and Developers Association of Canada, 74 Victoria St., Suite 1002, Toronto, Ontario M5C 2A5, Canada, (416) 362-1969, fax 416-362-0101.

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

### April

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

**Computer Simulated Mineral Exploration 22nd Workshop**, April 1–30, 1993, 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, fax (33 1) 64 69 47 01, telex 694 736 F.

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

**Mantle Composition, Structure, and Processes Workshop**, April 4–8, 1993, Soda Springs, California. Send letters of application by Sept. 30, 1992, to: Jane E. Nielson, U.S. Geological Survey, MS 975, 345 Middlefield Rd., Menlo Park, CA 94025, (415) 329-4948, fax 415-329-4936; or B. Carter Hearn, Jr., U.S. Geological Survey, 959 National Center, Reston, VA 22092, (703) 648-6768, fax 703-648-6789.

**Mechanisms of Deformation and Failure in Rocks and Ceramics**, April 12–16, 1993, San Francisco, California. Information: Joanne Fredrich, TerraTek, Inc., University Research Park, 420 Wakara Way, Salt Lake City, UT 84108, (801) 584-2487, fax 801-584-2432.

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

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

**Application of Geophysics to Engineering and Environmental Problems (SAGEEP), 6th Annual Symposium**, April 18–21, 1993, San Diego, California. Information: Mark Cramer, ExpoMasters, 7632 E. Costilla Ave., Englewood, CO 80112, (303) 771-2000, fax 303-843-6232.

**Society for Industrial and Applied Mathematics**, Conference on Mathematical and Computational Issues in the Geosciences, April 19–21, 1993, Houston, Texas. Information: SIAM Conference Coordinator, 3600 University City Science Center, Philadelphia, PA 19104-2688, (215) 382-9800, fax 215-386-7999, E-mail: meetings@siam.org.

**Operationalization of Remote Sensing International Symposium**, April 19–23, 1993, Enschede, The Netherlands. Information: J. L. van Genderen, ITC, P.O. Box 6, 7500 AA Enschede, The Netherlands, phone 31-53-874 254, fax 31-53-874 436, telex 44525 itc nl.

**Geoscience Education and Training International Conference**, April 20–24, 1993, Southampton, England. Information: Dorrik A.V. Stow or Esther Johnson, Dept. of Geology, University of Southampton, Southampton, SO9 5NH, England, phone 0703-593049, fax 0703-593052, telex: 47662 SOTONU G.

**Petroleum Source Rocks: Formation, Diagenesis and Expulsion**, April 25–29, 1993, Calgary, Alberta, Canada. Information: Hans Wielens, Unocal Canada Exploration Ltd., Box 2120, Calgary, Alberta T2P 2M4, Canada, (403) 268-0370, fax 403-268-0101; or Marc Bustin, Department of Geological Sciences, University of British Columbia, Vancouver, B.C. V6T 1Z4, Canada, (604) 822-6179, fax 604-822-6088; Steve Calvert, Department of Oceanography, University of British Columbia, Vancouver, B.C. V6T 1Z4, Canada, (604) 822-5210, fax 604-822-6091.

### May

**National Earthquake Conference**, May 3–5, 1993, Memphis, Tennessee. Information: 1993 NEQC, c/o CUSEC, 2630 E. Holmes Rd., Memphis, TN 38118-8001, (901) 345-0932, fax 901-345-0998.

**Pacific Sections 1993 Convention**, American Association of Petroleum Geologists, SEPM, Society of Exploration Geophysicists, Association of Engineering Geologists, Society of Petroleum Well Log Analysts, Society of Core Analysts, and American Institute of Professional Geologists, May 5–7, 1993, Long Beach, California. Information: Don Clarke, City of Long Beach—Department of Oil Properties, 333 West Ocean Blvd., Long Beach, CA 90802, (310) 590-6084.

**GEOTECHNICA 1993, International Trade Fair and Congress for Geosciences and Technology**, May 5–8,

## Short-Course Series

### Principles and Applications of MODFLOW

March 23-26, 1993

Instructors:

**Peter F. Andersen and Robert M. Greenwald (Geo Trans, Inc.)**

This course focuses on the use of the U.S.G.S. Three-Dimensional Finite-Difference Ground-water Flow Model MODFLOW and its accompanying programs. Lectures on the principles of ground-water flow modeling and the use of MODFLOW will be complemented by hands-on computer sessions during which participants will work through a series of real-world problems.

For more information contact the IGWMC.

international ground water modeling center  
**igwmc**

Institute for Ground-Water Research and Education  
Colorado School of Mines  
Golden, Colorado 80401-1887  
Phone: (303) 273-3103  
FAX: (303) 273-3278

## ROCK AND MINERAL AUCTION

### GSA North-Central Section Meeting—Rolla, Missouri

The C. L. Dake Geological Society at the University of Missouri–Rolla, will hold a rock and mineral auction at the GSA North-Central Section Meeting in Rolla, on Sunday, March 28, for early registrants. The auction will be held in Centennial Hall at the University of Missouri–Rolla beginning at 4:00 p.m. Everyone is invited to participate in the purchase of specimens. If you wish to sell specimens, you should register a maximum of five lots between 11:00 a.m. and 3:00 p.m. Questions should be addressed to Shawn Williams, President of the Dake Geological Society, Department of Geology and Geophysics, University of Missouri–Rolla, Rolla, MO 65401. This highly successful and pleasant auction has been held annually for the last 20 to 25 years. Come and participate.

1993, Cologne, Germany. Information: KölnMesse, Messe- und Ausstellungs-Ges.m.b.H. Köln, Messeplatz 1, Postfach 21 07 60, W-5000 Köln 21, Germany, phone (0)2 21/821-0, fax (0)2 21/821-25 74, telex 8 873 426 mua d.

**USA/CIS Second Joint Conference on Environmental Hydrology and Hydrogeology**, Industrial and Agricultural Impacts on the Hydrologic Environment, May 15–21, 1993, Arlington, Virginia. Information: American Institute of Hydrology, 3416 University Ave. S.E., Minneapolis, MN 55414-3328, (612) 379-1030, fax 612-379-0169.

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

**GSA Cordilleran-Rocky Mountain Section Meeting**, May 19–21, 1993, Reno, Nevada. Information: Richard A. Schweickert, Dept. of Geological Sciences, Mackay School of Mines, University of Nevada, Reno, NV 89557-0138, (702) 784-6050; or Walter S. Snyder, Dept. of Geosciences, Boise State University, Boise, ID 83725, (208) 385-3645, fax 208-385-4061.

**Midwest Friends of the Pleistocene**, May 21–23, 1993, Sturgeon Bay, Wisconsin. Information: Allan F. Schneider, Dept. of Geology, University of Wisconsin—Parkside, Box 2000, Wood Road, Kenosha, WI 53141, (414) 595-2439.

**American Geophysical Union Spring Meeting**, May 24–28, 1993, Baltimore, Maryland. Information: AGU—Meetings Department, 2000 Florida Avenue, N.W., Washington, DC 20009, (202) 462-6900, fax 202-328-0566, E-mail: dsolomon@kosmos.agu.org. (Abstract deadline: March 4, 1993.)

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

**American Society of Limnology and Oceanology, Society of Wetland Scientists, Society of Canadian Limnologists, Joint Annual Meeting**, May 30–June 3, 1993, Edmonton, Alberta, Canada. Information: Marcel Ouellet, Institut National de la Recherche Scientifique, 2700 rue Einstein, P. Box 7500, Sainte-Foy, Québec, (418) 654-2631, fax 418-654-2562.

**June**

**Case Histories in Geotechnical Engineering Third International Conference**, June 1–6, 1993, St. Louis, Missouri. Information: Shamsher Prakash, Conference Chairman, University of Missouri—Rolla, Rolla, MO 65401-0249, (314) 341-4489, fax 314-341-4729.

**Global Aspects of Coral Reefs: Health, Hazards, and History**,

June 7–10, 1993, Coral Gables, Florida. Information: Global Reef Meeting, University of Miami/RSMAS, 4600 Rickenbacker Causeway, Miami, FL 33149-1098, fax 305-361-4632.

**Geology and Confinement of Toxic Wastes International Symposium**, June 8–11, 1993, Montpellier, France. Information: Michel Barrès, BRGM—Département "Environnement," BP 6009, 45060 Orleans Cedex, France, phone 33-38 64 34 14, fax 33-38 64 30 13, Telex BRGM 780 258 F.

■ **Maine Mineral and Geological Society 10th Annual Gem, Mineral and Fossil Show**, June 12–13, 1993, Portland, Maine. Information: Gerry Bates, P.O. Box 2333, South Portland, ME 04116-2333.

■ **Rapid Excavation and Tunneling 11th Conference**, June 13–17, 1993, Boston, Massachusetts. Information: Meetings Department, SME P.O. Box 625002, Littleton, CO 80162, (303) 973-9550, fax 303-979-3461.

**Rock Mechanics 34th U.S. Symposium**, June 27–30, 1993, Madison, Wisconsin. Information: Bezalel C. Haimson, Dept. of Materials Science and Engineering, 1509 University Avenue, Madison, WI 53706, (608) 265-3021, fax 608-262-8353, E-Mail: haimson@macc.wisc.edu.

**NATO Advanced Study Institute on Feldspars and Their Reactions**, June 29–July 10, 1993, Edinburgh, Scotland. Information: Ian Parsons, Dept. of Geology & Geophysics, University of Edinburgh, Edinburgh, EH9 3JW, UK, fax 44-31-668-3184.

**July**

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

**Society for Industrial and Applied Mathematics**, Annual Meeting, July 12–16, 1993, Philadelphia, Pennsylvania. Information: SIAM Conference Coordinator, 3600 University City Science Center, Philadelphia, PA 19104-2688, (215) 382-9800, fax 215-386-7999, E-mail: meetings@siam.org. (Abstract deadline: February 5, 1993.)

**Geological and Landscape Conservation International Conference**, July 17–24, 1993, Great Malvern, United Kingdom. Information: D. O'Halloran, JNCC, City Road, Peterborough, PE1 1JY, UK, phone 0733-62626, fax 0733-893 971.

**10th International Clay Conference**, July 18–23, 1993, Adelaide, Australia. Information: Conference Secretariat, Ellisservice Convention Management, P.O. Box 753, Norwood, SA 5067, Australia, phone +61.8.332.4068, fax +61.8.364.1968.

**August**

**Intraplate Volcanism International Workshop**, The Polynesian Plume Province, August 1993, Tahiti, French Polynesia. Information: Workshop Tahiti 1993 Organization Committee, H.G. Barszczus, Centre Géologique et Géophysique, Case 060, Université de Montpellier II, 34095 Montpellier

Cedex 5, France, phone 33-67-634-983, fax 33-67-523-908.

■ **Hydrometallurgy—Milton E. Wadsworth International Symposium**, August 1–5, 1993, Salt Lake City, Utah. Information: Meetings Department, SME, P.O. Box 625002, Littleton, CO 80162, (303) 973-9550, fax 303-979-3461.

**Geochemistry of the Earth Surface 3rd International Symposium**, August 1–6, 1993, University Park, Pennsylvania. Information: Lee Kump, Dept. of Geosciences, Pennsylvania State University, 210 Deike Bldg., University Park, PA 16802, (814) 863-1274, fax 814-865-3191.

**Belt Symposium III: Field Conference on New Geologic Perspectives of the Middle Proterozoic Belt-Purcell Basin**, August 14–21, 1993, Whitefish, Montana. Information: Belt Symposium III, c/o Western Experience, Inc., 4881 Evening Sun Lane, Colorado Springs, CO 80917.

**Carboniferous to Jurassic Pangea: A Global View of Environments and Resources**, August 15–19, 1993, Calgary, Alberta, Canada. Cosponsored by the Canadian Society of Petroleum Geologists and the Global Sedimentary Geology Program. Information: Benoit Beauchamp or Ashton Embry, Geological Survey of Canada, 3303 33rd St. NW, Calgary, Alberta T2L 2A7, Canada, (403) 292-7126, fax 403-292-4961.

**Mine Design International Congress**, Mining into the 21st Century, August 23–26, 1993, Kingston, Ontario, Canada. Information: Peter Scott, Public Relations, ICMD/Relations publiques, CICM, Depart-

ment of Mining Engineering/Département de génie minier, Queen's University/Université Queen's, Kingston, Ontario K7L 3N6, Canada, (613) 545-2212, fax 613-545-6597.

■ **Hydrothermal Reactions Fourth International Symposium**, August 31–September 3, 1993, Nancy, France. Information: 4th ISHR, CREGU, BP-23, 54501-Vandoeuvre-lès-Nancy Cedex, France, telex: 960934, fax (33).83.44.00.29, E-mail: internet CREGU ciril.fr, or FRciil71.bitnet.

**September**


■ **Coal Science 7th International Conference**, September 12–17, 1993, Banff, Alberta, Canada. Information: David Brown, P.O. Bag 1280, Devon, Alberta T0C 1E0, Canada, (403) 450-5200, fax 403-987-3430.

**Fractography, Geological Society of London Thematic Meeting**, September 13–14, 1993, London, United Kingdom. Information: M. S. Ameen, GeoScience Limited, Silwood Park, Buckhurst Road, Ascot SL5 7QW, UK, phone 0344 872220, fax 0344 872438.


**WORLDTECH I, International Congress on Mining Development**, September 15–17, 1993, Philadelphia, Pennsylvania. Information: Meetings Department, SME, P.O. Box 625002, Littleton, CO 80162, (303) 973-9550, fax 303-979-3461.

**Andean Geodynamics 2nd International Symposium**, September 21–23, 1993, Oxford, England. Information: P. Soler, ISAG 93, ORSTOM, CS1, 213 rue Lafayette, 75480 Paris Cedex 10, France,

Meetings continued on p. 48



The Geological Society of America



## Congressional Science Fellowship 1993–1994

**T**he Geological Society of America is accepting applications for the 1993–1994 Congressional Science Fellowship. The Fellow selected will spend a year (September 1993–August 1994) in the office of an individual member of Congress or a congressional committee for the purpose of contributing scientific and technical expertise to public policy issues and gaining firsthand experience with the legislative process. The American Association for the Advancement of Science conducts an orientation program to assist the Fellow seeking a congressional staff position in which he or she can work on major legislative issues.

**Criteria**

The program is open to highly qualified earth scientists in early or mid-career. Candidates should have exceptional competence in some area of the earth sciences, cognizance of a broad range of matters outside the

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

**Award**

The GSA Congressional Science Fellowship carries with it a \$38,000 stipend, and limited health insurance, relocation, and travel allowances. The fellowship is funded by GSA and by a grant from the U.S. Geological Survey. (Employees of the USGS are ineligible to apply for this fellowship. For information about other programs, contact AAAS or the Geological Society of America.)

**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 16, 1993



*The Geological Society of America*

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**APPLICATION FOR EMPLOYMENT MATCHING SERVICE**  
(Please type or print legibly with black ink)

TITLE Dr.  Mr.  Ms.  Mrs.  Miss

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

ORGANIZATION \_\_\_\_\_

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

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

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

<p><b>EXPERIENCE</b> Must use specialty codes listed below. Choose three that best describe your expertise in order of importance.</p> <p>1. _____ 2. _____ 3. _____</p>	<p><b>PRESENT SPECIALTY</b> Choose one from codes listed below _____</p> <p><b>YEARS EXPERIENCE IN THIS SPECIALTY</b> _____</p>
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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 \_\_\_\_\_

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.

<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>	

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  
 American Express or Optima

Card Expires Mo/Yr \_\_\_\_\_ Card Number \_\_\_\_\_ Signature \_\_\_\_\_ Date \_\_\_\_\_  
 Required for credit card payment

I agree to release GSA or their representatives from responsibility for errors that may occur in processing or distributing these 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 \_\_\_\_\_

# 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 25-28 for the 1993 GSA Annual Meeting in Boston, Massachusetts.

To register, complete the application form on this page, 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 September 1, 1993. If we receive your materials by September 1, 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!

**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.**

## ← APPLICANT FORM

**Meetings** continued from p. 47

fax 33-1 48 03 08 29. (Abstract deadline: April 1, 1993.)

**International Association of Volcanology and Chemistry of the Earth's Interior (IAVCEI) General Assembly**, Ancient Volcanism and Modern Analogues, September 25-October 1, 1993, Canberra, Australia. Information: IAVCEI General Assembly, Acts, GPO Box 2200, Canberra, ACT 2601, Australia, phone +61 6 2573299, fax +61 6 2573256.

**Global Boundary Events** (Interdisciplinary Conference of IGCP Project 293, Geochemical Marker Events in the Phanerozoic), September 27-29, 1993, Kielce, Poland. Information: Barbara Studencka, Muzeum Ziemi PAN, Al. Na Skarpie

20/26, 00-488 Warszawa, Poland, phone (4822) 217 391, fax (4822) 297-497; or Helmut H.J. Geldsetzer, Geological Survey of Canada, 3303 33rd St. N.W., Calgary, Alberta T2L 2A7, Canada, (403) 292-7155, fax 403-292-5377.

**Accelerator Mass Spectrometry 6th International Conference**, September 27-October 1, 1993, Canberra and Sydney, Australia. Information: AMS-6, ACTS, GPO Box 2200, Canberra ACT 2601, Australia, phone 61-6-249 8105, fax 61-6-257 3256.

**October Basin Inversion International Conference**, October 4-9, 1993, Oxford, England. Information: Peter Buchanan, CogniSeis Development, Stanley House, Kelvin Way, Crawley, West Sussex, RH10 2SX, UK. (Abstract deadline: April 1993).

**Society for Organic Petrology 10th Annual Meeting**, October 9-13, 1993, Norman, Oklahoma. Information: Brian Cardott, Oklahoma Geological Survey, 100 E. Boyd St., Rm. N-131, Norman, OK 73019-0628, (405) 325-3031, fax 405-325-7069.

**International Association for Mathematical Geology**, October 10-15, 1993, Prague, Czechoslovakia. Local Chairman: Vaclav Nemecek, K. Rybinickum 17, Praha 1-Strasnice, Czechoslovakia; Technical Program Committee cochairmen—North and South America: John C. Davis, Kansas Geological Survey, University of Kansas, Lawrence, KS 66047, (913) 864-3965, fax 913-864-5317, E-mail: john\_davis.moore\_hall@msmail.kgs.ukans.edu; Europe, Africa, and Asia: Jan Harff, Institute for Baltic Sea Research, Seestr. 15, 0-2530 Warnemuende, Germany, phone 49 381 58.261,

fax 49 381 58.336, E-mail: harff@geologie.io-warnemuende.dbp.de.

**Federation of Analytical Chemistry and Spectroscopy Societies 20th Annual Meeting**, October 17-22, 1993, Detroit, Michigan. Information: FACSS, P.O. Box 278, Manhattan, KS 66502, (301) 846-4797. (Abstract deadline: February 1, 1993.)

**New Developments in Geothermal Measurements in Boreholes**, sponsored by GeoForschungsZentrum Potsdam, Geothermal Association of Germany, IUGG International Heat Flow Commission, International Association for Mathematical Geology, and the Kansas Geological Survey at The University of Kansas, October 18-23, 1993, Klein Köris, Germany. Information: E. Hurltig, GFZ Potsdam, Talegrafenberg A45, 0-1561 Potsdam, Germany, phone

## 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 on this page. 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 1993, 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 round. However, GSA also conducts the Employment Interview Service each fall in conjunction with the Society's Annual Meeting (this year in Boston, Massachusetts, October 25-28). 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.

## EMPLOYER FORM ►



The Geological Society of America

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

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**Geological Society of America Annual Meeting**, October 25-28, 1993, Boston, Massachusetts. Information: GSA Meetings Department, P.O. Box 9140, Boulder, CO 80301, (303) 447-2020, fax 303-447-1133. (Abstract deadline: July 7, 1993.)

**Asociación de Ingenieros de Minas, Metalurgistas y Geólogos de México XX Convención**, October 26-29, 1993, Acapulco, Guerrero, Mexico. Information: Fernel Arvizu Lara, AIMMGM, A.P. 4073, C.P. 06400 Mexico, D.F., Mexico.

**November International Circum-Pacific and Circum-Atlantic Terrane Conference VI**, November 5-21, 1993, Guanajuato, Mexico. Information: Fernando Ortega-

Gutiérrez, fax 52 (5) 548-0772; or David G. Howell, fax 415-353-3224.

**American Geophysical Union Fall Meeting**, December 6-10, 1993, San Francisco, California. Information: AGU-Meetings Department, 2000 Florida Avenue, N.W., Washington, DC 20009, (202) 462-6900, fax 202-328-0566, E-mail: dsolomon@kosmos.agu.org. (Abstract deadline: September 9, 1993.)

### 1994 Meetings

#### January

**Remote Sensing for Marine and Coastal Environments, 2nd Thematic Conference**, January 31-February 2, 1994, New Orleans, Louisiana. Information: Robert Rogers, ERIM, Box 134001, Ann Arbor, MI 48113-4001, (313) 994-1200, ext. 3234, fax 313-994-5123.

#### April

**Transport and Reactive Processes in Aquifers IAHR Symposium**, April 11-15, 1994, ETH-Zürich, Switzerland. Information: Th. Dracos or F. Stauffer, Institute of Hydromechanics and Water Resources Management (IHW), ETH-Hönggerberg, CH-8093 Zürich, Switzerland, phone (01)377 30 66 or (01)377 30 79, fax (01)371 22 83.

#### June

**Geochronology, Cosmochronology, and Isotope Geology Eighth International Conference (ICOG-8)**, June 5-11, 1994, Berkeley, California. Information: Garniss H. Curtis, Institute of Human Origins-Geochronology Center, 2453 Ridge Road, Berkeley, CA 94709, (415) 845-4003, fax 415-845-9453.

#### July

**Earthquake Engineering Fifth U.S. National Conference**, July 10-14, 1994, Chicago, Illinois. Information: Claudia Cook, Newmark Civil Engineering Laboratory, University of Illinois, 205 N. Mathews, Urbana, IL 61801-2397, (217) 333-0498.

**Cyclicity in Global Geology, Australian Geological Convention Symposium**, September 1994, Perth, Australia. Information: Bryan Krapez, C.McA. Powell, Department of Geology, University of Western Australia, Nedlands, W.A. 6009. (Abstract deadline: March 31, 1993.)

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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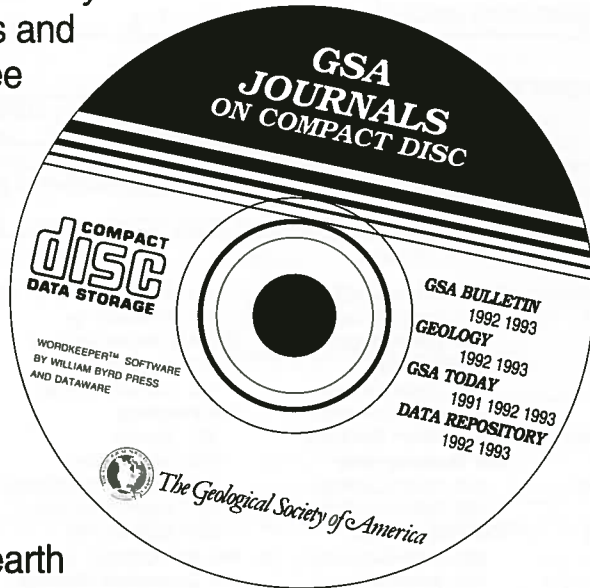
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## Positions Open

### INVERTEBRATE PALEONTOLOGIST University of Miami, Coral Gables

The Department of Geological Sciences, College of Arts and Sciences invites applications for a tenure track position at the assistant professor level from persons who use paleontology as a research tool in such fields as paleoecology, environmental geology and global climate change. The department is particularly interested in expertise in shallow water marine invertebrate paleontology to complement our studies in the coastal evolution of Southern Florida.

The position is located at the main campus in Coral Gables.

Applicants will be expected to teach undergraduate courses in Invertebrate Paleontology, Historical Geology and Evolution of the Biosphere. The successful applicant also will be expected to collaborate with other faculty, guide graduate students, advise undergraduate students, seek extramural research funds, develop and maintain an active research program and participate in the general activities of the University.

The department works closely with the Division of Marine Geology and Geophysics at the Rosenstiel School located on the Key Biscayne campus approximately seven miles from the main campus.

Research interests of the current five faculty members range from coastal and climate evolution, to isotopic studies of the mantle, Caribbean ore deposits, volcanism, tectonics, coastal and shallow marine sedimentation, carbonate processes, sediment diagenesis and hydrology.

Applicants should submit a letter summarizing their research interests, a curriculum vitae and the names of three references to Dr. Harold Wanless, Chairman, Faculty Search Committee, Department of Geological Sciences, University of Miami, P.O. Box 249176, Coral Gables, FL 33124.

We expect to fill the position by August 15, 1993.

The University of Miami is an equal opportunity affirmative action employer and a smoke/drug free workplace. We do not discriminate on the basis of race, religion, color, sex, age, national origin, or disability. We encourage applications from females, veterans, the disabled, and minority group applicants.

### HYDROGEOLOGIST

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### HYDROGEOLOGIST / ENVIRONMENTAL HYDROSCIENTIST Stanford University

The Department of Geological and Environmental Sciences at Stanford University is seeking to hire an environmental hydroscintist or hydrogeologist with broad geologic interests in the physical and chemical processes of subsurface fluid flow.

This is a tenure-track position for an Assistant or Associate Professor who would be an essential part of an interdisciplinary, quantitative hydrogeology program. The candidate should have strong commitments to graduate research and teaching, and demonstrate an enthusiastic willingness to participate in the undergraduate teaching program in the environmental sciences. The candidate is expected to interact closely with researchers studying subsurface fluid flow in the Departments of Geophysics and Petroleum Engineering, as well as those in the Environmental and Water Studies Program in the School of Engineering.

The application deadline is March 19, 1993. Please send a letter of interest, a statement of teaching and research objectives, a curriculum vitae, a publication list, and the names and addresses of three references to: Professor Steven Gorelick, Department of Applied Earth Sciences, Stanford University, Stanford, CA 94305-2225.

Stanford University has a strong institutional commitment to the principle of diversity. In that spirit, we particularly encourage applications from women, members of ethnic minorities, and individuals with disabilities.

### ENVIRONMENTAL

#### MINERALOGIST/STRUCTURAL GEOLOGIST

**State University of New York, Oswego, New York**  
The Department of Earth Sciences at the State University College at Oswego, invites applications for a tenure-track position at the assistant professor level beginning fall of 1993. The successful candidate is expected to teach general education courses in Introductory Geology as well as Mineralogy, Petrology, and Structural Geology. Other courses may include Environmental Geology and Geochemistry (low temperature). We are especially interested in candidates who are able to contribute to our proposed Environmental Sciences program. This new program is centered around a strong geology core. In addition to teaching, this successful candidate will be expected to continue scholarly development and research.

Our department has a strong commitment to undergraduate liberal-arts education. We have our own computer laboratory for student use in research and course work. Computational facilities include networked Macintosh and DOS-based microcomputers, laser printer, pen plotter, and CD ROM drive. The department houses equipment for water and sediment sampling and analysis, as well as for preparation of thin sections. Zeiss and Nikon research microscopes are available for petrographic study of rocks and minerals.

We offer a B.A. and a B.S. in Geology and a B.S. in Geochemistry in cooperation with the Department of Chemistry. Our department also offers a B.A. and B.S. in Meteorology. We have four geologists, four meteorologists, and two astronomers at the present time.

The candidate should have a Ph.D. by December 1993. Send letters, resume and transcripts with three letters of recommendation by March 15, 1993 to Dr. David J. Thomas, Chair, Department of Earth Sciences, State University of New York, Oswego, New York 13126.

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**Traveling Fellowship: Interdisciplinary Research Training Group (RTG).** Graduate students are invited to Minnesota for up to 3 months to enhance training in "Paleorecords of Global Change." Stipend (provided for citizens, nationals or permanent residents of the U.S.), travel and living allowance, and tuition. Application deadline April 1 (for travel July 1 - December 31) and October 1 (for travel January 1 - June 30). For application contact Sue Julson, University of Minnesota, Ecology, Evolution and Behavior, 318 Church St., S.E., Minneapolis, MN 55455. Phone (612) 625-7677; FAX: (612) 625-4490. An Equal Opportunity Educator and Employer.

**1993 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 1993 Ocean Drilling Summer Research Program. SOEST will host this eight week program at the University of Hawaii's Manoa campus in Honolulu from June 6 to July 31. Student participants will engage in faculty-directed research, lectures and field trips relating to the science of the Ocean Drilling Program. Successful applicants will receive: (1) travel expenses to and from Hawaii, (2) room and board for the duration of the program, (3) travel funds to visit the active Kilauea volcano, and (4) a student stipend of \$2,000. Citizens or permanent residents of the U.S. and its territories are eligible. A minimum GPA of 3.0 is required. The application deadline is March 1, 1993.

For applications contact: Dr. Craig R. Glenn, ODSRPU Coordinator, University of Hawaii, Department of Geology & Geophysics, Honolulu, HI 96822, Tel. 808-956-2200.

**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-US Science Support Program associated with ODP. Application deadline is March 1, 1993. 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.

**Complex Systems at the Earth's Surface.** Opportunities exist of graduate research into the fundamental nature of landforms and of the processes which create them at the Scripps Institution of Oceanography, University of California, San Diego.

A combination of computer simulation, theory and field observations are used to address general questions regarding self-organization, pattern formation and nonlinear dynamics, as well as specific mechanical processes operating on coastal and arid landforms. Current applications include beach cusps, ripples, dunes, alluvial fans, patterned ground, landslides and sediment transport. Facilities include Silicon Graphics workstations, the Mojave Desert and a research beach. Quantitative background in physics or related field is preferred.

For more information regarding this program and application to Scripps/UCSD, please send a resume, undergraduate transcripts, names, addresses and phone numbers of 3 references and a statement of interest to Prof. Brad Werner, Complex Systems Laboratory, Center for Coastal Studies 0209, Scripps Institution of Oceanography, La Jolla, California, 92093-0209. (619) 534-0583. UCSD is an EO/AA employer.

**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, 1993. Applicants must be currently enrolled in a Masters or Ph.D. program at a private or state college or university. Four to six grants ranging from \$800 to \$1300 each will be awarded for

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**Student Travel Grants.** The GSA Foundation will award matching grants to each of the six GSA Sections to assist students wishing to travel to GSA Section and Annual meetings. For applications contact individual Section secretaries. For Section information, contact GSA (1-800-472-1988).

*Eighth International Conference on Geochronology, Cosmochronology and Isotope Geology*

# ICOG 8

BY THE GOLDEN GATE

Berkeley, California USA

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Isotopic investigations, crossing the bounds of cosmochronology, geochronology, and isotope geology, have become an integral part of many interdisciplinary research studies. As a reflection of this trend, this meeting is planned around thematic topics in studies of the Earth and extraterrestrial materials. Pre- and post-meeting field trips have been planned to explore areas in the western U.S. and Canada. Social events will take advantage of the diverse activities and beautiful sights of the greater San Francisco Bay Area.

To receive First Circular, contact:  
Garniss H. Curtis, ICOG-8 Chair  
Geochronology Center-IHO  
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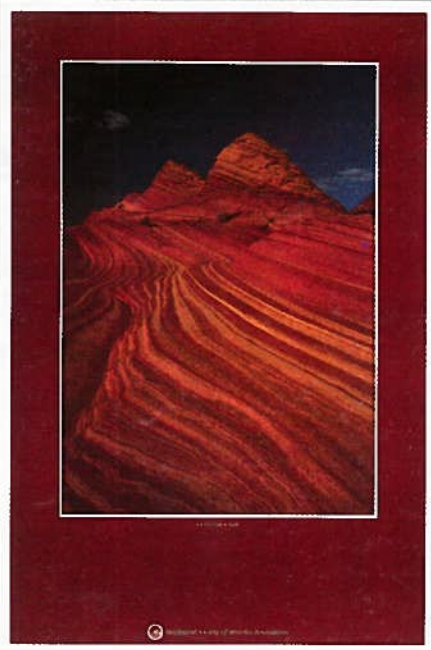
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## IEE Internship Program Offers Opportunities for Students in Environmental Practice

Employment opportunities for geologists in environmental areas have increased significantly in recent years. Employment with environmental and geotechnical companies that provide a broad range of services in environmental engineering and urban geology offer new challenges for recent graduates in the earth sciences. In addition, many large chemical and petroleum companies and government agencies at all levels have need for personnel trained in geology who can become conversant with environmental regulatory requirements.

With the missions of the Departments of Defense and Energy undergoing significant change as a consequence of the end of the Cold War, this trend can be expected to increase dramatically. For example, the Department of Energy recently shut down the uranium fuel plant at Fernald, Ohio, and changed its mission completely to environmental restoration. Last August the DOE awarded a contract potentially valued at \$4 billion over an 8-year period to oversee the environmental restoration activities at the Fernald site. Similarly, in March 1993 the DOE will announce the award of a major contract for waste management and environmental restoration activities at its Hanford site in Washington state. As other facilities are selected for site investigations and remedial activities, the demands for qualified environmental geoscientists will provide numerous and varied opportunities for those entering the job market.

The Internship Program of the GSA Institute for Environmental Education is an effort to apprise students majoring in geoscience of these opportunities and to help meet the increasing needs of industry and government. The program coordinates the placement of advanced students in limited-term positions of supervised training in environmental practice prior to completion of their degrees. The internships provide an opportunity for the student to evaluate possible interests in working in geoenvironmental science, and also provide insight into specific areas of knowledge that are particularly valuable in pursuing those interests. The selected work environments will expose the interns to activities that both utilize and complement their academic training and provide guidance for additional course work when they return to school to complete their degrees.

The IEE Internship Program is open to both graduate and undergraduate students in the geological sciences who have an overall grade-point average of 3.0 or higher, based on A = 4.0. Undergraduate students must have junior standing with a minimum of 18 semester hours (or equivalent) in geoscience. Participants would intern at a local or site office of the sponsoring firm, typically during the summer and the school term immediately preceding or following it. Transportation costs to and from the location of the internship are provided; compensation during the internship is commensurate with educational background and the local cost of living.

Students interested in participating in the IEE Internship Program should write for an application form to:



Institute for Environmental Education  
Geological Society of America  
P.O. Box 9140  
Boulder, CO 80301-9140

## Call for Nominations

### 1993 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 1993 award will be presented at the autumn AASG meeting to be held during the GSA Annual Meeting in Boston. Members of the selection committee are Chairman Frank E. Kottowski, New Mexico Bureau of Mines and Mineral Resources; John P. Kempton, Illinois Geological Survey; and Diane L. Conrad, Vermont Division of Geology 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 sent to Executive Director, GSA, P.O. Box 9140, Boulder, CO 80301. Deadline: March 31, 1993.**

### 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).

### 1992 Recipients

Recipients of the 1992 award presented at the GSA Annual Meeting in Cincinnati are Edwin J. Hartke and Henry H. Gray, Indiana Geological Survey, for their report "Geology for environmental planning in Monroe County, Indiana," Special Report 47 (1989), Indiana Geological Survey.

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