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INSIDE

A Candidate for the Baja British Columbia Fault System in the Coast Plutonic Complex

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ABSTRACT

Results of part of ACCRETE, a multidisciplinary project to investigate the processes of crustal formation in the Coast orogen of British Columbia, suggest that a candidate for the Baja British Columbia fault zone, across which 1500 to 2000 km of displacement could have occurred between Late Cretaceous and early Tertiary time, is present in the Coast orogen. Evidence comes from new structural data that reveal a sequence of high-temperature deformational events. Early deformation consisted of partitioned transpression recorded by a broad zone of contemporaneous southwest-directed thrusting and dextral orogen-parallel strike-slip shearing. Subsequent uplift and exhumation of the high-grade core of the orogen accompanied by syntectonic plutonism produced fabrics that erased much of the evidence for earlier strike slip and thrust deformation. We suggest a cause-and-effect relation as to why Late Cretaceous to early Tertiary granodioritic to tonalitic plutons of the 2000-km-long Coast Plutonic Complex are restricted to the region of the Baja British Columbia fault. The cause is basaltic magma intruded into the crust from conduits produced by strike-slip faults passing into the mantle. These magmas provided the heat for the crustal melting that produced the tonalitic plutons. The result is that deformation is confined to regions softened by heating and melting. Continuing episodes of deformation and basaltic underplating and the consequent melting and recrystallization at high temperatures obscure evidence of prior deformation.

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Editor's note: This paper illustrates the influence of 1997 GSA Day Medal winner Ted Irving, whose determinations of paleolatitudes showed thousands of kilometers of northward translation of the outer tectonic elements of the northwestern North American Cordillera.

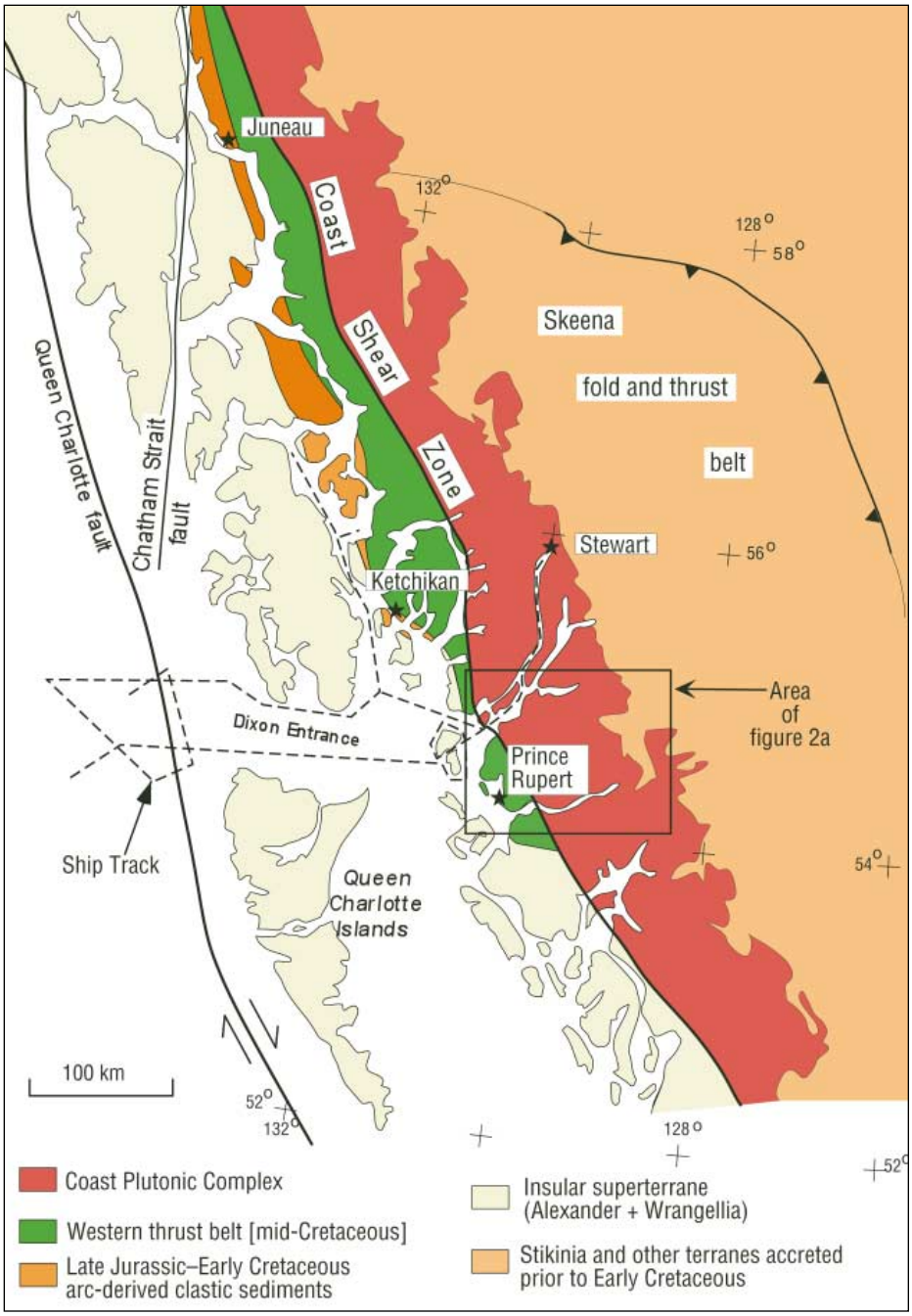

Figure 1. Simplified map showing terranes within Coast orogen in British Columbia. The red area is generally called the Coast Plutonic Complex, but within area of Figure 2a, where high-grade metamorphic rocks are dominant, it is called the Central Gneiss Complex. The western thrust belt is called the Coast Mountains orogen by Cowan et al. (1997). The Skeena fold and thrust belt is described by Evenchick (1991). Ship track for 1994 ACCRETE seismic experiment is approximate.

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In Memoriam

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Salt Lake City, Utah
March 29, 1997

Wallace W. Hagan
Lexington, Kentucky
July 18, 1997

Dorothy Hill
Queensland, Australia
April 23, 1997
(correction of August *GSA Today* listing)

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Vernon Hill, Virginia
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INTRODUCTION

One of the most intensely debated tectonic questions in Cordilleran tectonics (e.g., Cowan et al., 1997) is the latitude of accretion of the Insular superterrane, which is now along the west coast of Canada and southeast Alaska (Fig. 1). Mobilist models suggest that these terranes have traveled from the latitude of present-day Baja California since the Late Cretaceous. Stationary models suggest that these terranes have been more or less at their present location with respect to North America since the mid-Cretaceous. Arguments for large-scale strike-slip translation are based mainly on paleomagnetic data (Bogue et al., 1995; Wynne et al., 1995; Ague and Brandon, 1996); arguments against it have been mainly geological (Gehrels et al., 1991a; McClelland et al., 1992a, 1992b; van der Heyden, 1992; Monger et al., 1994).

The Coast shear zone (Fig. 1) is a prominent structural feature that extends along the western boundary of a line of Late Cretaceous to early Tertiary magmatic bodies known as the Coast Plutonic Complex. Attention has focused on this shear zone (e.g., Cowan, 1994) as a possible location for strike-slip translation. However, Cowan et al. (1997) reviewed studies reporting that kinematic indicators at the Coast shear zone indicate down-dip movement or flattening and, because these movements are younger than 65 Ma, they postdate the time of suspected strike-slip motion. Accordingly, Cowan et al. (1997, p. 133) concluded that the 1500–2000 km of displacement, if it occurred, would be within the Coast Plutonic Complex to the east. They named the suspected fault the Baja British Columbia fault. If the Coast Plutonic Complex contains such a strike-slip fault system, it would rank at the top of the world's longest known intracontinental transcurrent fault systems.

In this paper, we present geologic data for a segment of the Coast Plutonic Complex (see Fig. 1) to the east of the Coast shear zone. This segment, which is called the Central Gneiss Complex (Fig. 2a), is a 50–100-km-wide zone of gneiss and migmatite intruded by Late Cretaceous to early Tertiary plutons. Because of its high proportion of Mesozoic and older gneiss and migmatite, the Central Gneiss Complex presents an opportunity to study the dynamic setting into which Late Cretaceous to early Tertiary plutons intruded. On the basis of our studies, we conclude

that large-scale orogen-parallel displacement probably occurred across the Coast Plutonic Complex between about 85 Ma and 60 Ma. This zone would be the proposed Baja British Columbia fault system.

The results summarized here are part of a collaborative endeavor among seismologists, geologists, geophysicists, and geochemists, begun in 1993, to study continental growth by accretion in the northeast Pacific. The project, called ACCRETE, aims to define and interpret the geologic and geophysical features of the crust, from surface to Moho, across the Coast orogen (see Fig. 1). Updates on progress are periodically posted on the ACCRETE Web site, at http://geo.princeton.edu/accrete/accrete.html. The activities and participants of the ACCRETE program are:

Crustal structure, crustal velocity models: John Diebold, Lamont Doherty Earth Observatory, Columbia University; Igor Morozov and Scott Smithson, University of Wyoming; Phil Hammer, Ron Clowes, and Bob Ellis, University of British Columbia; Nik Christensen, Purdue University; Kristan Rohr, Geological Survey of Canada; Anne Trehu, Oregon State University.

Geological studies: Lincoln Hollister, Princeton University; Maria Luisa Crawford, Bryn Mawr College; Cameron Davidson, Beloit College; Keith Klepeis, University of Sydney; Margi Rusmore, Occidental College; Glenn Woodsworth, Carol Evenchick, Lisel Currie, and Suzie Gareau, Geological Survey of Canada.

Detrital zircon studies; boundaries of accreted terranes: George Gehrels, University of Arizona.

U/Pb ages to constrain structural and plutonic histories: George Gehrels; Krishna Sinha, Virginia Polytechnic Institute.

Define zones of paleomagnetic anomalies: Robert Butler, University of Arizona.

Geochemistry of plutons, map source areas of plutons: Krishna Sinha.

Prior work directed at the question of large-scale strike-slip displacement was mainly concentrated along the Coast shear zone. Here, we first review some of this work, and then integrate our new results with other studies across the Central Gneiss Complex to define the geologic history for the period of possible northward transport of the Insular superterrane. Finally, we propose a cause-and-effect relationship of pluton generation and strike-slip faulting for the Coast Plutonic Complex.

Coast Shear Zone

The Coast shear zone (Fig. 1) marks the western boundary of the Coast Plutonic Complex (Brew and Ford, 1978), and truncates a top-to-the-west mid-Cretaceous thrust system that lies to its

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CALL FOR NOMINATIONS REMINDERS

Penrose and Day Medals, and Honorary Fellowship

Nominations for 1998 Penrose and Day Medals and for Honorary Fellowship in the Society are due by **FEBRUARY 2, 1998.**

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 $15,000, was endowed by Dr. and Mrs. Fred A. Donath.

For the year 1998, only those candidates born on or after January 1, 1963, are eligible for consideration. In choosing candidates for the Young Scientist Award, scientific achievement and age will be the sole criteria. Nominations for the 1998 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 in addition to the person making the nomination.

Deadline for nominations for 1998 is **FEBRUARY 2, 1998.**

Officers and Councilors

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

Deadline for nominations for 1998 is **FEBRUARY 18, 1998.**

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, 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. Deadline for nominations for 1998 is **MARCH 2, 1998.**

John C. Frye Environmental Geology Award

In cooperation with the Association of American State Geologists (AASG), 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 $1000 cash prize from the endowment income of the GSA Foundation's John C. Frye Memorial Fund. The 1998 award will be presented at the autumn AASG meeting to be held during the GSA Annual Meeting in Toronto, Canada.

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.

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). Deadline for nominations for 1998 is **MARCH 30, 1998.**

National Awards

The deadline is **April 30, 1998,** for submitting nominations for these four awards: William T. Pecora Award, National Medal of Science, Vannevar Bush Award, Alan T. Waterman Award.

Materials and supporting information for any of the nominations may be sent to GSA Executive Director, Geological Society of America, P.O. Box 9140, Boulder, CO 80301. For more detailed information about the nomination procedures, refer to the October 1997 issue of *GSA Today,* or call headquarters at (303) 447-2020, extension 140.

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west (Crawford et al., 1987; Rubin et al., 1990; McClelland et al., 1992b; Klepeis et al., 1996). Plutons younger than 85 Ma (most 75 to 50 Ma) occur east of the Coast shear zone. Plutons with ages of 100 to 90 Ma dominate to the west. Any discussion of the tectonic history of the Coast orogen must explain why *no* Late Cretaceous to early Tertiary plutons occur west of the Coast shear zone. This point is addressed in the last section.

Previous studies have found that the Coast shear zone: (1) may be a suture zone formed by near orthogonal collision between accreted terranes (Ingram and Hutton, 1994); abundant evidence of important flattening at the Coast shear zone has been documented (Ingram and Hutton, 1994; Klepeis et al., 1996); (2) may be the locus of postaccretion tilting of previously amalgamated crustal terranes west of the Coast shear zone (McClelland et al., 1992b; Cook and Crawford, 1994); (3) was the zone across which the high-temperature core of the orogen, the Central Gneiss Complex, was uplifted and exhumed (Hollister, 1982; Klepeis et al., 1996); (4) was an important strike-slip fault. Many workers have sought evidence for strike-slip displacement within the Coast shear zone without success. However, evidence for a major, dextral, high-temperature shear zone has been reported by Andronicos et al. (1996) about 10 km east of the Coast shear zone (Figs. 2a and 3). Klepeis et al. (1996) also described a component of late dextral displacement for the Coast shear zone at Portland Inlet and farther to the north.

A series of tabular, foliated tonalite plutons and dikes, collectively known as the "foliated tonalite sill" (Brew and Ford, 1978) occur within and along the entire eastern side of the Coast shear zone in southeastern Alaska. These plutons and dikes range in age from about 72 to about 58 Ma (Gehrels et al., 1991). They have nearly vertical western contacts and steeply northeast dipping eastern contacts as far south as the Skeena River (Fig. 2a). The Quottoon pluton (Hutchison, 1970), within the area of this study, is part of the "foliated tonalite sill" (Fig. 2). Gehrels et al. (1991b) reported an age of 58 Ma where this pluton crosses the Skeena River. The location of the Coast shear zone along the western boundary of the string of foliated tonalite plutons, and the great length of both, strongly imply that the plutons were intruded into a zone of weakness that extended into the mantle lithosphere (Ingram and Hutton, 1994). Because fabrics produced by deformation in the Coast shear zone affect the tonalite plutons and dikes (Klepeis et al., 1996), deformation along the Coast shear zone must overlap and postdate their intrusion.

When the tonalite plutons intruded the Coast shear zone, hot (>700 °C) migmatitic rocks within the Central Gneiss Complex were already juxtaposed against colder (~400 °C) rocks of the western thrust belt (Crawford et al., 1987; Hollister, 1982; Klepeis et al., 1996). Hollister (1982) considered that this juxtaposition occurred between about 60 and 50 Ma as the Central Gneiss Complex was being exhumed at a rate of 1–2 mm/yr. The Quottoon pluton was intruded during this uplift, as indicated by east-side-up, high-temperature fabrics within both the pluton and the Coast shear zone (Ingram and Hutton, 1994; Klepeis et al., 1996). The resulting steep thermal gradient implies a sharp rheological contrast across the Coast shear zone during uplift, when the Quottoon pluton was intruding.

We emphasize that the fundamental, crustal-scale break that controlled emplacement of the foliated tonalite sills existed prior to their intrusion. Most deformation described at the Coast shear zone was synchronous with or postdated these sills. The location and displacement history across this zone prior to the intrusion of the Quottoon pluton is not established.

We argue that because the uplift of the Central Gneiss Complex involved migmatitic rocks at temperatures of 600 to 700 °C, older kinematic indicators were overprinted by high-temperature penetrative deformation across the Coast shear zone associated with this uplift. Heat from the plutons and dikes intruded during this

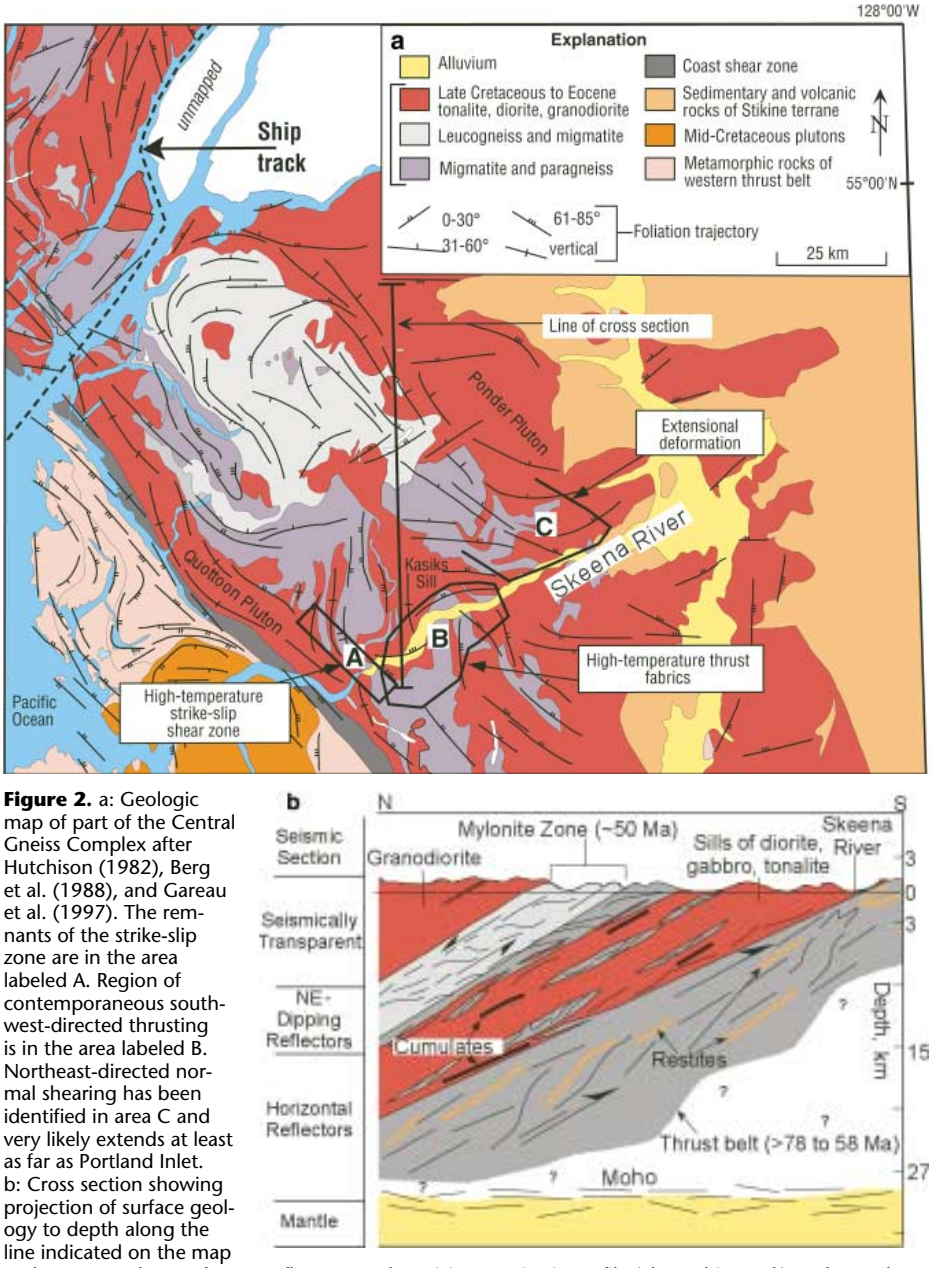

Figure 2. a: Geologic map of part of the Central Gneiss Complex after Hutchison (1982), Berg et al. (1988), and Gareau et al. (1997). The remnants of the strike-slip zone are in the area labeled A. Region of contemporaneous southwest-directed thrusting is in the area labeled B. Northeast-directed normal shearing has been identified in area C and very likely extends at least as far as Portland Inlet. b: Cross section showing projection of surface geology to depth along the line indicated on the map and correspondence of some reflectors on the ACCRETE seismic profile (along ship track) to the geology (see Hollister et al., 1996). The north end of the cross section is correlated with the seismic section at the end of the arrow along the ship track.

Figure 3. (looking down and northeast) of the high-temperature dextral shear zone in location A in Figure 2a. The amphibolite xenolith contains internal foliation at ~90° to external foliation, indicating clockwise rotation consistent with asymmetry of the tails. The amphibolite xenolith to the left of the coin is cut by synthetic shears filled with leucosome, indicating the presence of melt during shearing. An asymmetric calcsilicate nodule also indicates dextral shearing. Note the low-angle, melt-filled synthetic shear band cutting the foliation near the base of the photo. Courtesy of Cameron Davidson.

uplift intensified the effect. High temperatures promoted recrystallization and recovery, leading to further resetting of fabrics.

Whereas Cowan et al. (1997) argued against the Coast shear zone being a locus of strike-slip motion, they considered that strike-slip motion could have occurred to the east along a hypothetical Baja British Columbia fault system within the Coast Plutonic Complex. We accept this possibility, but we emphasize that the Coast shear zone cannot be excluded as part of the Baja British Columbia fault system.

Central Gneiss Complex

Andronicos et al. (1996) found evidence for dextral strike-slip motion across a northwest-trending shear zone in the Central Gneiss Complex (Figs. 2a and 3). This shear zone is at least 3 km thick and can be traced for ~25 km along the east side of the Quottoon pluton (area A in Fig. 2a). Lineations in the shear zone are northwest-trending and have gentle to moderate plunges. The structures recording dextral kinematics formed at high enough temperatures that leucosomes (melt patches) are concentrated in asymmetric boudin necks and shear bands (see photo). Medium to coarse grain sizes indicate initial recovery and grain growth after deformation when the rocks were still hot. The shear zone and associated kilometer-scale isoclinal folds are crosscut by the 58 Ma Quottoon pluton, which was itself affected by the final phases of dextral shearing. These relations suggest that the Quottoon pluton intruded an active dextral transpressive shear zone during the waning stages of deformation.

Within the part of the Central Gneiss Complex shown in Figure 2a, large regions of gently north to northeast dipping layering contain abundant kinematic (movement) indicators for apparent top-to-the-southwest thrusting (area B in Fig. 2a; Fig. 2b; Hollister et al., 1996). Rusmore et al. (1996) found similar features just south of this area. The sequence with high-temperature, penetratively deformed layering is over 3 km thick where it was defined in area B in Figure 2a. Tonalitic sills ranging from meters to kilometers in thickness are intruded mostly concordantly into the layering (Fig. 2b). Dates of 75 Ma from zircon inclusions in garnets, and of 65 Ma from zircons in the matrix of the layered sequence (Woodsworth et al., 1983) imply that thrusting began prior to the intrusion of the Quottoon pluton. Field relations (Andronicos et al., 1996) confirm that the Quottoon pluton intruded after thrusting was largely complete. Metamorphic *P-T* paths of the high-grade rocks containing the thrust fabric show that they were at

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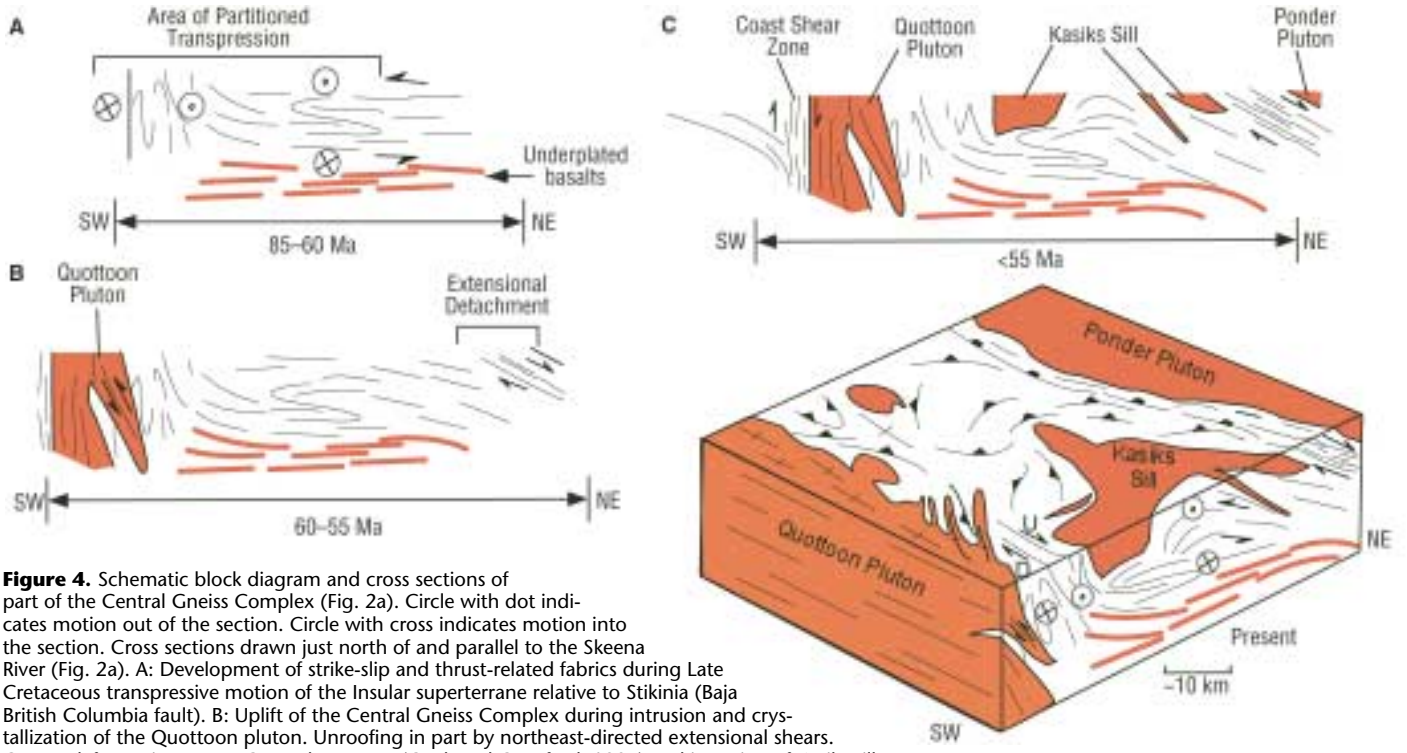

Figure 4. Schematic block diagram and cross sections of part of the Central Gneiss Complex (Fig. 2a). Circle with dot indicates motion out of the section. Circle with cross indicates motion into the section. Cross sections drawn just north of and parallel to the Skeena River (Fig. 2a). A: Development of strike-slip and thrust-related fabrics during Late Cretaceous transpressive motion of the Insular superterrane relative to Stikinia (Baja British Columbia fault). B: Uplift of the Central Gneiss Complex during intrusion and crystallization of the Quottoon pluton. Unroofing in part by northeast-directed extensional shears. C: Late deformation across Coast shear zone (Cook and Crawford, 1994) and intrusion of Kasiks sill and Ponder pluton (see Fig. 2).

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temperatures over 600 °C during thrusting between 85 and 60 Ma, at depths of at least 25 km between 70 and 60 Ma, and at depths of 10 to 5 km when cooled rapidly from over 600 °C down to 300 °C at 50 Ma (Hollister, 1982). Kilometer-scale folds within the thrust package that are deflected and refolded by the shear zone indicate that strike-slip deformation outlasted thrusting. Similar metamorphic conditions and kinematic and geometric compatibility suggest that the thrust and strike-slip zones formed a partitioned transpressive system in which displacements occurred synchronously on horizontal and vertical surfaces (Fig. 4A).

Farther east, along the eastern side of the Central Gneiss Complex (area C in Fig. 2a), the ductile thrust fabric is cut at a low angle by a moderately dipping (~30° east to northeast; Fig. 2b), 4-km-thick mylonite zone with top-to-the-east-northeast shear sense (Fig. 4B). This zone of normal shear sense was first recognized by Heah (1991), who constrained the age to be between 60 and 50 Ma. This is more or less the same time as the uplift and exhumation of the Central Gneiss Complex (Hollister, 1982). Microfabric analyses indicate that this lower temperature mylonitic fabric was superimposed on the higher temperature migmatitic thrust fabric.

In the strain history across the Central Gneiss Complex (Fig. 4), the earliest recorded strain was transpressive and was accommodated by partitioned thrust and strike-slip–related shearing that largely predated the intrusion of the Quottoon pluton. The top-to-the-southwest ductile thrusting predates and overlaps the dextral strike-slip deformation. Fabrics related to transpression and to the intrusion of the "foliated tonalite sill" are postdated by extensional fabrics related to shearing and emplacement of synextensional plutons (Fig. 4B). High temperatures persisted throughout the deformation history of the Central Gneiss Complex, leading to complex strain gradients and overprinting relations that are difficult to interpret.

Baja British Columbia Fault Zone

On the basis of our analysis of the structures in the area shown in Figure 2a, net large-scale northward displacement across the Central Gneiss Complex is likely. Significantly, the emplacement of the 83 to 50 Ma middle to lower crustal plutons and migmatites in this region overlaps the period when relative motions between the Kula and North America plates were predominantly transpressive (Engebretson et al., 1985). The orientation of the Coast shear zone was appropriate for strike-slip motion during this time period. Plutons deformed by the top-to-the-south thrusting have U/Pb dates ranging from 83 to 63 Ma. The 58 Ma Quottoon pluton at the Skeena River puts a younger limit on the transpressive stage. Pre–58 Ma southwest-directed thrusting could produce the uplift that is recorded by rapid Late Cretaceous to early Tertiary erosion in this area (Plafker et al., 1994). Eocene extension along the eastern side (Heah, 1991) contributed to exhumation.

This synthesis provides arguments for substantial cumulative strain throughout the Central Gneiss Complex. As shown in Figure 4, the complex pattern of structural fabrics can be attributed to strike-slip, normal, and thrust faulting complicated by local mobilization and upward flow of melt. Under the high-temperature (sillimanite stability field) conditions in the complex between 83 and 50 Ma, new ductile deformational fabrics should have formed continuously, overprinting and obliterating earlier fabrics. Cumulate amphibole in the Quottoon pluton indicates derivation from a tonalitic liquid intruded at a temperature over 1000 °C. Assuming that the Coast shear zone was a boundary to the Central Gneiss Complex during intrusion of the Quottoon pluton and subsequent uplift, preexisting kinematic indicators would not be preserved. Instead, the Coast shear zone records kinematics of pluton emplacement and the rapid uplift of the hot core of the Central Gneiss Complex which lasted until about 50 Ma.

Following collision of the Insular superterrane and formation of the 100 to 90 Ma imbricate thrust system and associated plutons, relative plate motions changed to oblique convergence across the northwest-trending coastline. This convergence was recorded by top-to-the-southwest thrusting and margin-parallel dextral strike-slip fabrics in rocks now at the latitude of the ACCRETE study area. By the time the foliated tonalite sill complex was intruded, the Kula (Pacific) plate had slowed and relative transcurrent motion across the Central Gneiss Complex had effectively stopped. This episode is recorded by rapid exhumation of the basement and by the normal detachment along the east side of the Central Gneiss Complex. The slowing and death of the Kula plate can be attributed to collision of the Insular superterrane with southern Alaska. This collision is recorded in the Chugach terrane at 58 to 55 Ma (Sisson and Pavlis, 1993).

Implications for Generation of the Tonalitic Plutons

A major piece of the puzzle is still missing. Why are Late Cretaceous–early Tertiary plutons *missing* west of the Coast shear zone? We offer our speculations.

The first question is the mechanism for generating the tonalitic plutons with batholithic proportions, given that some 1500 to 2000 km of orogen-parallel displacement occurred in the Coast orogen during their emplacement. If these plutons were generated above a subduction zone within an arc, or by melting at the base of tectonically overthickened crust during thermal relaxation, some magma should have leaked across the Coast shear zone. The fact that this did not happen calls for an alternative hypothesis.

Another consideration is that a large-scale strike-slip fault system causing thousands of kilometers of northward translation of the Insular superterrane must involve the mantle lithosphere. As such, a zone of fracture or weakness extending to the asthenosphere or a Benioff zone(?) could provide an access path to the crust for basaltic magma. Upon reaching the base of the crust, these magmas could pond, providing the exceptional heat source needed to generate the tonalitic melts that intruded the Coast Plutonic Complex at temperatures of >1000 °C. An important consequence of such melting and associated metamorphism is the maintenance of a softened and weakened crust. The continuous intrusion of basaltic magmas and thermal softening of the mantle lithosphere provides a feedback mechanism for confining strike-slip displacement to a single zone.

We suggest that the western edge of the weak part of the mantle shear zone coincided with the Coast shear zone. To account for the lack of Late Cretaceous–early Tertiary plutons west of the Coast shear zone, the crust and mantle in this area must have been cool enough that melt leaking into this region from the Central Gneiss Complex solidified very quickly. In essence, the Coast shear zone marked the edge of a thermal wall. A much stronger mantle and crust west of this wall caused deformation to be confined to the batholith complex.

Evidence for basaltic magmas intruding the Central Gneiss Complex during the orogenic episode comes from numerous synplutonic basaltic dikes in the tonalitic plutons and small intrusive ultramafic bodies. Synplutonic dikes occur as pillowed mafic layers within the tonalite plutons and as mafic enclaves. Ultramafic bodies occur as small sills within the layered metamorphic rocks and range in composition from pyroxenite to hornblendite. Secondary evidence for the involvement of basalt comes from the exceptionally high temperatures of the tonalite plutons. Such high temperatures require an exceptional heat source, and mafic magmas derived from the mantle are an obvious candidate.

An important implication of the Central Gneiss Complex containing the record of strike-slip motion in the ductile lower crust is that the roots of a former strike-slip fault can be observed and studied on the surface. We need not go 20 km below

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the surface to understand large strike-slip faults like the San Andreas. Understanding how displacements are transmitted from the asthenosphere through the mantle lithosphere and the lower crust to the earthquake zone requires the inductive reasoning of geologists who can identify and analyze the roots of ancient displacement zones. Such a place appears to exist in the Coast Mountains of British Columbia and southeast Alaska.

ACKNOWLEDGMENTS

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REFERENCES CITED

Ague, J. J., and Brandon, M. T., 1996, Regional tilt of the Mt. Stewart batholith, Washington, determined using aluminum in hornblende barometry: Implications for northward translation of Baja British Columbia: Geological Society of America Bulletin, v. 108, p. 471–488.

Andronicos, C. L., Davidson, C., and Hollister, L. S., 1996, A dextral orogen parallel transcurrent shear zone at the eastern margin of the Quottoon Pluton, Coast Orogen, British Columbia: Eos (Transactions, American Geophysical Union), v. 77, p. F651.

Berg, H. C., Eliott, R. L., and Koch, R. D., 1988, Geologic map of the Ketchikan and Prince Rupert quadrangles, southeastern Alaska: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1807, scale 1:250 000.

Bogue, S. W., Gromme, S., and Hillhouse, J. W., 1995, Paleomagnetism, magnetic anisotropy, and mid-Cretaceous paleolatitude of the Duke island (Alaska) ultramafic complex: Tectonics, v. 14, p. 1133–1152.

Brew, D. A., and Ford, A. B., 1978, Megalineament in southeastern Alaska marks southwest edge of Coast Range batholithic complex: Canadian Journal of Earth Sciences, v. 15, p. 1763–1772.

Cook, R. D., and Crawford, M. L., 1994, Exhumation and tilting of the western metamorphic belt of the Coast orogen in southern southeastern Alaska: Tectonics, v. 13, p. 528–537.

Cowan, D., 1994, Alternative hypotheses for the mid-Cretaceous paleogeography of the Western Cordillera: GSA Today, v. 4, p. 181, 184–186.

Cowan, D. S., Brandon, M. T., and Garver, J. I., 1997, Geologic tests of hypotheses for large coastwise displacements—A critique illustrated by the Baja British Columbia controversy: American Journal of Science, v. 297, p. 117–173.

Crawford, M. L., Hollister, L. S., and Woodsworth, G. J., 1987, Crustal deformation and regional metamorphism across a terrane boundary, Coast Plutonic Complex, British Columbia: Tectonics, v. 6, p. 343–361.

Engebretson, D. C., Cox, A., and Gordon, R. G., 1985, Relative motions between oceanic and continental plates in the Pacific Basin: Geological Society of America Special Paper 206, 59 p.

Evenchick, C. A., 1991, Geometry, evolution, and tectonic framework of the Skeena fold and thrust belt, north-central British Columbia: Tectonics, v. 2, p. 527–546.

Gareau, S. A., Woodsworth, G. J., and Rickli, M., 1997, Regional geology of the northeastern quadrant of Terrace map area, west-central British Columbia: Geological Survey of Canada Current Research 1997-A, p. 47–55.

Gehrels, G. E., McClelland, W. C., Samson, S. D., and Patchett, P. J., 1991a, U-Pb geochronology of detrital zircons from a continental margin assemblage in the northern Coast Mountains, southeast Alaska: Canadian Journal of Earth Sciences, v. 28, p. 899–911.

Gehrels, G. E., McClelland, W. C., Samson, S. D., Patchett, P. J., and Brew, D. A., 1991b, U-Pb geochronology of Late Cretaceous and early Tertiary plutons in the northern Coast Mountains batholith: Canadian Journal of Earth Sciences, v. 28, p. 899–911.

Heah, T. S. T., 1991, Mesozoic ductile shear and paleogene extension along the eastern margin of the central gneiss complex, Coast belt, Shames River area, near Terrace, British Columbia [M.S. thesis]: Vancouver, University of British Columbia, 155 p.

Hollister, L. S., 1982, Metamorphic evidence for rapid (2 mm/yr) uplift of a portion of the Central Gneiss Complex, Coast Mountains, B.C.: Canadian Mineralogist, v. 20, p. 319–332.

Hollister, L. S., Andronicos, C., and Diebold, J., 1996, Correlation of deep crustal reflectors of the ACCRETE seismic section with subsurface exposures of rocks formed in the lower crust: Eos (Transactions, American Geophysical Union), v. 77, p. F651.

Hutchison, W. W., 1982, Geology of the Prince Rupert–Skeena map area, British Columbia: Geological Survey of Canada Memoir 394, 116 p.

Ingram, G. M., and Hutton, D. H. W., 1994, The Great Tonalite Sill; emplacement into a contractional shear zone and implications for Late Cretaceous to early Eocene tectonics in southeastern Alaska and British Columbia: Geological Society of America Bulletin, v. 106, p. 715–728.

Klepeis, K. A., Crawford, M. L., and Gehrels, G. E., 1996, Structural history of the coast shear zone near Portland Inlet, Ak/BC: Eos (Transactions, American Geophysical Union), v. 77, p. F651.

McClelland, W. C., Gehrels, G. E., Samson, S. D., and Patchett, P. J., 1992a, Protolith relations of the Gravina belt and Yukon-Tanana terrane in central southeastern Alaska: Journal of Geology, v. 100, p. 107–123.

McClelland, W. C., Gehrels, G. E., Samson, S. D., and Patchett, P. J., 1992b, Structural and geochronologic relations along the western flank of the Coast Mountains batholith: Stikine River to Cape Fanshaw, central southeastern Alaska: Journal of Structural Geology, v. 14, p. 475–489.

Monger, J. W. H., van der Heyden, P., Journeay, J. M., Evenchick, C. A., and Mahoney, J. B., 1994, Jurassic-Cretaceous basins along the Canadian Coast Belt: Their bearing on pre–mid-Cretaceous sinistral displacements: Geology, v. 22, p. 175–178.

Plafker, G., Moore, J. C., and Winkler, G. R., 1994, Geology of the southern Alaska margin, *in* The geology of Alaska: Boulder, Colorado, Geological Society of America, Decade of North American Geology, v. G-1, p. 389-451.

Rubin, C. M., Saleeby, J., Cowan, D. S., Brandon, M. T., and McGroder, M. F., 1990, Regionally extensive mid-Cretaceous west-vergent thrust system in the northwestern Cordillera: Implications for continent-margin tectonism: Geology, v. 18, p. 276–280.

Rusmore, M. E., Gehrels, G. E., and Shula, S., 1996, Evolution of the Central Gneiss Complex (CGC), 54°N lat., British Columbia: Eos (Transactions, American Geophysical Union), v. 77, p. F651.

Sisson, V. B., and Pavlis, T., 1993, Geological consequences of plate reorganization: An example from the Eocene southern Alaska fore arc: Geology, v. 21, p. 913–916.

van der Heyden, P., 1992, A Middle Jurassic to early Tertiary Andean-Sierran arc model for the Coast Belt of British Columbia: Tectonics, v. 11, p. 82–97.

Woodsworth, G. J., Loveridge, W. D., Parrish, R. R., and Sullivan, R. W., 1983, Uranium-lead dates from the Central Gneiss Complex and Ecstall pluton, Prince Rupert map area, British Columbia: Canadian Journal of Earth Sciences, v. 20, p. 1475–1483.

Wynne, P. J., Irving, E., Maxson, J. A., and Kleinspehn, K. L., 1995, Paleomagnetism of the Upper Cretaceous strata of Mount Tatlow: Evidence for 3000 km of northward displacement of the eastern Coast Belt, British Columbia: Journal of Geophysical Research, v. 100, p. 6073–6091.

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Each month, *GSA Today* features a short science article on current topics of general interest. For guidelines on submitting an article, contact either *GSA Today* Science Editor:

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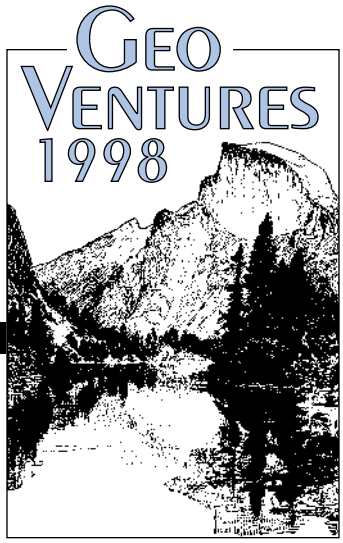
FUTURE . . . GeoVentures are a special benefit created for members, but they are open also to guests and friends. GeoVentures is the overall name for adult educational and adventure experiences of two kinds: GeoTrips or GeoHostels. Both are known for expert scientific leadership. Fees for both are low 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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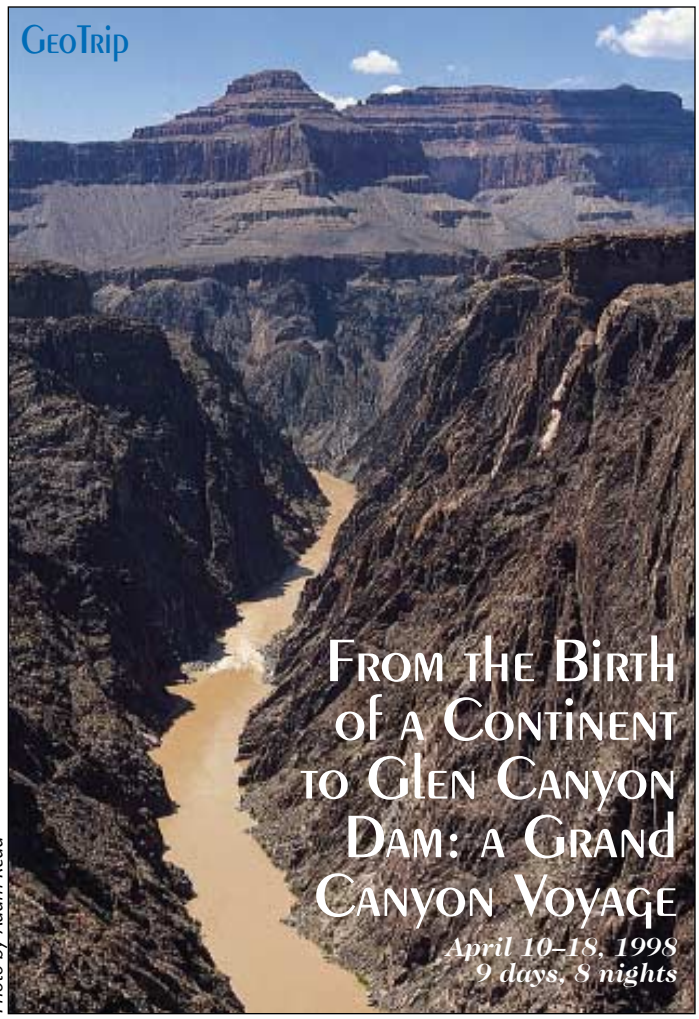

Photo by Adam Read

Scientific Leaders

Brad Ilg, Cerro Alto Geological Consultants, Inc., Glorieta, New Mexico
Jeff Bennett, Northern Arizona University, Flagstaff, Arizona
Mike Timmons, University of New Mexico, Albuquerque, New Mexico
Joel Pederson, University of New Mexico, Albuquerque, New Mexico

This fantastic trip will float the Colorado River in the Grand Canyon with several Grand Canyon geologists. Brad Ilg, the lead instructor for the trip, has been guiding exciting geology river trips in the Grand Canyon since 1990 for various universities and museums. His work on the Precambrian rocks of the Upper and Middle Granite Gorges is included in the new *Geologic Map of the Eastern Grand Canyon*. Brad will show the group seldom-visited side canyons in the Granite Gorges, locations that yield insights to the island-arc origins of the highly deformed Precambrian rocks. The group will discuss the models for continental growth through island arc accretion and examine features that record island arc assembly to the proto–North American continent. Mike Timmons, a Grand Canyon Supergroup specialist and professional Grand Canyon river guide, will lead the group to the old "horse thief trail" in Chuar Valley, to explore the Precambrian rift-related Chuar sedimentary rocks, visit 800-million-year-old stromatolites, and see the incredibly organic-rich Precambrian Chuaria Formation. Jeff Bennett, a Grand Canyon beach and aquatic systems specialist and professional Grand Canyon river guide, will lead discussions on the results of the experimental flood of 1996 and discuss sediment mass balance and river systems dynamics in the postdam environment. The strong monsoon season of 1997 has had a dramatic effect on the sediment load in the river channel, and the group will see, first hand, the effects of another artificial flood scheduled for release during the fall of 1997. Joel Pederson, a geomorphologist and sedimentologist working in the Grand Wash Trough at the western end of the canyon, will review the evidence for the timing of the cutting of the canyon. He will also review the various models for the evolution of the Grand Canyon, from stream capture via headward erosion to Major John Wesley Powell's models of "superposition" and "antecedence."

This is an exceptional opportunity for the physically fit person to visit the world's premier natural laboratory. April is a beautiful time of year to visit the Grand Canyon. There are few other trips on the river at that time, and the weather is usually perfect for hiking. Participants will see locations in the Grand Canyon that are rarely visited by standard commercial trips. We will run some of the world's best white water and visit such magical locations as Elves Chasm and Deer Creek Falls, in the context of learning about the cutting edge of Grand Canyon geologic theory.

Schedule ***(Note: The on-river schedule is subject to change)***

April 10 Travel day to Las Vegas, Nevada. Stay at Maxim Hotel.
April 11 Depart Maxim Hotel at 6:00 a.m. and travel by bus to Lee's Ferry. Arrive Lee's Ferry at 10:30 a.m. Meet scientific leaders for pre-trip orientation; start down river at 11:00 a.m. Camp at South Canyon.

April 12 Boat to Lava Canyon. Stop at Red Wall Cavern and granaries at Nankoweap Canyon.
April 13 Boat to Crystal Canyon. Hike Lava Canyon, visit horse thief trail in Chuar Valley. Stop at Mineral Canyon to examine granulite-grade migmatites. Stop at Vishnu Canyon to examine amphibolite-grade metasedimentary rocks.
April 14 Boat to Stone Creek. Stop at Tuna Canyon to study an island-arc–related pluton. Stop at Elves Chasm to see "oldest rock in the Southwest." Stop at Blacktail Canyon.
April 15 Boat to National Canyon. Hike from Tapeats Creek through Precambrian Unkar Group to Thunder River and down to Deer Creek Falls.
April 16 Boat to 224 Mile Canyon. Run Lava Falls.
April 17 Boat to Separation Canyon. Hike Hurricane fault up to flank of Diamond Peak.
April 18 Boat to Pearce Ferry. Leave for Las Vegas, Nevada, by bus at 11:00 a.m. Arrive Las Vegas about 3:00 p.m. Fly out of Las Vegas late afternoon.

Lodging, Meals, and Transportation

Arizona River Runners and the science leaders will provide all meals, field instruction, professional river guides, river-related equipment (including camping gear), and transportation from Las Vegas, Nevada, to Lee's Ferry, Arizona, on April 11 and from Pearce Ferry, Arizona, to Las Vegas, Nevada, on April 18.

Elite Travel is familiar with the trip itinerary and can handle all reservations in and out of Las Vegas; they can also arrange hotel and airfare discounts. Call Jill or Dora with Elite Travel at 1-800-441-5880.

Physical Requirements

This trip includes several moderately difficult, always optional, hikes that are usually less than two miles round trip from the boats. Although at a reasonable pace with many points to rest and to explore the geology, these hikes should be undertaken only by persons in good health who are physically active. Verification of health coverage will be required. No rafting experience is necessary.

Fee and Payment

GSA Member: $1745 *Nonmember: $1845*
Based on 25 people. The trip may be more if there are fewer registrants. A $200 deposit, due with your reservation, is refundable through January 2, 1998, less $50 processing fee. Total balance due: January 2, 1998. Minimum age: 21.

Included: All meals beginning with lunch on April 11 and ending with breakfast on April 18. Transportation by bus from Las Vegas, Nevada, to Lee's Ferry, where you will meet the science leaders and crew, and bus transportation from Pearce Ferry, Arizona, back to Las Vegas, Nevada. All river equipment including tents, sleeping bags, sleeping pads, geological reading materials, and river guidebook.

Not included: Airfare to and from Las Vegas.

GeoHostel

Geology of the Southwestern San Juan Mountains

Durango, Colorado
June 27–July 2, 1998 • 5 days, 6 nights

Scientific Leaders: *Gregory Holden and Ken Kolm, Colorado School of Mines, Golden, Colorado.*

GeoHostel

Geology of the Grand Teton–Yellowstone Country

Jackson, Wyoming
July 18–23, 1998 • 5 days, 6 nights

Scientific Leaders: *Rob Thomas and Sheila Roberts, Western Montana College, Dillon, Montana.*

Please see the December issue of GSA Today for more information on the 1998 GeoHostels.

Grand Canyon Registration

Send a deposit to hold your reservation; please pay by check or credit card. You will receive further information and a confirmation of your registration within two weeks after your reservation is received.

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GT981—Grand Canyon	$200	____	$_____

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Institute for Environmental Education

What I Did On My Summer Vacation: Reports from Badlands and Denali National Parks

In the summer of 1997, the Institute for Environmental Education inaugurated its National Park Service Internship Program by sponsoring undergraduate interns at Denali and Badlands National Parks. Two interns were selected from an applicant pool of about fifty interested undergraduates. Stipends were provided by a generous grant from the Frank A. Campini Foundation. Brenda K. Saville, a senior at the University of Iowa, was selected as the intern at Badlands, and Sarah Schlichtholz, a University of Montana senior, was chosen for Denali. Below, they report on their experiences.

Sarah Schlichtholz hiking out of Long Creek after a heavy rainfall. Denali lies somewhere behind the clouds.

They Don't Seem So Bad to Me

Brenda K. Saville

The 1997 summer in the Badlands was indeed an experience. Viewing the geology, paleontology, and prairie ecology of the park helped put the Badlands into a perspective not achievable in a classroom. Interacting with many visitors—by answering questions, assisting with problems, and giving presentations—was personally gratifying. Doing in-depth research for a presentation about fossils and the prairie led to a greater knowledge of these subjects. And the weather! It was not the hot dry summer that I had expected; there were many cool and rainy days. By the middle of August, the grass was still green and lush. The average annual rainfall of 15–16 inches was reached by August 16!

What did the internship involve? First there were two weeks of training. We learned about the mission of the park, its resources and visitor protection plans, and what it means to be an interpreter. There were field trips to show us the geology, paleontology, and prairie ecology, and courses on first aid and CPR.

Within the 40-hour work week, I gave daily presentations (such as talks about fossils, and guided walks in the prairie). Other duties involved roving the trails and campgrounds to interact with visitors, working on individually assigned projects, and assisting the Badlands Natural History Association staff in the gift shop.

I created my own presentations. There was not a preset script to follow, and research was therefore an absolute necessity. In this way I came to understand the importance of the fossils, geology, and prairie of Badlands National Park. My fossil talk focused on the extinct mammals of the Oligocene, and especially the oreodont beds of the Brule Formation. Much has been written about the vast number of fossils found in these Oligocene sediments, but it is hard to comprehend until one sees for one's self the huge numbers of exposed fossils.

One of my special projects was to write text for the back of a paleontology poster. The text dealt with the Badlands geology, fossilization process, theories about the animals shown on the poster, and the future of Badlands National Park paleontology. Another project was to draw some of the extinct mammals for poster presentations. The prairie walk involved taking visitors for a one-hour introduction to prairie ecology. This was a favorite visitor activity.

My internship in Badlands National Park provided me with a wonderful opportunity to increase my knowledge of geology and paleontology, learn about prairie ecology, share this knowledge with the public, and, I hope, impart some of my enthusiasm for this wonderful environment.

My Summer With the WAGS

Sarah Schlichtholz

I arrived in Denali National Park and Preserve in mid-June to work for 11 weeks within the Water, Air, Ground, and Soils (WAGS) Branch of the Research and Resource Preservation Division. After a short orientation on the workings of headquarters, I immediately began work on producing a paleontology database for the park. I created the relational database management system designed specifically to acquire, organize, find, and present information concerning paleontological data reported from the vicinity. The actual input of the data and the cross-correlation of various documents required the remainder of the summer. In all, the database of paleontology of Denali National Park consists of 1,068 cited fossils from 276 localities. Fossils include Paleozoic and Mesozoic marine invertebrates and microfossils, Mesozoic and Cenozoic plant material, and Cenozoic insect and pollen data.

Time and helicopter support allowed visits to three target areas to collect samples for the park reference collection. I also participated in a wide range of other projects to experience the full spectrum of the WAGS Branch activities. I took part in the long-term monitoring of the East Toklat glacier, and I assisted in surveying major slumping and potential gravel loss along the Denali road. Within the Drunken Forest mud flows, I serviced rain gauge equipment and observed new activity. I investigated the Cantwell Formation with visiting researchers from Allegheny College, and I joined the Alaska Department of Geophysical and Geological Survey in a mapping effort of the Healy quadrangle just southeast of the park boundary.

Finally, I collected water samples for chemical and suspended-sediment analyses, measured discharge, and conducted other hydrologic tests in Stony Creek, Rock Creek, and Long Creek. For the Long Creek monitoring effort, my companions and I hiked into the valley between the Dutch and Peters Hills from the Denali State Park boundary—packs filled with bedding and cooking supplies shoved between filters, sample bottles, and pH and TDS testers. After we installed the equipment, it did its duties for the next 24 hours and left us to contemplate the rain, the clouds, the erratics, the bears, and our isolation.

Besides work (which hardly seemed like work at all), I had several opportunities to visit the park and experience the back country, the wilderness, and the wildlife. On several of these trips "down the road," I investigated the regional geology on my own, doing general reconnaissance of the rocks and structures I encountered. I have developed a strong urge to solve once and for all the Denali fault problem and put the Triassic section of the south side in order. I should have no problem coming up with a master's thesis for the future. ■

GSAF UPDATE

Robert L. Fuchs

From the Ground Up

Last summer, while waiting for a concert to begin at the Aspen Music Festival, my wife and I had a brief conversation with a friend, just widowed, who mentioned the problems she was having with her late husband's estate. His death followed a long illness. "We thought we had arranged everything, and instead I have been inundated with difficult matters that are proving to be very messy and taking a lot of time to resolve," she lamented.

Just two days later, in a telephone conversation, a GSA member described the turmoil surrounding a deceased professor's estate. Again, the family knew that he had taken care to arrange everything.

These two conversations aroused my curiosity: Are these isolated incidents or are there chronic problems occurring in settling individuals' estates? Further, what exactly are the problems and are they be preventable? I decided to call an acquaintance who is a broker at a large national firm that customarily deals with the trusts and estates of wealthy individuals. His comments, paraphrased here, were interesting.

Such difficulties are fairly frequent and typically relate to three easily overlooked "traps." The first trap is underestimating the value of estate assets. The long-running bull market in stocks and the unusual appreciation of real estate can create unexpectedly high net worth. Ten and twenty percent annual increases in market indices have made personal investments and the assets in tax-sheltered retirement plans much more valuable. Homes bought 25 years ago for $25,000 may now be worth 25 times the purchase price.

Additionally, many of these homes, together with bank accounts and other assets, are held in joint tenancy. This form of ownership fixes the distribution of the property and may adversely affect the outcome of other estate planning efforts. Similarly, life insurance payable to an estate may unnecessarily become a taxable asset by adding to the adjusted gross value of the estate.

In fact, the common problem in all these instances is incomplete planning. If a husband and wife establish a living trust to avoid probate yet do not transfer and retitle a high-value asset such as the family home, an important benefit of the trust may be lost. And the surviving spouse, at an emotionally difficult time, must cope with a matter thought to have been taken care of.

What can be done to prevent or minimize the risk of costly planning failures?

Competent advisors—attorneys, accountants or financial consultants—with proven estate planning expertise are essential. Equally essential is coordination among the advisors. One estate in trouble had had three planners; each talked to the estate owner but none talked to each other. Thus, even with excellent advice, individuals must play an active role in their own estate planning by asking questions, providing information, and confiding even the most sensitive matters to at least one key advisor.

The GSA Foundation's library has several booklets available that can help you become familiar with the fundamentals of effective estate planning. Our selection includes "Planning Your Bequests," "Trusts in Financial Planning," "Estate Planning for Women," "Planning for Real Estate Owners," and "Estate Planning for the 21st Century." Call, write, or e-mail the Foundation for a copy of one or all of the booklets.

The reading is easy and the results can be profound. ■

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—Fred Pough

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SAGE REMARKS

Karen L. Bice, Pennsylvania State University

Using Geology to Engage Young Minds in Science

As a geologist, you have the advantage of knowing a lot about one of the most accessible sciences for young minds. You would have difficulty finding a larger, more receptive audience of creative minds than in the local elementary school—perhaps the ideal place in which to initiate Science Awareness through Geoscience Education.

Since December 1995, earth science has been a distinct discipline in the national K–12 science curriculum. While many of the K–5 school teachers I have talked to have fond memories of an introductory geoscience course taken in their freshman year in college, even those individuals have a poor understanding of Earth, and few have ever had to prepare a hands-on earth science activity for their classroom. Teachers are looking to improve and expand the earth science units they teach. This requires more variety of materials, new ideas, and closer interaction with earth scientists. Fortunately, there is increasing involvement by professional societies in K–12 earth science. The activities available to teach earth science in many elementary schools almost invariably come without what is really needed to make them work: support from a knowledgeable, enthusiastic earth scientist. Members of the GSA Partners in Education Program (PEP) are among those serving as valuable resources to individual teachers, schools, and school districts. We invite you to join us simply as someone who contributes to the early earth science education of a small group of vital individuals. To whatever extent you feel comfortable and are able, get involved in an elementary school.

During each of the past six years, I have visited one grade at Radio Park Elementary School in State College, Pennsylvania, starting in the kindergarten and graduating through the ranks to the fifth grade. In a sense, I have tracked one group of about 80 kids through their elementary school career. This telling of my experiences is perhaps less "sage remarks" than one earth scientist's perspective of what it takes to interest and challenge a group of kids as they mature from six to eleven year-olds. The challenge to me has been to continually challenge the students at an appropriate level of understanding. The advantage to the teachers has been ready access to a local resource for ideas, answers, and some materials. I hope that one of the benefits to the students has been knowing first hand a scientist who believes that each one of them is capable of making valid observations and solving meaningful problems.

Kindergarten and First Grade Experiences

Young kids seem to be naturally fascinated by rocks, but they are far from ready to put rocks, minerals, and fossils into the larger context of earth processes. Similarly, they are not able to understand the difference between a rock and a mineral. They use the term "fossil" correctly, but everything else is a "stone" or a "rock." At the kindergarten and first grade levels, it seemed to me that content was therefore not as important as simply providing the students with the opportunity to handle and ask questions about a wide variety of rocks, minerals, and fossils.

For the kindergartners, it was fun to play geologist, using a magnifying glass or hand lens, drawing pictures of rocks in a notebook. One kindergarten child, whom I knew to be overly active, occupied himself throughout my entire visit by experimenting with the pumice in a beaker of water. He relished the role of demonstrator and did not disrupt the class. The first graders were ready to compare the streak and hardness of a few minerals, but the names of the minerals seemed unimportant.

At this level, it is good to demonstrate the widely varying physical properties of obsidian, pumice, chalk, magnetite, halite, graphite, talc, sulfur, mica. Be willing to sacrifice a good halite, pyrite, galena, or calcite specimen in a demonstration of "how minerals break." This makes a safe "magic trick" —"I simply put the piece of halite into this canvas sample bag, hit it with my rock hammer, and ..." pour out a dozen perfectly formed tiny cubes. If a microscope is available, have the children look at table salt. Where have we seen that before? Let the children write on the board with (naturally occurring) chalk, on black construction paper with talc, on white paper with graphite. Children at this age also like to be shown seemingly impossible tricks. "I'll bet you that I can use a rock to write your name" or "Do you think rocks float?" These experiments may sound overly simplistic to us as adults, but we all have to work hard to avoid packing too much into our next GSA meeting presentation: a simple idea conveyed using a simple example often goes a long way in teaching.

Second and Third Grade Experiences

The seven to nine year-olds were clearly ready for a somewhat more structured lesson and were ready to solve a "problem." Thinking that I had been invited to speak only to one second grade class, I planned to introduce the students to the concepts of geologic time, of rocks as having a determinable age, and of the correlation of widely distributed rock units using fossil assemblages. I prepared boxes containing sand in which I had buried fossils. I knew that this age group is rabid about dinosaurs, so, having only one fossil dinosaur bone, I substituted 2-inch plastic dinosaur models in lovely neon pink, green, and orange. I planned to give the students a simple chart of fossil ranges, have them sieve the sand "collecting" fossil specimens, and assign ages to each "assemblage." The afternoon before the planned visit, however, I learned that it had been arranged that I would speak to all six of the second and third grade classes, at one time, gathered on the floor of one classroom. A hands-on activity was out of the question, and I had one evening to design an activity that would not only convey a geological concept, but would hold the attention of over 150 seven to nine year-olds.

I pulled out one of the three resource books compiled by the SEPM Committee on K–12 earth science education (www.ngdc.noaa.gov/mgg/sepm/k12/). An activity titled "Detective Work on Fossil Footprints" by Lauret Savoy and Steven Roof showed promise as a demonstration activity, provided I created large-scale versions of the visual aids required. The exercise is based on a dinosaur trackway preserved in the Morrison Formation of southeastern Colorado. Using three pieces of poster board, I recreated the suggested large dinosaur–small dinosaur–predator trace-fossil patterns in three large "puzzle pieces."

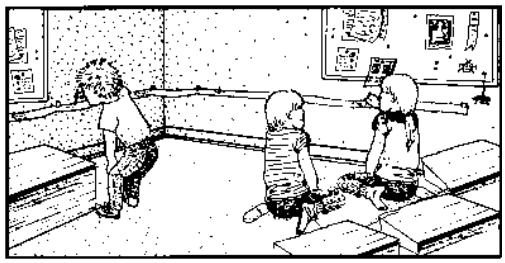
After introducing the concept that ancient history can be reconstructed from fossil evidence, I taped the poster board trackway up one section at a time, allowing the children to offer suggestions to answer "What was going on here?" Each puzzle piece added something to the story and allowed more possible ancient scenarios. The students' wonderfully creative minds generated ideas that I had not anticipated, tending as I do toward "most likely explanations." In the end, of course, we could not be sure what had happened,

SAGE Remarks *continued on p. 14*

SAGE Remarks *continued from p. 13*

but the children had created at least three plausible interpretations and there was some brief, deafening debate of their relative merits.

Following this, we turned to the extinction of the dinosaurs and other animals. This is a natural context in which to introduce the concept of geologic time. I tacked up and unrolled the first five feet of a roll of remnant wallpaper on the back of which I had drawn the geological time scale at a scale of 1 inch = 10 million years. Using volunteers from the group and stick-on notes, we marked the earliest evidence of such popular life forms as sharks, horses, flowering plants, trees, and humans. We marked the first and last occurrences of trilobites and dinosaurs. The first five feet of this chart encompassed the Phanerozoic. Rolled out to the middle of the audience, the 33-foot roll stretched back into the early Archean. The students were dazzled when they heard that we'd need nearly five more feet of paper to reach the age of Earth.



It hadn't been easy, but this thrown-together trace fossil–time scale visit was perhaps the most rewarding one I have made. Still, I wasn't willing to try it again anytime soon, so the next year I agreed to visit only one classroom. Fortunately, the third grade curriculum that year included a geology unit. I begged unwanted sediment and rock samples from the Penn State repositories and was able to provide a set that represented a simple metamorphic series: jar of mud, shale, slate, phyllite, schist, and gneiss. A set of questions on index cards accompanied each specimen, guiding the students' observations about texture. These were displayed for a week along a long, low window sill in the third grade classroom. The students wrote their observations in journals and, on the basis of clues built into the teacher's lessons, tried to reason out how and why these rocks were different. I visited the next week, and the children could present their cases before the geologist, ask questions and get the metamorphic story, told at an 8- and 9- year-old level.

Having discussed layering and compaction of sediments to form sedimentary rocks, the students brought their own "sediments" from home—marbles, beads, glitter, pebbles, the omnipresent plastic dinosaur—and made their own "rocks" using plaster, sand, and water. The ingredients were mixed in paper cups, a layer of matrix and larger "grains" being added each day for several days, with sometimes a fossil leaf between layers. The exercise provided an excellent opportunity to feel the latent heat of crystallization as gypsum crystals formed in the cups. Returning with a canvas sample bag and rock hammer when the rocks were fully formed, I broke a student's "rock," if he or she wanted. We were able to find molds and casts and to see individual layers, separated by well-constrained 24-hour hiatuses.

Fourth and Fifth Grade Experiences

It had become more and more challenging to anticipate the capabilities of the elementary school students, and I began to fear underestimating their level of understanding. Beginning with the fourth grade, I decided to go "overprepared," ready to move on to a slightly more complex scientific concept as long as the children appeared to follow.

By age nine or ten, most children in central Pennsylvania have been to a commercial tourist cave. Browsing a Carlsbad Caverns souvenir shop, I had recently discovered how to "Grow Beautiful Crystal Formations from Magic Rocks! ($2.50 plus tax)." Having neglected to purchase any of these pieces of magic limestone, I picked some up along the side of the local basketball court. Each student brought a glass jar from home, and the school supplied a gallon bottle of distilled white vinegar. I reminded the children of the dominant local rock type (limestone), and introduced the concepts of partial dissolution of calcite in the presence of a weak acid (vinegar or the local rain) and the precipitation of a similar mineral (aragonite) following the release of a dissolved gas (carbon dioxide). Seeing that the class had followed me so far, I was ready with a simple chemical equation describing the process. I tried to make this a very simplified introduction to the idea that many things that happen in the earth can be expressed as something that looks like a math "word" problem.

Each student put a rock sample in the jar and half covered it with vinegar. Carbon dioxide bubbles released from the rock surface indicated the chemical "reaction in action." The aragonite crystals grew over the next two weeks. Some children added food coloring to the evaporating liquid. All kept daily records of their observations. One student's journal contained poems about her crystals.

The same year that I visited the fourth grade, I happened to have purchased several palm-sized pieces of the fossiliferous Green River Formation at Ulrich's Fossil Gallery (phone 307-877-6466), near Fossil Butte National Monument, Wyoming. The fine-grained claystone matrix surrounding well-preserved fish bones is easily crushed and removed by using a steel needle. Under close supervision and wearing protective goggles, the students took turns "excavating" 50-million-year-old fish bones. The fourth grade students found this "really cool." Several wanted to know where they could get a piece of fossil fish for themselves. (While this activity would have fit well with the third grade rock making activity, I wouldn't have allowed younger children to work with the sharp needles. I recall having used the same tool to stabilize poor unfortunate squid and frogs in high school biology lab.)

Again in the fifth grade, the elementary curriculum included a formal earth science unit. The teachers were glad to have a resource person, and I answered questions and supplied ideas when possible. One pre-packaged activity that the teachers planned to use involved reconstructing Gondwana. The children cut continental shapes from a map photocopied onto 11" by 17" paper and glued them onto a large sheet of construction paper. There was no right or wrong way to do this, because the exercise was based only on the observation that the continents appeared to fit together like puzzle pieces. After the students had this first pass at Gondwana, I supplied a version of the same initial map with several topographic features and rock and fossil distributions drawn in. The teachers were instructed to introduce the idea that if two land masses were once joined together and subsequently "pulled apart," mountain ranges and fossil beds that were once continuous might now be separated by ocean. Armed with these data, the students re-did their Gondwana reconstruction and compared it to the earlier version.

A few questions remained; for example, where to put Madagascar? What to do with Iceland? At that point, I visited one of the three fifth grade classrooms armed with a colorful sea-floor age map (http://www.ngdc.noaa.gov/mgg/image/), block diagrams of a spreading center and subduction trench, and a flip book illustrating plate motions of the last 750 million years, courtesy of Chris Scotese, the Paleomap Project, and the University of Texas at Arlington Geosociety (fax 817-273-2628). I pointed out to the students how what they had done in revising their reconstruction of a supercontinent (they liked that term) mimicked the discovery by geologists of new information which added to

SAGE Remarks *continued on p. 15*

SAGE Remarks *continued from p. 14*

the development of the theory of plate tectonics. We took the problem a step further with the introduction of sea-floor age mapping, changes in Earth's magnetic polarity and discovery of a tremendous mountain ridge in the middle of the Atlantic Ocean.

We discussed sea-floor spreading, and I helped the students calculate how much wider the North Atlantic has become since they were born, since their teacher was born, and since Columbus sailed the ocean. The flip book was a tremendous hit. They found Gondwana in the book and compared it to their reconstruction. I explained how and when Iceland had formed and that they could simply throw it away in order to reconstruct a supercontinent. (As a paleoclimate modeler, I routinely get to treat landmasses in this manner.) We talked about the problem of Madagascar and how sea-floor age mapping has helped to constrain the best answer.

Until the fifth grade, it was very important to most of the kids to be able to show me the things they had collected. Although many parents enjoy buying beautiful amethyst and pyrite samples for their children, the greatest enthusiasm I saw was for the nondescript pebble or fragment of calcite-filled vein dug up in the backyard. I have also seen more than my share of concrete, asphalt, roofing material, and glass and iron slag. I have become very tactful in saying, "This is not a real rock," but only because I have had to do it so many times. Fortunately, rocks and minerals are the raw materials for these human-made wonders, so there is a story to be told. There is almost always a story to be told.

To the extent that you are able, involve yourself in the lives of a group of potential scientists who want and need a mentor. Call the principal of the local school and introduce yourself. Make yourself available to answer teachers' and students' questions via phone or e-mail. Suggest activities or sources of materials. Donate rock, mineral, and fossil specimens. Offer to visit the school and lead a hands-on activity. Offer to address a large group, when a hands-on activity is not possible. Ask to be put in contact with any scout or youth groups that meet at the school after hours.

I suppose that, in a sense, I have adopted an elementary school. The rewards of our relationship have been, to me, priceless. I hope that next year I am wanted in the middle school. But if I am not, there is a group of imaginative, inquisitive, receptive 5 and 6 year-olds entering kindergarten who may have never heard of a geologist or talked to one, but they've probably each got a rock they collected somewhere. ■

LETTER TO THE EDITOR

Edwards Aquifer and Edwards Limestone—Nomenclature and Confusion

Sharp and Banner ("The Edwards Aquifer: A Resource in Conflict," *GSA Today,* v. 7, no. 8) assert, "Some confusion still persists over differences between hydrostratigraphic and stratigraphic nomenclature." But with the very next sentence they add to this confusion by stating, "It is not always recognized, for instance, that although the Edwards aquifer is present in the San Antonio area, the Edwards Limestone is not!" As geologists who have worked on various facets of Edwards stratigraphy, structure, hydrogeology, and geomorphology over approximately the past 30 years, we were mystified by this comment, and initially (until receiving clarifying communications from Sharp) were unsure as to whether our problems in understanding stemmed from the nuances of stratigraphic nomenclature or from a misstatement of geologic fact.

Sharp and Banner know … that members of the Edwards Group crop out extensively in the San Antonio area. A drive … around the north side of the city provides views of this rock unit in dramatic road cuts. Likewise, the space shuttle photograph used in Figure 1 of Sharp and Banner's report shows fault-bounded Edwards clearly visible as a dark tonal band (although the Edwards aquifer is the sole source of water for San Antonio, the Edwards Limestone [formerly a formation] is not present under that name). The key to understanding this statement is their use of the capital letter "L." It is a subtle point, meaningful only to geologists schooled in such matters.…

In the face of all the subtleties of stratigraphy and nomenclature, the Edwards is a name that is still highly useful and widely employed. In the dissertation (Rose, 1968, p. 21) that preceded the monograph in which the Edwards was raised to Group status (Rose, 1972), the following statement addresses this issue of amending a long-standing, useful name.

> To quarrymen, water-well drillers, subsurface geologists, foundation engineers, amateur rockhounds, geomorphologists and most surface geologists (who are not stratigraphic specialists) "Edwards" means and has meant for 70 years the light-colored, shelly, cherty, porous, resistant limestone and dolomite above the Glen Rose and below Buda, Del Rio, Georgetown, or Kiamichi. Indeed, it has been one of the few stratigraphic terms that allowed even loose communication between workers in far-flung fields of geological endeavor. Any future attempts at revision of stratigraphic nomenclature may as well face the inevitable: like most truly useful terms, the name is here to stay.

Sharp and Banner point out the multifaceted sociopolitical context of the geologic and hydrogeologic setting of the Edwards. But our experience has been that technical expertise is often overridden in such a politically and emotionally charged atmosphere. Hence, it is essential that we scientists take great care in making academic points about (say) geologic nomenclature. Otherwise, confusion will be fomented among experts and the general public alike.

Notwithstanding this cautionary statement, … potential impacts on the Edwards aquifer by San Antonio's unslaked demand for water suggest a modification of Sharp and Banner's statement to read, "It is not generally recognized that, although the Edwards limestone is present in the San Antonio area, the Edwards aquifer may not always be!"

References Cited

Rose, P. R., 1968, Edwards Formation, surface and subsurface, Central Texas [Ph.D. thesis]: Austin, University of Texas, 301 p.

Rose, P. R., 1972, Edwards Group, surface and subsurface, Central Texas: University of Texas at Austin Bureau of Economic Geology, Report of Investigations, no. 74, 198 p.

C. M. Woodruff, Jr., Peter R. Rose
Rose and Woodruff Associates
Austin, TX 78701

Patrick L. Abbott
San Diego State University
San Diego, CA 92182

GSA Grants Support Student Research

June R. Forstrom, *Research Grants Administrator*

Grants for Graduate Students

The purpose of the general research grants program is to provide partial support of master's and doctoral thesis research in earth science for graduate students at universities in the United States, Canada, Mexico, and Central America. GSA strongly encourages women, minorities, and persons with disabilities to participate fully in this grants program. Applicants need not be members of GSA. Funding for this program is provided by a number of sources, including GSA's Penrose and Pardee endowments, the National Science Foundation, industry, individual GSA members through the GEOSTAR and Research Grants funds, and numerous dedicated research funds that have been endowed at the GSA Foundation by members and families.

Applications must be on current GSA forms available in geology departments in the United States and Canada, or from the Research Grants Administrator, GSA, P.O. Box 9140, Boulder, CO 80301-9140 or jforstro@geosociety.org. Evaluations from two faculty members are required on GSA appraisal forms. The deadline is February 1 each year for grants awarded in April. In 1997, 478 proposals were received; 188 of them were funded. A total of $303,960 was awarded.

Specialized Grants

Recipients of special named awards are selected by the Committee on Research Grants from applicants to the general research grants program; only one application is needed to apply, and it must be postmarked by February 1. It is not necessary for applicants to indicate that they wish to be considered for a specialized grant. The committee considers all qualified applicants when selecting recipients for special awards.

The Gretchen L. Blechschmidt Award supports research by women interested in achieving a Ph.D. in the geological sciences and a career in academic research, especially in the fields of biostratigraphy and/or paleoceanography, and who have an interest in sequence stratigraphy analysis, particularly in conjunction with research into deep-sea sedimentology.

The aim of the John T. Dillon Alaska Research Award is to support research that addresses earth science problems particular to Alaska, especially field-based studies dealing with the structural and tectonic development, and those that include some aspect of geochronology (either Paleontologic or radiometric) to provide new age control for significant rock units in Alaska.

The Robert K. Fahnestock Memorial Award is made annually to the applicant with the best application in the field of sediment transport or related aspects of fluvial geomorphology.

The Lipman Research Award is to promote and support graduate research in volcanology and petrology.

The Bruce L. "Biff" Reed Award is for graduate students pursuing studies in the tectonic and magmatic evolution of Alaska and also can fund other geologic research.

The Alexander Sisson Award supports research for students pursuing studies in Alaska and the Caribbean.

The Harold T. Stearns Fellowship Award is awarded annually in support of research on one or more aspects of the geology of Pacific islands and of the circum-Pacific region.

Division Grants

Nine of the 12 GSA divisions award grants for outstanding student research within the respective division's field of interest. The Committee on Research Grants will select candidates from the general research grant applicants for awards by the Engineering Geology, Geophysics (Allan V. Cox Award), Hydrogeology, Sedimentary Geology, and Structural Geology and Tectonics Divisions.

The Archaeological Geology Division awards the Claude C. Albritton, Jr. Scholarships for graduate students in the earth sciences and archaeology. Contact Reid Ferring, Institute for Applied Sciences, P. O. Box 13078, University of North Texas, Denton, TX 76203.

The Coal Geology Division awards the A. L. Medlin Scholarship Award and a Field Research Award to students who submit the best proposals of research projects in the field of coal geology. Guidelines are available from the division secretary.

The Planetary Geology Division offers two S. E. Dwornik Student Paper Awards in the field of planetary geology annually. Contact Cassandra R. Coombs, Department of Geology, College of Charleston, 66 George Street, Charleston, SC 29424-0001.

The Quaternary Geology and Geomorphology Division awards the J. Hoover Mackin and Arthur D. Howard Research Grants to support graduate student research on Quaternary geology or geomorphology. Applications are available from the division secretary, J. Steven Kite, Department of Geology and Geography, West Virginia University, P.O. Box 6300, Morgantown, WV 26506-6300. The deadline for applications is February 15, for grants awarded in April.

The Geoscience Education, History of Geology, and International Divisions do not currently award grants for student research.

Section Grants for Undergraduate and Graduate Students

Recipients for graduate research grants from the South-Central Section are selected from applicants to the GSA general research grants program who are recommended by the Committee on Research Grants to the Management Board of the section for final selection. Eligibility is restricted to graduate students attending a college or university within the geographic area of the section.

The South-Central Section also awards grants to undergraduate students; applications are available from the section secretary, Rena M. Bonem, Department of Geology, Baylor University, P.O. Box 97354, Waco, TX 76798-7354. The deadline is October 15, for grants awarded in December.

The North-Central Section awards grants to undergraduate students within the geographic boundary of the section. For further information contact the section secretary.

The Southeastern Section awards grants for both undergraduate and graduate student members of GSA who are enrolled in institutions within the geographical boundaries of the section. Application forms can be obtained from the section secretary, Harold H. Stowell, Department of Geology, Box 870338, University of Alabama, Tuscaloosa, AL 35487-0338. The deadline is February 1 for grants awarded in April.

The Northeastern Section offers research grants for undergraduate students who are enrolled at institutions within the section and are Student Associates of GSA. Contact the section secretary, Kenneth N. Weaver, Maryland Geological Survey, 2300 St. Paul St., Baltimore, MD 21218, for application forms. Applications must be postmarked by February 7 for grants awarded in April.

The remaining two sections—Rocky Mountain and Cordilleran—do not currently offer research grants. ■

WASHINGTON REPORT

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. These reports present summaries of agency and interagency programs, track legislation, and present insights into Washington, D.C., geopolitics as they pertain to the geosciences.

Glaciers and Vice President Gore

Gore Visits Glacier National Park and Proclaims Global Warming Is a Reality

"My purpose today is not to be alarmist—nor is it to say that we need radical changes in the way we live and work. But it's time to face the facts: Global warming is real. We helped to cause it—and by taking reasonable, common-sense steps, we can help to reduce it."

On September 2, 1997, Vice President Gore visited Glacier National Park, Montana, to present his views on the issue of global climate change. The Vice President also hiked eight miles for a first-hand look at a shrinking glacier, Grinnell, which has receded about 3,100 feet since the 1850s. The Vice President stated that he wanted to see evidence of the effects of global climate change on one of our nation's disappearing natural treasures. Oddly, aside from coverage in Montana newspapers immediately following his visit, his comments and trip have received little attention. Written transcriptions of his presentation are not even available from the White House Press Office.

As previously described (August 1997 Washington Report), climate change is an issue of serious concern to President Clinton and Vice President Gore. In October, the president hosted a White House Conference on the subject to make the case to the American people that important steps are needed to address this problem and to gain insights from business leaders, environmentalists, economists, scientists, and others about how best to move forward. President Clinton is also committed to developing a comprehensive policy, including legally binding targets and timetables for emissions reductions, in time for a major international climate-change negotiation scheduled for this December in Kyoto, Japan. The president has emphasized the importance of flexible, market-based mechanisms for achieving reductions and has insisted that any agreement be truly global in scope, including substantial commitments from developing countries.

As part of a whirlwind one-day round trip, Vice President Gore, speaking at the Many Glacier Hotel, with a backdrop of some of the most spectacular glacial erosion in the country, began his speech with some of the strongest pro-environmental statements that he has made since becoming vice president. He stated, "To look out on Glacier's alpine beauty is to want to preserve it and protect it—for our children, and for our children's children. That's a responsibility President Clinton and I have taken very seriously—not just here in Glacier, but in all of America's special places. That's why we prevented oil and gas drilling in the Arctic Refuge. That's why we preserved 1.7 million precious acres in Utah by creating the Grand Staircase–Escalante National Monument. That's why we protected 1.4 million acres of the unique California desert. That's why we're restoring the Florida Everglades. That's why we're protecting Yellowstone National Park from the dangers of mining on its borders. That's why we're putting record resources into our parks and rivers and wilderness preserves. To President Clinton and me, preserving America's special places isn't just good public policy—it's a moral obligation."

Specifically referring to the park's glaciers, Gore said, "The 50 glaciers in this park— which date back to the last Ice Age, 10,000 years ago—are melting away at an alarming rate. Over the last century, we have lost nearly three-quarters of all the glaciers in this park.... If this trend continues, in about thirty years, there won't be any glaciers left at all.... What's happening at Glacier National Park is part of a global pattern. Glaciers are retreating worldwide. This is strong evidence of global warming over the past century—the disruption of our climate because of greenhouse gas emissions into the atmosphere, all over the world. The overwhelming evidence shows that global warming is no longer a theory—it's a reality. Greenhouse gases keep rising at record rates. The last few decades have been the warmest of this century—and the ten warmest years in this century have all occurred since 1980...."

The vice president stated that scientists recognize that there is a "a discernable human influence on global climate." He continued "If we stay on our present course, scientists predict that average global temperatures will rise by 2 to 6 degrees Fahrenheit in the next century. That may not sound like much. But keep in mind that the difference in temperature between today and the last Ice Age, when all the glaciers in this park were formed, is only about 9 degrees Fahrenheit. That's why, if we fail to act, scientists believe the human impact of global warming will be severe: Infectious diseases could spread, affecting families and children in regions that had been too cold for tropical viruses to survive. Farmers and rural communities could be in jeopardy, since farms depend on a stable climate to be productive. Back in 1988, when we faced both record temperatures and droughts, the United States lost a third of its grain supply. We could face greater floods, droughts, and heat waves. Some see the unusually severe flooding in the Midwest, the Dakotas, and around the country—those "hundred-year floods" that seem to be happening every couple of years now—as early evidence of this. As we see here at Glacier, the impact on our natural heritage and special places could be just as strong."

Well-informed and well-prepared, Gore described the consequences of global warming: "Our seas could rise by one to three feet, flooding thousands of miles of Florida, Louisiana, and other coastal areas. A sea level rise of just one foot could place a third of the Florida Everglades completely underwater; it would also threaten our coral reefs, and endanger the countless varieties of fish that live in them. With warmer temperatures, we could lose important parts of our forests. Some have predicted that the Northeast could lose all of its sugar maples; and in New Hampshire's White Mountains, the fall foliage would lose its vibrant colors."

The vice president offered the following insights into what a Clinton administration response should be: "What we need is an approach that is prudent and balanced. On one hand, we must recognize that energy consumption has led to enormous increases in our standard of living throughout this century , and we want to continue those increases. On the other hand, we see all around us today glaciers that have survived for 10,000 years, now facing the prospect of melting away in a single century. We've seen people struck by severe heat waves—more than 40 lives lost in Chicago just two years ago—and many others who have lost homes, jobs,

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continued from p. 17

even their lives to increasingly heavy storms. We need to understand our role in climate change—and we need to act to address it."

Gore stated that the United States alone cannot stop global warming. "Because winds circle the earth within a few weeks, greenhouse gases don't respect national borders. Any real solution to global warming must be an international solution—including developing nations as well as industrialized ones."

Gore described the future plans of the Clinton Administration as follows: "This December, when the nations of the world meet in Kyoto, Japan, on this issue, the United States will work to achieve realistic, binding limits on the emissions of greenhouse gases. We will emphasize approaches that are flexible and market-based, to give industry the opportunity to develop the most cost-effective solutions. We will continue our efforts in research and development. We will work with industry, with environmental groups, with all who share a stake in this problem here at home. And we will ask all nations, developed and developing, to join with us to meet this challenge."

Gore concluded "We don't have all the answers today. But we know we must reverse the trend of global warming. We must safeguard our precious natural resources, and put a premium on public health and safety. Thirty years from now, I want my grandchildren to live in a world that is safer from disease, freer from droughts and floods, able to grow the food they need for their children and families. But just as importantly, I want them to understand that God created only one earth—and that its parks and forests and wilderness preserves can never be replicated. Our responsibility to this land is one of the most profound and sacred responsibilities we have. It is really a responsibility to each other—and to future generations. Ultimately, that's why we came here today, to the very crown of this continent. We've got to start facing up to that responsibility—not just for the sake of these glaciers that are melting before our very eyes, but for the sake of our children. Here in the shadow of these glorious mountains, let us resolve to make that start—let us protect this land for its rightful inheritors—and let us fulfill our obligation to the millions of families who have yet to enjoy it."

Not everyone agrees with the vice president's evaluation. A press release from the Science & Environmental Policy Project in Fairfax, Virginia, proclaims "Gore's Defense of Glacier Tourism Trivializes Global Warming Debate." It continues "Gore's contention that Montana glaciers are shrinking because of global warming ... represents a considerable concession on the part of climate activists.... Unable to sustain claims of melting ice caps, sea levels halfway up the Washington Monument, drought , hurricanes, pestilence, etc., activists have reduced the debate to a defense of Montana tourism...."

Obviously, this issue is far from being settled. Future Washington Reports will follow the debate closely. ■

GSA Honors 50-Year Fellows

Sam L. Agron
Paul-Emile Auger
Ewart M. Baldwin
Thomas F. Bates
Robert W. Blair
Burton H. Boyum
Donald M. Brown
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Robert A. Christman
Alfred Clebsch
Aureal T. Cross
John C. Crowell
Robert V. Cushman
Wallace De Witt, Jr.
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Paul H. Dudley
William C. Ellis
Weldon D. Frankforter
Charles V. Fulmer
Jacob E. Gair
Robert L. Gamer
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George C. Grow, Jr.
George Gryc
Raymond C. Gutschick
Frederick R. Haeberle
William W. Hambleton
Edwin L. Hamilton
Warren B. Hamilton
Clyde T. Hardy
Milton T. Heald
L. F. Hintze
Douglas L. Inman
Ernest J. W. Irish
Mead Leroy Jensen
Cecil H. Kindle
Ellis L. Krinitzsky
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Ralph L. Langenheim, Jr.
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S. Benedict Levin
John L. Loftis, Jr.
V. Standish Mallory
Samuel T. Martner
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Bruce C. Netschert
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E. Bruce Parmelee
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Athel G. Unklesbay
Joseph E. Upson II
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Edgar L. Weinberg
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Sidney E. White
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Herbert E. Wright, Jr.

GSA Offers Awards in Geomorphology and Micropaleontology

Through the generosity of W. Storrs Cole, two awards for support of research are offered through GSA. The Gladys W. Cole Memorial Research Award provides support for the investigation of the geomorphology of semiarid and arid terrains in the United States and Mexico. It is to be given to a GSA Member or Fellow between 30 and 65 years of age who has published one or more significant papers on geomorphology. Funds cannot be used for work already accomplished, but recipients of a previous award may reapply if additional support is needed to complete their work. The amount of this award in 1998 will be $11,000.

The second award, the W. Storrs Cole Memorial Research Award, has been established to support research in invertebrate micropaleontology. This award will carry a stipend of $9,000 in 1998, and will be given to a GSA Member or Fellow between 30 and 65 years of age who has published one or more significant papers on micropaleontology.

Additional information and application forms may be obtained from the Research Grants Administrator, GSA, P.O. Box 9140, Boulder, CO 80301.

All applications must be postmarked on or before **February 1, 1998.** Actions taken by the Committee on Research Grants will be reported to each applicant in April.

These are two of GSA's most prestigious awards; all qualified researchers are urged to apply.

Denis M. Shaw, Chair, and Andrew Miall, Co-Chair

The tract of land that the world calls North America is under the jurisdiction of three governments—Canada, Mexico, and the United States.

National boundaries are set by political actions and generally have little relation to natural features. Geological boundaries, by contrast, know nothing of politics; the structural units and geological history of North America are common to all three national leaseholders.

The Annual Meeting of the Geological Society of America for 1998 is moving outside the United States, to Toronto, Canada, and the theme for that meeting—Assembly of a Continent—has a dual interpretation. It expresses, first, the commonality of the lands we occupy and, second, our hope and expectation that earth scientists will assemble from all areas of the continent, as well as from around the world.

We shall construct a scientific program built around that theme, and we urge the sponsors of symposia and theme sessions to make use of it. That will, of course, be easiest for regional, structural, tectonic, or stratigraphically related topics. But the metaphor of a common continental crust and evolutionary history for all the human population from the Arctic to the Tropic of Cancer and from 55° to 165° W can be used as a frame for more diverse subjects in anthropology, hydrology, education, geochemistry, Quaternary, environmental studies, petrology, and mineralogy.

Our goals are similar to those expressed for the 1997 meeting in Salt Lake City—to encourage the attendance and participation of geoscientists from all disciplines and all countries, and to build the technical program around their interests, regardless of where they live and work.

At the time of this writing, 13 field trips have been proposed, comprising four in hydrogeology, four in the Grenville, and five in stratigraphy, archaeology, and history of the Great Lakes Region. Trips and the meeting will take place under weather that will be substantially the same from New England across the Midwest.

NEW for '98: **A KEYNOTE SYMPOSIUM** with all-invited speakers will be offered each day (total of four). These sessions will be selected competitively, the primary criterion being excellence. Each topic should be on the leading edge in a scientific category or area of public policy, address broad fundamental problems, be interdisciplinary, or focus on global problems. Divisions, Associated Societies, SAGE, IEE, and GSA *members* may submit proposals. Flexible, creative programming is encouraged. Specific guidelines are available on request from the GSA Meetings Department: **meetings@geosociety.org.** Selection will be on a competitive basis, after review by a panel of Joint Technical Program Committee representatives; the GSA Annual Program Committee will make the final decisions. Web submission is encouraged.

A **SYMPOSIUM** is a group of formal presentations embodying a central topic, designed to promote the exchange of timely or state-of-the-art information. Symposia refer to sessions with ENTIRELY INVITED PAPERS. The symposia formats, either oral or poster (but not mixed), are produced largely at the discretion of designated conveners who are responsible for inviting and scheduling speakers. With the exception of the keynote symposia, only GSA divisions, specified GSA associated societies, and the local annual meeting committee may sponsor symposia—with occasional exceptions. Each society or division selects and approves the conveners of its symposium. There are no restrictions on the lengths of talks or discussion periods, other than those imposed by the half-day limitation. Using 15-minute intervals, this means a maximum of 16 papers in oral mode; however, symposia talks are more frequently 20 minutes long.

THEME SESSIONS are a set of topically focused, volunteered abstracts. Theme sessions are a way of arranging volunteered abstracts into interdisciplinary groupings that make for scientific sense. Themes do not require formal sponsorship by an organization. The stronger theme sessions, however, do benefit from active support (hard work) by those interested in the success of the session.

Theme sessions, which can be either oral or poster, but not mixed, have variable lengths depending on the submitted number of pertinent and high-quality abstracts. However, a minimum of 16 abstracts is usual for an oral theme session. A minimum of 16 is also usual for a poster theme session. If, at the abstracts deadline, sufficient abstracts have not been received, the theme session will

Theme Proposals *continued on p. 20*

Theme Proposals *continued from p. 19*

be dropped, and the papers continued in the review process for standard discipline sessions.

Please note: An abstract submitted to a theme session is considered volunteered, not invited. Since a person may be speaker on only ONE volunteered abstract, please remind your colleagues that if an author submits more than one volunteered abstract with the same person as speaker, all abstracts listing that speaker may be rejected. This limitation does not apply for those who are invited speakers for symposia.

Process for Proposing a Keynote Symposium or Theme Session: Proposals Due January 2, 1998

Proposals for keynote symposia and theme sessions MUST be made using a 1998 submittal form.

We much prefer you use the electronic submittal form that will be on the Web by *November 1* (www.geosociety.org). Paper copies are also available from GSA Headquarters by contacting: (303) 447-2020 x133 or e-mail: meetings@geosociety.org. All proposals must be at GSA by January 2, 1998; this is a hard deadline.

1. Designate a convener (symposium) or advocate (theme session). A convener may invite speakers. On the other hand, the advocate may encourage *(not invite)* abstracts that will fit the theme session's concept. Society or division membership may help the advocate in this process. No doubt, when the theme session title is announced, other papers will be voluntarily submitted in addition to those that were solicited or intended. The theme session advocate will serve as liaison with the *Joint Technical Program Committee (JTPC) organizer* assigned to that theme session. For oral presentations the conveners and advocates usually become the session chairs. Symposia and theme sessions conveners and advocates will be identified in the call for papers (April), the final meeting announcement (June), and usually then again as session chairs.

2. For theme sessions, after choosing a title, select no more than *three* of the categories that best describe the interdisciplinary aspects of the proposal, from the list included on the form. Pick carefully, because authors who submit abstracts will need to select both a session and a category. It is an advocate's responsibility to tell colleagues about the submission categories.

3. Fill in and send the proposal form, including a brief (50 word) description of the subject. This will be used for publication in the call for papers in *GSA Today* and other GSA mailings. Descriptions over 50 words long will be edited.

4. Advise authors to submit abstracts directly to GSA to be received by July 13.

Additional Information

Copies of abstracts will be sent to conveners and advocates by July 21. All volunteered abstracts (including those for theme sessions) will also go to scientific reviewers designated by JTPC members. The theme advocate will then rank the abstracts and arrange them into a *tentative* order of presentation, to aid the JTPC in scheduling. If there are too many abstracts for a theme session, some will have to be moved. If there are a large number of abstracts, however, additional sessions will be allotted to that theme. An advocate has the opportunity at several points to make the priorities and rationale clear to the JTPC organizer.

Conveners will send in a list of their speakers also.

Short (15-minute) introduction or review periods may be added by a convener or advocate at the time of session submittal and are subject to approval by the technical program chairs. Such addition automatically reduces by one the number of abstracts that may be presented.

The standard mode of presentation is a half-day oral session scheduled Monday through Thursday. Usually 16 papers are presented, with slides or displays as visual support. Poster mode proposals will be considered for half-day sessions. The poster mode has the same limitations as the oral mode: Usually a minimum of 16 papers will be necessary to make the theme session viable.

TORONTO
1998 Annual Meeting
October 26–29

Date and Time Preferences

Although exact times have not been finalized for the 1998 meeting, we might anticipate them to be similar to past meetings: Sunday through Thursday, 8:00 a.m.–12 noon and/or 1:30–5:30 p.m.

Volunteered presentations take place only during the official meeting days, Monday through Thursday. Theme sessions, therefore, will not be scheduled on Sunday. Likewise, poster sessions do not occur on Sunday.

The JTPC will arrange the technical program keeping in mind suggestions from societies, divisions, conveners, and advocates. While trying to accommodate the needs of many diverse groups, the technical program chair makes the final scheduling decisions. Quality of the technical program as a whole takes precedence over all other considerations.

Abstracts Schedule

March 1	Paper copy 1998 abstract forms will be available from Nancy Carlson at GSA (303) 447-8850 x161; e-mail: ncarlson@geosociety.org. Conveners and advocates will automatically be mailed a set of forms in March.
May 1	Electronic abstract form will be on GSA home page for active submission. http://www.geosociety.org. (Over 62% of abstracts were successfully submitted electronically in 1997).
July 13	**Abstracts Deadline.** Paper copy original and 5 copies due at GSA. Electronic copies accepted until 12 midnight.
September 1	Accepted abstracts that are submitted electronically will appear on the Web after September 1. All speakers and titles appear on the Web with links to those abstracts submitted electronically.

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BOOK REVIEWS

The Geology of Earthquakes.
By Robert S. Yeats, Kerry Sieh, and Clarence R. Allen. Oxford University Press, New York, 1996, 568 p., $65 (hardbound).

Millennium fervor is upon us, so in that spirit I'll begin with the question: If only one source could be selected to best represent the state of knowledge of earthquakes at the end of the 20th century, would it be *The Geology of Earthquakes*? The question is not frivolous: the book is that good. In fact the authors invoke Charles Richter's 1958 classic *Elementary Seismology* as the model for what they wish to accomplish: a thorough, up-to-date treatment, accessible to a wide-ranging, nonspecialist audience. How well they succeed I'll defer to the end, but the goal is audacious and would be intimidating to a less stellar lineup of scientists. Earthquake science, however, has matured and expanded to the point that it has become embarrassingly clear that someone must take on this challenge, and I congratulate these authors for doing so.

Richter's *Elementary Seismology*—idiosyncratic, somehow simultaneously selective and comprehensive, entertaining and frustrating—has served seismology (and geology) well for nearly 40 years. One could argue that the study of earthquakes as a science in its own right was established by this book. Yet it is astonishing what is *not* to be found there. It was pre–plate tectonics (although its *Geography of Earthquakes* section clearly identifies most now-known plate boundaries and interiors); it also was pre–digital computer, pre-WWSSN, pre–stereographic focal mechanism, pre–seismic moment and moment tensor, and pre–paleoseismology. Therefore, it predated nearly all the concepts and tools used by modern earthquake scientists. Richter synthesizes seismology's early era, but the modern era has nothing comparable.

Earthquakes are *les tremblements de terre* to the French, and indeed the English dictionary definition is "a shaking or trembling of the earth" (Webster's). Not here. True to its title, scant attention is paid to the seismic waves radiated by abrupt fault rupture. Rather, the authors view an earthquake as a "quantum in [the long-term geological process of] building a mountain or pulling apart a valley." This perspective pervades the book; it is very much a book about faults and faulting. Detailed case histories are included for nine surface-faulting earthquakes, and seven excellent historical vignettes describe how early pioneers, ranging from Zechariah (ca. 520 B.C.E.) to Charles Darwin (1809–1882), forged the link between faults and earthquakes. The introductory chapters provide succinct overviews of plate tectonics, rock deformation, geology of the source, seismic waves, tectonic geodesy, Quaternary dating techniques and tectonic geomorphology. For the most part these are comprehensive and well written. The treatment of seismic waves, magnitudes, and seismic moment, however, is cursory, well below the level of the other chapters. Also introductory but placed at the end to wrap things up is a fine philosophical overview of seismic hazard assessment written by Clarence Allen.

The four chapters on faulting are the heart of the book; unlike the introductory material, which is available in many other places, they form a contribution of lasting significance and importance. It's not that the material is new (for example, only about 14% of the 440 figures are original), but I know of no other source where one can find an analysis of active faulting worldwide in the depth and detail found here. Robert Yeats (normal and reverse faults and subduction zone megathrusts) and Kerry Sieh (strike-slip faults) provide masterful overviews of the major faulting regimes of Earth, full of the insight and perspective gained from their lifetimes as students of Earth's curious tendency to release a small proportion of its internal heat energy in brittle, stick-slip fashion.

One apprehension, given the backgrounds of all three authors, is that this book would have a strong California bias. It appears that Yeats et al. were aware of this possibility and strove to avoid it. How successful they were depends on your own biases or lack thereof. I estimate California text and figures occupy between one-fourth and one-third of the book. And let's face it: much of the best knowledge of how faults work and earthquakes occur comes from California studies. The level of editing is good but not infallible. The huge reference list has omissions and errors, and numerous minor glitches turn up, mostly in the introductory chapters (such as the Mid-Atlantic and Australian-Antarctic ridges located midway between active continental margins [p. 11] or 1 Newton being the force that accelerates a mass of 1 g at 1 m/s^2 [p. 71]). Production quality is very good; photographs are crisp and clear, and many reproduced figures have been redrawn for clarity. Cost considerations evidently ruled out use of color, which is unfortunate; I would have preferred a work that overall is first class to go first class.

The appendix Table of Historic[al] Earthquakes with Surface Rupture is alone worth the price of the book. It has 321 entries, with the basic faulting data summarized and the primary reference(s) given. It is more comprehensive than the 1994 Wells and Coppersmith database's 244 entries (for comparison, Richter, Table 14-1, lists 62 examples). One drawback, however, is that only surface rupture lengths and maximum surface offsets are included. No attempt is made to estimate the more difficult but more useful average displacement and subsurface fault dimensions. What is remarkable is that of the approximately 5 million earthquakes ($M_w \geq 5$) that have occurred in historical time (anno Domini), this, the most complete table of surface ruptures, is a mere few hundred, roughly 0.01%. Even if only 1% of the actual number is described, it is evident that coseismic fault rupture that reaches the surface is a very special occurrence indeed.

To return to the initial question: If Richter gave us the best pre–plate tectonics view of the understanding of earthquakes, is *The Geology of Earthquakes* its end-of-the-century heir apparent? No. Whereas Richter uniquely blended the mid-century information content of seismic waves and geology, this book, by intention, addresses only the latter. It does so superbly—better than any other single source. But so much fundamental information on the primary subsurface faulting process is available, if only indirectly, from analysis of the seismic wavefield, the resulting picture is necessarily incomplete. Who can provide the complete picture? The report of the National Academy of Sciences Committee on the Science of Earthquakes, due in 1998, has this as its goal, but no book written by committee has ever amounted to much. No, I believe it will take a Richteresque individual, distilling a lifetime spent puzzling the riddles of earthquakes, to provide us with our elusive millennium benchmark.

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Ocean Circulation Theory. *By Joseph Pedlosky. Springer-Verlag, New York, 1996, 453 p., $89.95.*

Pedlosky is also the author of a previous book, *Geophysical Fluid Dynamics,* from which a whole generation of graduate students in ocean and atmosphere sciences has benefited. As that book deals with the wider subject of fundamental fluid mechanics and its application to geophysical fluids, only one chapter is devoted to ocean circulation theories. The discussion is further limited to homogeneous models, reflecting the state of the knowledge at that time. Since then, major advancements in stratified models have fundamentally altered our understanding of the ocean circulation. Although the field is

Book Reviews *continued on p. 23*

THE GEOLOGY of NORTH AMERICA

VOL. A: GEOLOGY OF NORTH AMERICA — AN OVERVIEW
edited by A. W. Bally and A. R. Palmer, 1988
GNA-A, 629 p., 2 microfiche cards in pocket, 12 plates in slipcase, indexed, ~~$70.00~~ **NOW $35.00**

VOL. C2: PRECAMBRIAN: CONTERMINOUS U.S.
edited by J. C. Reed, Jr., and others, 1993
GNA-C2, 666 p., 7 plates in slipcase, indexed,
~~$98.50~~ **NOW $49.25**

VOL. D2: SEDIMENTARY COVER — NORTH AMERICAN CRATON: U.S.
edited by L. L. Sloss, 1988
GNA-D2, 520 p., 8 plates in slipcase, indexed,
~~$49.50~~ **NOW 24.75**

VOL. F2: THE APPALACHIAN-OUACHITA OROGEN IN THE UNITED STATES
edited by R. D. Hatcher, Jr., W. A. Thomas, and G. W. Viele, 1989
GNA-F2, 781 p., 12 plates in slipcase, indexed, ~~$75.00~~ **NOW $37.50**

PRICES slashed

VOL. G1: THE GEOLOGY OF ALASKA
edited by George Plafker and H. C. Berg, 1994
GNA-G1, 1056 p., indexed, 1 microfiche, 13 plates in slipcase, indexed, ~~$135.00~~ **NOW $67.50**

VOL. G3: THE CORDILLERAN OROGEN: CONTERMINOUS U.S.
edited by B. C. Burchfiel, P. W. Lipman, M. L. Zoback, 1992
GNA-G3, 734 p., indexed, 4 microfiche cards in pocket, 10 plates in slipcase, indexed, ~~$105.00~~ **NOW $52.50**

VOL. H: THE CARIBBEAN REGION
edited by G. Dengo and J. E. Case, 1991
GNA-H, 538 p., indexed, 1 microfiche card in pocket, 14 plates in slipcase, ~~$80.00~~ **NOW $40.00**

VOL. I2: THE ATLANTIC CONTINENTAL MARGIN: U.S.
edited by R. E. Sheridan and J. A. Grow, 1988
GNA-I2, 620 p., 16 plates on 8 sheets in slipcase, indexed,
~~$49.50~~ **NOW $24.75**

VOL. J: THE GULF OF MEXICO BASIN
edited by A. Salvador, 1992
GNA-J, 578 p., 6 plates in slipcase, indexed,
~~$77.50~~ **NOW $38.75**

VOL. K2: QUATERNARY NONGLACIAL GEOLOGY: CONTERMINOUS U.S.
edited by R. B. Morrison, 1991
GNA-K2, 670 p., 8 plates in slipcase, indexed,
~~$85.00~~ **NOW $42.50**

VOL. L: THE ARCTIC OCEAN REGION
edited by A. Grantz, L. Johnson, and J. F. Sweeney, 1990
GNA-L, 654 p., 3 microfiche cards in pocket, 11 plates in slipcase, indexed, ~~$85.00~~ **NOW $42.50**

VOL. M: THE WESTERN NORTH ATLANTIC REGION
edited by P. R. Vogt and B. E. Tucholke, 1986
GNA-M, 720 p., 11 plates in slipcase, indexed,
~~$47.50~~ **NOW $23.75**

VOL. N: THE EASTERN PACIFIC OCEAN AND HAWAII
edited by E. L. Winterer, D. M. Hussong, and R. W. Decker, 1989
GNA-N, 577 p., 12 plates in slipcase, indexed, ~~$54.50~~ **NOW $27.75**

VOL. O2: HYDROGEOLOGY
edited by W. Back, P. R. Seaber, and J. S. Rosenshein, 1988
GNA-O2, 534 p., 3 pocket plates, indexed, ~~$55.00~~ **NOW $27.50**

VOL P2: ECONOMIC GEOLOGY, U.S.
edited by R. B. Taylor, D. D. Rice, and H. J. Gluskoter, 1991
GNA-P2, 630 p., 9 plates in slipcase, indexed,
~~$80.00~~ **NOW $40.00**

VOL P3: ECONOMIC GEOLOGY: MEXICO
edited by G. P. Salas; translated into English by C. Petzall, 1991
GNA-P3, 448 p., indexed, ~~$62.50~~ **NOW $35.00**

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The Decade of North American Geology DNAG

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still rapidly evolving, a certain degree of maturity has been attained that calls for a synthesis of existing theories, to take stock of what we know and don't yet know, and possibly reveal venues for future research. This need is particularly acute for graduate students and researchers just entering the field who would like to get an overview of the subject. The publication of this book is thus quite timely, and fulfills this need admirably.

The book begins with a short discussion of Sverdrup balance, which was proposed more than half a century ago and remains the foundation of most ocean circulation theories. Pedlosky then proceeds to discuss theories of a homogeneous ocean, a stratified ocean, the equatorial undercurrent, and abyssal circulation. Pedlosky has made major contributions to all these areas, as clearly manifested in his in-depth discussion of the subjects. While this familiarity may have influenced topic selection, the progression is quite logical and covers most aspects of general ocean circulation.

In the discussion of Sverdrup balance, I found the cautionary note regarding the scant observational evidence of the balance particularly welcome. Eddy-resolving numerical calculations carried out recently to address the question are not mentioned, perhaps for the reason that it is more difficult to interpret numerical results. The chapter on homogeneous models contains some standard materials, but also extensive discussion on dynamical consistency of the Sverdrup balance. Considerable coverage is devoted to the study of Ierley and Ruehr, which is undoubtedly the most comprehensive to date. While the original work of Il'in and Kamenkovich is acknowledged, it should also be noted that essential physics leading to the singular perturbation of the Sverdrup interior is not much different from that of the classical problem of boundary-layer separation. This physics is well explained, for example, in Batchelor's *Introduction to Fluid Dynamics*. Much of the singular behavior discussed in the chapter of course stems from the assumed laminar dynamics. As Pedlosky puts it nicely, "It is really we and not the fluid that experience the difficulty."

In the chapters on stratified models, Pedlosky first considers the case when density surfaces are displaced only slightly from being level, and then when they intersect the surface. This is followed by a brief discussion of nonadiabatic effects. Important dynamical concepts such as geostrophic contour, potential vorticity mixing, shadow zone, and beta spiral are introduced. Pedlosky should be commended for inclusion of numerical calculations and observational data in support of dynamical deductions. With regard to mixing of potential vorticity, since the contour maps presented are valid only outside strong currents, they can be supplemented by observations across boundary currents (Gulf Stream, for example). Taken together, these observations suggest a homogenization of potential vorticity more general than implied by the conditions of its original derivation. To account for this, Pedlosky mentions the possible importance of eddy mixing, which may not be parameterized in terms of a constant eddy diffusivity. This is a subject of great importance which has not yet been fully integrated into existing theories.

As is characteristic of Pedlosky's approach, the derivations in the book are generally rigorous and precise. One minor concern is that detailed analyses of some subtler features may elude readers as to their physical significance and relevance to the ocean. Examples include an ocean of more than two layers and a submarine ridge with multiple openings. Whereas their inclusion provides a more complete account, one should guard against reading too much into idealized models, the use-

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Book Reviews *continued from p. 23*

fulness of which lies in their simplicity and robustness. I also feel that additional physical explanations on a more intuitive level would have helped readers in more difficult passages.

Overall, the book is quite extensive in its coverage of large-scale ocean circulation, although I would have preferred a more prominent role ascribed to eddies. The book is well organized and written with care. It should serve as a valuable reference source for all researchers interested in general ocean circulation. Because the material is derived from a graduate course that Pedlosky has taught, the book is also suitable as a textbook, but only for advanced students who have some familiarity with fluid dynamics.

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Fluid Physics in Geology. *By David Jon Furbish. Oxford University Press, New York, 1997, 476 p., $62.50.*

Several years ago, while browsing in my university library, I found myself moderately insulted by a book entitled *Geophysical Fluid Dynamics;* this is not the classic by J. Pedlosky, but another of the many with that title (or some variation of it). The insult was the author's initial assertion that GFD (geophysical fluid dynamics) is, strictly speaking, fluid dynamics, which takes into account Earth's rotation. Being someone who mainly worries about the fluid mechanics of Earth's solid yet mobile mantle, for which rotation is unimportant, I felt excluded and marginalized, albeit briefly (i.e., for however long it took me to slap the book closed). Nevertheless, to many scientists, the term "GFD" somehow excludes the dynamics of almost 70% of the mass of Earth—i.e., that which is nominally solid (the other 30% is the liquid outer core, not the oceans and atmosphere).

Thus, it is particularly consoling to find a legitimate text on the fluid dynamics of the solid earth: *Fluid Physics in Geology.* (The book claims only to cover the physics of fluids on and in the Earth's crust; however, it covers the essential fluid dynamics for the mantle as well, and thus the book is broader than author David Jon Furbish states.) There are indeed other texts on applications of continuum mechanics in the geological sciences; but in these texts, fluid flow is only a part of the overall coverage. *Fluid Physics in Geology* is one of the first attempts (that I am aware of) to provide a comprehensive study of fluids as appropriate for geology. Like most engineering or physics books on fluid mechanics, this book includes treatments of dimensional analysis (e.g., the Buckingham Pi theorem), fluid statics, kinematics (how motion is mathematically described), the basic conservation laws of mass and energy, and then inviscid, viscous, and finally turbulent flows. However, the book also provides two features that are unique for a fluid mechanics text. First, in addition to the aforementioned types of flow, it gives a thorough treatment of fundamental porous media flow; this is vitally important for the many geoscience students whose best prospects for postgraduate employment are currently in hydrology and environmental science. Second, the book builds on an introduction to the fundamental microscopic and statistical physics of fluids, porous media, and fluid properties (e.g., what does viscosity mean in terms of the molecular exchange of momentum); this is (to my knowledge) a rarity among general fluids texts and is in fact extremely refreshing and enlightening. It is for this reason that the book is titled rightly *Fluid Physics …* instead of *Fluid Dynamics….*

Fluid Physics in Geology is very clearly and well written (though perhaps not concise and at times downright chatty; but even this is better than being too terse), and the physics is presented rigorously, for the most part (more on this below). Each chapter has an excellent layout, giving first the fundamental concepts, followed by a series of worked, sometimes quite complex, geologically relevant examples. The range of examples, however, could have been greatly broadened. In particular, perhaps too many examples involve two-dimensional channel flow (or some variation of it) while other classic geological flow problems, such as diapirism (e.g., salt domes and granitic plutons) and gravity currents (finite fluid masses spreading under their own weight, such as lava flows and oil slicks), are ignored completely. Nevertheless, I would (and probably will) use it as a textbook in my own classes, and I cannot give it a higher recommendation than that.

However, the book is not perfect; it contains enough inconsistencies and lapses in rigor to keep it from being an authoritative fluid dynamics text. For example, in the midst of a lengthy and careful derivation of the conservation of energy equation, the book incorrectly associates internal energy with temperature only (in fact, internal energy must be at least a function of two thermodynamic variables, most simply entropy and density); moreover, this slight of hand is done by using the ideal gas law, even though the treatment involves dissipative heating in viscous fluids (which are clearly not ideal gases). The book also errs in several discussions involving elasticity and compressibility. For example, acoustic wave speed is mistakenly associated with the modulus of isothermal compressibility (instead of adiabatic compressibility), and the variation of density with pressure for a constant compressibility is used to show that material gets less compressible the more dense it becomes (somewhat self-contradictory, given the assumption of constant compressibility). Perhaps the most egregious error is that of highlighting the importance of the incompressible, constant-viscosity, viscous flow (Navier-Stokes) equations by summarizing them in their own brief subsection. Following the flow equation, the book lists density as a general (not necessarily slowly varying) function of temperature and pressure (in violation of the incompressibility assumption), and viscosity as temperature-dependent (in violation of the isoviscous approximation).

The shortcomings listed above (and others not worth mentioning) are perhaps relatively minor infractions that possibly only a fluid dynamicist could get excited about. Nonetheless, they entail fundamental physical concepts of which the instructor and student (and author) should be aware. Even so, this book is a highly welcome first attempt at rigorously defining the field of geological fluid dynamics. Although as a text it should be used with caution, it fills an important niche in giving a comprehensive coverage of geologically relevant fluid physics. Thus, I would strongly recommend it as a well-structured, adequately rigorous text for an extremely useful course in geological fluid mechanics.

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Preliminary Announcement

ROCKY MOUNTAIN SECTION, GSA 50th Annual Meeting

Flagstaff, Arizona
May 25–26, 1998

SETTING

Flagstaff, Arizona, will host the 1998 Rocky Mountain Section meeting of the Geological Society of America. The meeting will be held on the campus of Northern Arizona University. The city is at the base of San Francisco Mountain, a composite cone over 12,600 feet in elevation and the highest point in Arizona. The San Francisco volcanic field covers approximately 2,000 square miles along the southern margin of the Colorado Plateau. There are more than 550 vents in the area, the latest eruption having occurred in A.D. 1065—Sunset Crater. The crater is 15 miles north of Flagstaff and is but one of many easily accessible volcanic features in the area. Flagstaff is on the southern margin of the Colorado Plateau province near the transition into the Basin and Range to the south. Excellent exposures of mid- to late Paleozoic strata occur south of Flagstaff in the Red Rock country near Sedona, Arizona. To the north, fluvial and eolian strata of Triassic and Jurassic age crop out throughout the Navajo and Hopi reservations and in the Lake Powell–Glen Canyon region. Grand Canyon National Park is 80 miles north of Flagstaff, and Petrified Forest National Park is 120 miles to the east.

In late May, the days are typically clear, and temperatures average 75–80 degrees F; nights are cool and pleasant. There is little precipitation this time of year.

Flagstaff lies at the junction of Interstates 40 and 17 and thus is easily reached by car. Rail service is available from the east and west, and Flagstaff airport is located approximately 3 miles south of the city.

CALL FOR PAPERS

Technical papers are invited for presentation in conventional theme sessions, various symposia, and poster sessions. The talks and posters will address all aspects of Rocky Mountain and Colorado Plateau geology. There will be 15 minutes for presentations and 5 minutes for discussions. Details for the posters sessions will be provided to the participants.

REGISTRATION

Preregistration by mail will be handled by the Geological Society of America Meetings Department, P.O. Box 9140, Boulder, CO 80301-9140. Registration details and forms will be published in *GSA Today* in February 1998. On-site registration will begin on May 24, 1998. For additional information, please contact Michael Ort, Registration Chairperson, Dept. of Geology, Northern Arizona University, Flagstaff, AZ 86011, Michael.Ort@nau.edu.

GSA is committed to making every event at the 1998 Rocky Mountain Section meeting accessible to all people. If you have any special needs, such as an interpreter or wheelchair, these will be provided. Please contact Larry Middleton (Larry.Middleton@nau.edu) or (520) 523-2429 by March 15, 1998.

FIELD TRIPS

Both pre- and postmeeting field trips have been planned. For details, please contact the field trip leaders; postal address for those at NAU is: Dept. of Geology, Northern Arizona University, Flagstaff, AZ 86011. General inquiries can be directed to the Field Trip Chair Ernie Duebendorfer, (520) 523-7510 or ernie.d@nau.edu, Dept. of Geology, Northern Arizona University, Flagstaff, AZ 86011.

1. **Miocene Volcanism and Geomorphology in Verde Valley and Petrology of Alkaline Rocks at House Mountain Shield Volcano, Sedona, Arizona.** 1 day. Richard Holm, NAU, dfh@al.ucc.nau.edu; Wayne Ranney, Zia Enterprises, Flagstaff; Kathryn Lee and James Witke, NAU.
2. **Exploration for and Ecological Importance of Shallow and Deep Ground Water Around the San Francisco Mountains.** 1 day. Abe Springer, NAU, aes@vishnu.glg.nau.edu; Don Bulls, USGS, Flagstaff.
3. **Volcanism and Sedimentation in the Miocene-Pliocene Hopi Buttes and Hopi Lake.** 2 days. Michael Ort, NAU, mho@nauvax.ucc.nau.edu; Jorge Vazquez, Todd Dallegge, and Wendell Duffield, NAU and USGS, Flagstaff.
4. **Permian Rocks in North-Central Arizona: A Comparison of the Sections at Grand Canyon and Sedona.** 2 days. Ronald Blakey, NAU, rcb@vishnu.glg.nau.edu; Larry Middleton, NAU.
5. **Structure and Metamorphism of Proterozoic Rocks Within the Mojave-Yavapai Boundary Zone, Northwestern Arizona.** 2 days. Ernie Duebendorfer, NAU, ernie.d@nau.edu; Matt Nyman, Dept. of Geological Sciences, University of Michigan, Ann Arbor, MI 48109.
6. **Tertiary Volcanic and Sedimentary Units and Structures Across the Central Arizona Transition Zone.** 1 day. Robert S. Leighty, Arizona Geological Survey, 416 Congress St., Suite 100, Tucson, AZ 85701, leighty@asu.edu.
7. **Floods, Debris Flows and Geomorphology Along the Colorado River, Grand Canyon.** Richard Hereford, U.S. Geological Survey, 2255 N. Gemini Dr., Flagstaff, AZ 86001, (520) 556-7159.

SYMPOSIA

The following symposia topics have been submitted, and it is anticipated that other specialized topics will be added. General questions concerning symposia should be addressed to Wendell Duffield, Technical Program Coordinator, U.S. Geological Survey, 2255 N. Gemini Dr., Flagstaff, AZ 86001, (520) 556-7205, wdufffield@flagmail.wr.usgs.gov. For the symposia below, prospective authors should contact individual chairmen. The postal address for those at NAU is Dept. of Geology, Northern Arizona University, Flagstaff, AZ 86001.

1. **Tertiary Evolution of the Transition Zone.** Nancy Riggs, NAU, Nancy.Riggs@nau.edu.
2. **Paleontologic and Stratigraphic Studies in the Grand Canyon Area: A Symposium in Honor of Stanley S. Beus.** David Elliott, NAU, David.Elliott@nau.edu.
3. **Synthesis of Recent Geomorphic Research Along the Colorado River.** Richard Hereford, U.S. Geological Survey, 2255 N. Gemini Dr., Flagstaff, AZ 86001, rhereford@flagmail.wr.usgs.gov.
4. **Evolution of Mid- to Late Proterozoic Basins in the Southwest—Tectonic and Depositional Settings.** Larry Middleton, NAU, Larry.Middleton@nau.edu.
5. **Late Cenozoic Evolution of the Colorado Plateau.** Jon Spencer, Arizona Geological Survey, 416 Congress St., Suite 100, Tucson, AZ 85701, jspencer@geo.arizona.edu.
6. **Geological Framework of the Grand Staircase–Escalante Monument Area.** Wendell Duffield, U.S. Geological Survey, 2255 N. Gemini Dr., Flagstaff, AZ 86001, wduffield@flagmail.wr.usgs.gov.
7. **Tectonics of the Southern Rio Grande Rift and Adjacent Basin and Range—Their Connection.** Greg Mack,

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Dept. of Geological Sciences, New Mexico State University, Las Cruces, NM 88003, gmack@nmsu.edu.

8. **Geoscience and Environmental Science Education Using Computer Multimedia: What Works and Why.** Michael Kelly, Center for Environmental Sciences and Education, NAU, Michael.Kelly@nau.edu.

9. **Middle and Late Mesozoic Tectonics of the Borderland: From Bisbee Extension to Laramide Shortening.** Timothy Lawton, Dept., of Geological Sciences, New Mexico State University, Las Cruces, NM 88003, tlawton@nmsu.edu.

10. **Active Tectonics of the Central and Northern Rocky Mountains.** David Lageson, Dept. of Earth Sciences, Montana State University, Bozeman, MT 59717-0348, uesam@msu.ocs.montana.edu.

11. **Water Quantity and Quality Issues Related to Perched Aquifers.** Abe Springer, Dept. of Geology, Northern Arizona University, Flagstaff, AZ 86011, Abe.Springer@nau.edu.

ABSTRACTS

Abstracts are limited to 250 words and must be submitted on official GSA abstract forms, available from Abstract Coordinator, Geological Society of America, P.O. Box 9140, Boulder, CO 80301, (303) 447-2020 or ncarlson@geosociety.org. An original and 5 copies are required for each abstract. Only one paper may be presented by each individual, although a person may be coauthor of additional papers. Please send abstracts to Wendell Duffield, U.S. Geological Survey, 2255 N. Gemini Dr., Flagstaff, AZ 86001.

Abstract deadline—January 8, 1998

PROJECTION EQUIPMENT

Projection equipment will be provided for standard 35 mm slides. Two projectors and two screens will be available. Authors should provide their own carousel, although a limited number will be available.

EXHIBITS

The cost for exhibit space will be $50 for an area about 12 by 12 feet. For further information, contact Paul Umhoefer, Dept. of Geology, Northern Arizona University, Flagstaff, AZ 86011, (520) 523-6464, Paul.Umhoefer@nau.edu.

STUDENT PRESENTATIONS

Awards will be given for the best and second best papers by a student. The Rocky Mountain Section of GSA strongly encourages students to present their research.

STUDENT TRAVEL SUPPORT

The GSA Rocky Mountain Section has funds to support travel to the meeting for students. Please submit requests to Ken Kolm, Division of Environmental Science and Engineering Department, Colorado School of Mines, Golden, CO 80401, kkolm@mines.colorado.edu.

Applications must be received by *March 15, 1998.*

SPECIAL EVENTS and GUEST PROGRAM

Planned events include a welcoming reception on the evening of May 24, 1998, and possibly a reception at the Museum of Northern Arizona. Section business meetings will also be held during the conference.

In addition to its excellent climate, Flagstaff offers the opportunity for visits to museums, ruins, the lovely Red Rock country of Sedona (30 miles to the south), and a scenic rail ride to Grand Canyon. There will be lots to do this Memorial Day weekend, and Flagstaff is the ideal place.

Address inquiries to Ronald Blakey, Special Events Chairperson, Dept. of Geology, Northern Arizona University, Flagstaff, AZ 86011, Ronald.Blakey@nau.edu.

ACCOMMODATIONS

Blocks of rooms have been reserved on the campus of Northern Arizona University, only a few minutes walk from the Dubois Center, the site of the sessions. A list of available local motels and hotels will be provided in the final announcement.

DETAILED INFORMATION

More information concerning registration, lodging, activities, and the program will be provided with the final announcement in *GSA Today,* and as part of the Rocky Mountain Section *Abstracts with Programs.* Address questions concerning registration to Michael Ort, Dept. of Geology, Northern Arizona University, Flagstaff, AZ 86011, Michael.Ort@nau.edu, and any other general questions to Larry Middleton, NAU, address above, Larry.Middleton@nau.edu., fax 520-523-9220. We hope to see you in Flagstaff in May! ■

New GSA Members

The following 934 Members were elected by Council action during the period from October 1996 to February 1997. (An asterisk indicates a transfer from Student Associate to Member status.)

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*Peter N. Adams
Kent F. Adamson
Guy W. Adema
Philippe Agard
*Kerry L. Aggen
Kevin E. Ahern
Jeff C. Aitken
Deborah E. Ajakaiye
Abdulhanit Akalin
Christine L. Albanese
Bashir A. Alfotawi
Betsy L. Allen
Charles E. Allen
John R. L. Allen
*Kambra M. Allen
Robert M. Allender
Richard B. Alley
Selma Alpay
Randall G. Alpizar
*Douglas E. Alsdorf
Stephen P. Altaner
C. Kevin Anderson
Dawn M. Anderson
*Gregory J. Anderson
Keri A. Anderson
*Lisa M. Anderson
Roger S. Anderson
*Ulf B. Andersson
Charles B. Andrews
Javier Arzote-Arroyo
Barbara C. Atkin
*Margaret M. Avard
Danielle M. Ayan
Stefan Back
Mara C. Bacsujlaky
Adrian C. Badescu
Lyle F. Baie
*Suzanne E. Bailey
Jean M. Baker
James W. Ball
Kia K. Baptist
*Marcy R. Barbour
*Edy M. Barillas
Michael F. Barinek
Ralph A. Barnes
*Bax R. Barton
*Karen A. Batten
*Lisa A. Battiato
Pattie C. Baucom
Thomas J. Bauman
Dmitry A. Bazykin
Deborah L. Beck
E. Glynn Beck
Mary A. Beck
Brian D. Begley
Rose-Anna Behr
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Jerome A. Bellian
Bryan E. Bemis
Steven R. Benham
*Kenneth D. Bergenham
Jennifer K. Bergin
Andrew P. Berkoski
Hermann Bermudez Aguirre
Michelle Bernard
Bruce G. Bernel
Bernardino Bertossa
Nathan E. Berube
Maryk R. Besonen
Gregg S. Beukelman
Patricia Beyer
*Adam E. Bielecki
Sue Ann Bilbey
Ilya N. Bindeman
Elisabeth Birkeland
Janice L. Bishop
Michele G. Bishop
Ronald E. Blackstone
Glenn W. Blaylock
Erich S. Bloodaxe
Steve M. Bohaty
Brian K. Bohm
Dudley W. Bolyard
Kevin W. Bonar
Matthew H. Bond
Susanne M. Borchert
*Fiorenzo Bordignon
Bernadette Bosie
Terence J. Bottrill
Michelle P. Boulet
*Theresa M. Boundy
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Walter W. Boyd
Deena G. Braunstein
Emily S. Bray
Lee E. Bray
Brendan R. Bream
Kim C. Brenner
Anna B. Breuninger
Gloria C. C. Britton
Thomas M. Brocher
Sarah L. Brown
Victoria L. Bruce
*Kristine M. Bryan
Natalia A. Bryxina
Leif M. Burge
Robert L. Burger
John E. Burghardt
Neil R. Burns
*William M. Burns
*John H. Burris
*Cynthia A. Burtnett
*Jay Patrick Busch
*Jeffrey M. Byrnes
Jose M. Calaforra
Nadine Calis
Carlos M. Camilletti
*Richard K. Carey
David Carleton
Sharman L. Carpenter
Duane B. Carter
Robert R. Casavant
Susan M. Casby-Horton
Enrico Casolari
Jonathan M. Castro
Jennifer L. Celeste
Michael Chapin
Amberlee E. Chaussee
Xunhong Chen
Fiona C. Childe
*Karen Chin
Moonsup Cho
*Ann M. Christensen
*Chris T. Christensen
Constance M. Christensen
*Frank C. Chuang
Thomas M. Church
Dick T. Claeson
Robert A. Claiborne, Sr.
Jeffrey J. Clark
Jordan F. Clark
Chris R. Clarkson
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*Brian P. Coffey
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Lee Ann Colarusso
Neil M. Coleman
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Jonathan W. Collier
Geoffrey C. Collins
Debra C. Colodner
*Sean L. Connin
*Katherine A. Connors
Stephen Conrad
Glenn S. Cook
*Michele L. Cooke
Janette L. Cookman
Christina L. Coppeler
Brian E. Corbett
Richard L. Coren
John P. Coughlon
*Brent A. Couzens
*E. Jun Cowan
Randel Tom Cox
Andrea Cozzi
Chapman L. Creighton
*Christopher M. Crescini
Thomas M. Cronin
*Rodney A. Crother
Mark F. Cummings
Tara M. Curtin
Frank J. Cynar
Dyanna M. Czeck
Adel A. Dabous
Matthew J. Dagon
*Todd A. Dallegge
Lisa R. Danielson
David W. Davenport
*Xan M. Davidson
Andrew G. S. Davies
Katherine S. Davies-Vollum
Marsha A. Davis
Penny Davis
Philip J. Davis
*Nancye H. Dawers
Sarah K. Deans
Peter F. DeCosta
Nicole A. Delude
Xinhua Deng
*Steven R. Dent
Catherine M. Dentan
Lisa S. Dernbach
Gina DeRosa
*Elisa E. Detels
Eric W. Dewar
*Edwin J. DeYoung
Camelia C. Diaconescu
Loretta "Lori" D. Dickson
Nathaniel W. Diedrich
Allen Dodson
James M. Dohm
K. Lyle Dokken
Lisa A. Doner
Timothy D. A. Donohue
Paul J. Donovan
Neal A. Doran
Barry G. Dorman
*Pierre Doucet
Carolyn B. Dowling
Erich Draganits
Robert A. Drake
*Vicki G. Drake
Steve Drda
*Brenda L. Driscoll
Rebecca M. Drury
Sarah E. Duffell
Thomas B. Dunkin
Michael T. Dunn
*Anna M. Duzs-Moore
*Gary S. Dwyer
*Sam Earman
Shane W. Ebert
*Ken S. Eden
William B. Egeland
C. Dale Elifrits
Ann L. Elledge
Annette S. Engel
Atsuhito Ennyu
Mark A. Erickson
E. K. Esawi
*Marcia A. Escamilla
Azat Eslamyzadeh
Sonia Esperanca
Andrew Evans, Jr.
Jeffrey C. Evans
William D. Everham
*Inge Ewing
June T. Fabryka-Martin
Stewart J. Fallon
Elfatih A. Farah
*Edward C. Farren
*Mostafa Fayek
Todd C. Feeley
Benjamin S. Felzer
Thomas R. Fenn
*Vera A. Fernandes
Scott R. Fidler
Sarah J. Finley
Seth Finnegan
*Sue A. Finstick
Rocco A. Fiori
Catherine A. Fisher
Tina G. Fitts
Jeffrey Flanzenbaum
Alastair Fleming
*Susan L. Folkert
*Robert E. Forsberg
John N. Foster
*Umberto Fracassi
Edward F. Frank
Mark R. Frank
S. Edward Franz
*Christian L. Frederick
Glen G. Fredlund
Claire Freydier
Wolfgang Frisch
Todd G. Fritch
Silvia Fumagalli
*Richard L. Funk
Brandon A. Gaither
Beatriz Garcia-Fresca
Mary I. Garland
Andrew J. Gavin
*Allen Gellis
Lynn M Gentile
Brenda Kirkland George
Christopher C. Gerbi
*Martha L. Gerdes
*Brian J. Gerike
Ayati Ghosh
Todd D. Gibbs
Heather-Marie Gibson
Michael A. Gibson
Shawn M. Gibson
Reto Giere
James C. Gierke
Andrew B. Gilbert
Bruce E. Gillett

New Members
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New GSA Fellows

The following 33 Members were advanced to Fellowship in May 1997.

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Ginger A. Barth
Colleen Barton
Mark T. Brandon
Gordon E. Brown, Jr.
Lokesh Chaturvedi
Chen-Lin Chou
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Anita L. Grunder
Ilmari J. Haapala
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Alan Levander
Kate C. Miller
Daniel R. Sarewitz
Lauret E. Savoy
Paul G. Silver
Richard P. Smith
Sean C. Solomon
Don W. Steeples
John R. Sumner
Peter K. Swart
Kenneth L. Taylor
Scott W. Tyler
Kenneth L. Verosub

New Members
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Holly S. Godsey
*Victoria G. Goetcheus
Elias Gomez
Adam Y. Goodman
David H. Goodwin
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*John C. Gosse
Steven C. Gottschalk
Gregory B. Graham
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Joseph R. Graney
Floyd Gray
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Martha A. House
*P. Kyle House
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Katherine M. Howard
James R. Howell
Richard G. Hoy
Bill Hoyne
*Jean C. Hsieh
Shawsong Huang
Jessica L. Huckemeyer
Laura L. Hult
*Richard C. Hummel III
Amber G. Huntoon
John V. Hurley
Jose M. Hurtado, Jr.
Matthew T. Hurtgen
Muin M. Husain
Kevin S. Hutchins
Randall D. Hutchins
*Jimmie L. Hutchison
James A. Hyatt
Hyoun-soo Lim
Motomu Ibaraki
*Bradley R. Ilg
Noam R. Izenberg
Bruce M. Jackson
Patricia B. Jackson
Ken R. Jacobs
*Stephen E. Jacobson
Faisal Jaffri
Bruce R. James
*Dawn E. Janney
Robert J. Janosy
Michael D. Jarvis
Margaret A. Jodry
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Brenton C. Johnson
Diane A. Johnston
Mark E. Jones
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Hiroshi Kawamura
Glenn B. Kays
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Elizabeth H. Keating
Rita D. Keefe
David C. Keith
*Randall A. Keller
Katie KellerLynn
Chris R. Kelson
Elizabeth M. Kennedy
Dale A. Kerner
William E. Kiene
Quinn T. Kiley
Tae J. Kim
Michael E. Kimlicko
*Geoffrey S. King
*Brian T. Kirchner
Mark A. Kirschbaum
Hans F. Kishel
*Cynthia E. Kissler
*Robert T. Klein
Jennifer Ann Kling
Joseph P. Klinger
Irina Kogan
*Michelle A. Kominz
Akachai Kongsawast
*Daniel J. Koning
Sarah K. Konrad
Michael S. Kovacs
Dana N. Kovaric
Pablo Kraemer
*Adam Kronen
Keith A. Krugh
James D. Kubicki
*Aaron J. Kullman
Alok Kumar
Anish Kumar
Niraj Kumar
Tina M. Kurtz
Sung-Tack Kwon
Phivos C. Kyprianou
Elizabeth Lacey
John I. LaFave
*Andreas Lang
Kathryn C. Langley
Christina J. Langston
Matthew K. Larsen
Al Larson
Kathryn R. Larson
Zakaria Lasemi
William L. Lassetter, Jr.
Eric A. Lauha
Jeremy J. Lawton
Jonathan N. Leahy
*Hermann Lebit
Denis R. LeBlanc
Hyo N. Lee
*Katherine F. Lee
Oliver T. H. Lehnert
*Kathleen J. Lemke
*Halard L. Lescinsky
Rebecca S. Lesher
Amy Leventer
Meghan H. Lewis
Matthew Leybourne
Zhiping Li
Juan H. Lias
*Johan Liebens
*Jennifer M. Lien
Robert T. Lierman
*Tsung-Yi Lin
Lonnie L. Lincoln
Sherri L. Littman
Brenda A. Lloyd
Stefanie E. Loader
Robert E. Locklair
Rowan Lockwood
Andrew S. Long
Timothy R. Long
Caroline M. Loop
Charles J. Lord
Jason S. Lore
Anthony R. Lotimer
Stephen E. Lowe
Karl W. Luckert
Marjorie A. Lucks
John A. Luczaj
Ramon Luna-Barcelo
Sebastian Luning
Amy S. Lunt
L. Kirk Lurvey
Christopher B. Mader
Charles W. Magee
Arshad Mahmood
Brian J. Mailloux
*Kent Malinowsky
*Paul E. Malmquist
Joseph M. Mankelow
*William F. Manley
Lorraine A. Manz
*Jacques A. Marcillac
Paul G. Marinos
Jeffrey C. Markussen
Charles M. Maroni
Kenneth R. Mars
Gerald J. Marshall
Laura E. Marston
*Jennifer P. Martin
Calvin M. Mather
Patrick D. Mattie
Jennifer M. Maude
*David P. Mayo
Charles L. McIlvaine IV
Constance E. McCambridge
Ann McCartney
*Walter B. McClendon
*Vicki S. McConnell
Tamsin C. McCormick
Timothy McCormick
Christine M. McCracken
Bryan B. McDonald
Christopher R. McFarlan
Mary McGann
Sheila R. McGinty
*Emmet H. McGuire
Larry D. McKay
Sean A. McKenna
Margaret E. McMillan
Allen K. McNamara
Alfred J. Mead
Esther E. Meader
James M. Mehegan
Sunil Mehta
Leslie A. Melim
Jennifer M. Menges
Matthew F. Mercurio
Clifford R. Merz
*William P. Meurer
Beverly D. Meyer
Karin L. Meyer
*Robert P. Meyer
Diana Meza
Jochen E. Mezger
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*Elizabeth J. Miksa
*Donald D. Miller
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Nancy Milton
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Steve A. Mizell
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Jessica D. Moore
Seth C. Moran
*Bonnie A. Morris
Lance Morris
Amy D. Morrison
Wendy E. M. Morrison
*David S. Morse
*John L. Mosley
A. Elizabeth Moundalexis
Erik A. Munroe
Hilary Muray
Candice M. Murphy
Kyle E. Murray
*Laura A. Murray
Richard L. Naff
Sonia A. Nagorski
Pedro Najar
*Tamara J. Nameroff
Edward N. Nealson
Jessica L. Nelson
Elizabeth A. Nemeth
Pete L. Nester
Dennis L. Newell
*Brent D. Newman
Robert L. Niblack
Douglas J. Nichols
Michael D. Nielsen
Christopher R. Niendorf
*Jose M. Nieto
Harlan B. Niles
Benito A. Noguez
Katy F. Noltimier
Britt H. Norlander
Rebecca J. Norman
*Clyde J. Northrup III
Kent S. Novakowski
*L. "Koldo" Nunez-Betelu
Jack K. Odum
Karen L. Ogden
Bwire S. Ojiambo
Karl H. Oliver
Gary A. Olmstead
Susannah Y. Oram
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Marcos A. Ortega-Guerrero
Bette L. Otto-Bliesner
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Johan Pae
Alois F. Pajak III
Tatyana M. Pak
David M. Palleiko
Mao Pan
Rongsheng Pan
Dinu I. Pana
*Kurt S. Panter
Young-Rok Park
*Mary A. Parke
*Beth L. Parker
Jan Pasava
Sandra Passchter
Karen A. Pate
Carrie J. Patterson
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*Michael R. Paul
*Timothy S. Paulsen
Lucia M. Peabody
Ian Pearson
*Jane N. Pedrick
Christopher J. Pepino
*Daniel J. Perez
Jaime G. Perez
Arndt Peterhaensel
Eric W. Peterson
Sam E. Phifer
Thomas Pichler
Kevin T. Pickering
Andrew H. Pitner
Piret Plink
L. Niel Plummer
Robert M. Pockar
Dana K. Polacsek
Ekaterina M. Polkanova
Caleb J. Pollock
Gayle L. Pollock
Warren A. Potma
*Lee S. Potter
Melissa L. Pratt
Maria G. Prokopenko
Jodi L. Purser
*Michael J. Quinn
Andrew G. Raby
Elizabeth A. Rachman
*Bret Rahe
*Michael S. Ramsey
*Wayne E. Randolph
*Eugene C. Rankey
Adam S. Read
Jason A. Rech
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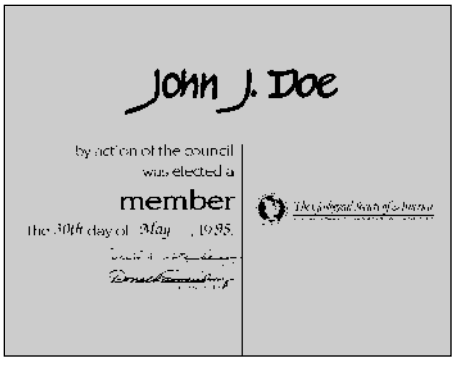

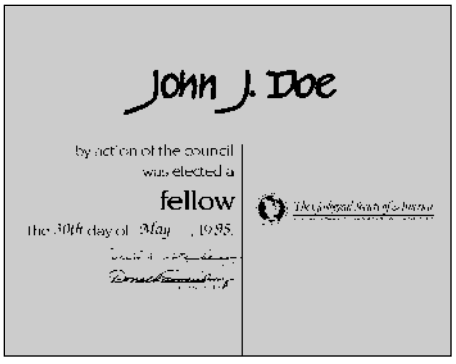

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The Award

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Criteria

The Dwornik Student Paper Award applies to papers presented at the annual Lunar and Planetary Science Conference held each March in Houston. Student applicants must be (1) the senior author of the abstract (the paper may be presented orally or in a poster session); (2) a U.S. citizen; and (3) enrolled in a college or university, at any level of their education, in the field of planetary geosciences. Papers will be judged on the quality of the scientific contributions, including methods and results; clarity of material presented; and methods of delivery, oral or display.

To Apply

The application form and instructions are found in the Call for Papers for the 29th Lunar and Planetary Science Conference, March 16–20, 1998, to be held in Houston, Texas. For further information contact Program Services Division, Lunar and Planetary Institute, 3600 Bay Area Boulevard, Houston, TX 77058-1113, phone (281) 486-2158, e-mail: simmons@lpi.jsc.gov. Web: http://cas.jsc.nasa.gov/meetings/LPSC98/. Only one abstract per student will be considered.

Deadline: ***January 9, 1998,*** for mailed abstracts; ***January 16, 1998,*** for electronic submissions.

November *BULLETIN* and *GEOLOGY* Contents

The Geological Society of America
BULLETIN
Volume 109, Number 11, November 1997

CONTENTS

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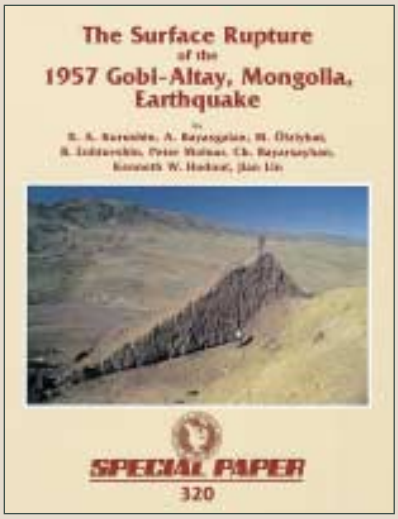

The 1957 Gobi-Altay earthquake is the last major earthquake (M ~ 8) to occur in a continental region. The full complement of processes that distinguishes continental tectonics from plate tectonics-internal deformation of blocks, conjugate faulting, variations in amounts of slip along faults, block rotations about vertical axes, basement folding, and even the formation of new faults (through fault-bend folding at the earth's surface)-occurred in 1957 and remain clearly exposed in the arid environment of the Gobi-Altay. Because of the variety of styles and the extent of deformation, the sub-parallel surface ruptures, ~25 km apart, provide a microcosm of intracontinental mountain building at a large scale.

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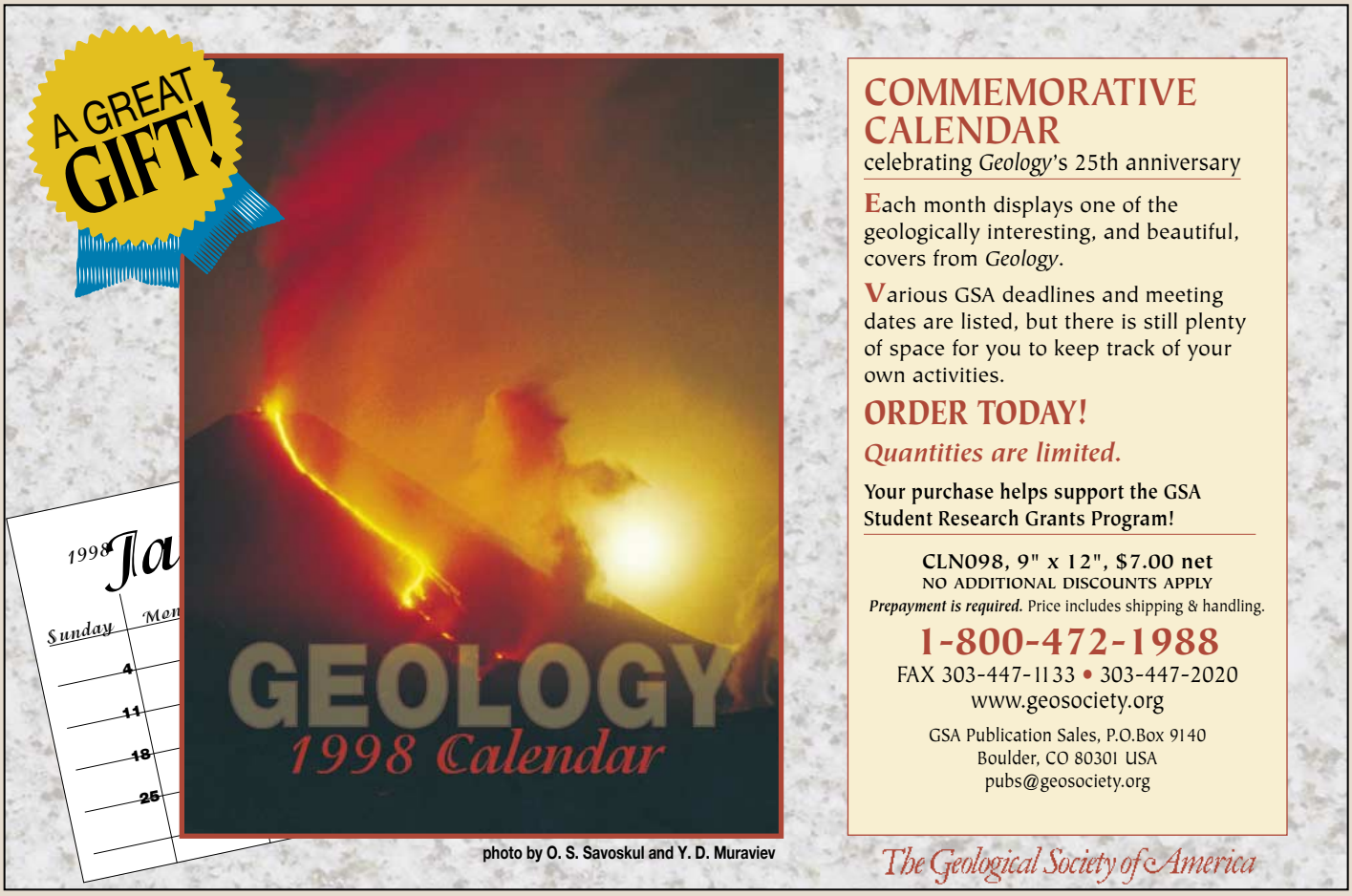

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CALENDAR

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1998 Penrose Conferences

May

May 14–18, **Linking Spatial and Temporal Scales in Paleoecology and Ecology,** Solomons, Maryland. Information: Andrew S. Cohen, Dept. of Geosciences, University of Arizona, Tucson, AZ 85721, (520) 621-4691, fax 520-621-2672, acohen@geo.arizona.edu.

June

June 4–12, **Evolution of Ocean Island Volcanoes,** Galápagos Islands, Ecuador. Information: Dennis Geist, Dept. of Geology, University of Idaho, Moscow, ID 83844, (208) 885-6491, fax 208-885-5724, dgeist@uidaho.edu.

July

July 4–11, **Processes of Crustal Differentiation: Crust-Mantle Interactions, Melting, and Granite Migration Through the Crust,** Verbania, Italy. Information: Tracy Rushmer, Dept. of Geology, University of Vermont, Burlington, VT 05405, (802) 656-8136, fax 802-656-0045, trushmer@zoo.uvm.edu.

September

Late September, **Ophiolites and Oceanic Crust: New Insights from Field Studies and Ocean Drilling Program,** northern California. Information: Yildirim Dilek, Dept. of Geology, Miami University, Oxford, OH 45056, (513) 529-2212, fax 513-529-1542, dileky@muohio.edu.

1998 Meetings

April

April 9–10, **Michigan Geological Survey Division 5th Symposium on the Geology of Michigan,** Lansing, Michigan. Information: Michigan Geological Survey Division, P.O. Box 30256, Lansing, MI 48909, Ray Vugrinovich, (517) 334-6937, fax 517-334-6919, vugrinov@state.mi.us.

April 17–19, **Mid-America Paleontology Society National Fossil Exposition,** Macomb, Illinois. Information: Tom Witherspoon, 6611 Miller Rd., Dearborn, MI 48126-1915.

May

May 11–14, **Yellowstone National Park and Montana State University Symposium,** Bozeman, Montana. Information: Carolyn Manley, Mountain Research Center, P.O. Box 173490, Montana State University, Bozeman, MT 59717-3490, (406) 994-5178, fax 406-994-5122, info@peak.mrc.montana.edu.

September

September 5–7, **American Quaternary Association (AMQUA) 15th Biennial Meeting,** Puerto Vallarta, Mexico. Information: Socorro Lozano Garcia, Instituto de Geología, Universidad Nacional Autónoma de México, Ciudad Universitaria, Apartado Postal 70-296, 04510, México D.F., Mexico, fax 52-5-550-6644.

Send notices of meetings of general interest, in format above, to Editor, *GSA Today,* P.O. Box 9140, Boulder, CO 80301, e-mail: editing@geosociety.org.

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GSA SECTION MEETINGS—1998

NORTHEASTERN SECTION, March 19–21, Holiday Inn by the Bay, Portland, Maine. Submit abstracts to: Marc C. Loiselle, Maine Geological Survey, 22 State House Station, Augusta, ME 04333-0022, (207) 287-2801, marc.c.loiselle@state.me.us. *Abstracts Deadline: November 14, 1997.*

NORTH-CENTRAL SECTION, March 19–20, Ohio State University, Columbus, Ohio. Submit abstracts to: David H. Elliot, Dept. of Geological Sciences, Ohio State University, 125 South Oval Mall, Columbus, OH 43210, (614) 292-5076, delliot@magnus.acx.ohio-state.edu. *Abstracts Deadline: November 14, 1997.*

SOUTH-CENTRAL SECTION, March 23–24, OU Continuing Education Center, Norman, Oklahoma. Submit abstracts to: Judson Ahern, School of Geology & Geophysics, University of Oklahoma, 100 E. Boyd St., Suite 810, Norman, OK 73019-0628, (405) 325-3253, jahern@ou.edu. *Abstracts Deadline: December 1, 1997.*

SOUTHEASTERN SECTION, March 30–31, Embassy Suites, Charleston, West Virginia. Submit abstracts to: Peter Lessing, WV Geological & Economic Survey, P.O. Box 879, Morgantown, WV 26507-0879, (304) 594-2321, lessing@geosrv.wvnet.edu. *Abstracts Deadline: November 21, 1997.*

CORDILLERAN SECTION, April 7–9, California State University, Long Beach, California. Submit abstracts to: James C. Sample, Dept. of Geological Sciences, California State University, Long Beach, CA 90840, (562) 985-4589, csample@csulb.edu. *Abstracts Deadline: December 12, 1997.*

ROCKY MOUNTAIN SECTION, May 25–26, Northern Arizona University, Flagstaff, Arizona. Submit abstracts to: Wendell Duffield, U.S. Geological Survey, 2255 Gemini Road, Flagstaff, AZ 86001, (520) 556-7205, wduffield@iflag2.wr.usgs.gov. *Abstracts Deadline: January 8, 1998.*

GSA Student Associate Member TRAVEL GRANTS

The GSA Foundation has awarded $4,000 grants to each of the six GSA sections. The money, when combined with equal funds from the sections, is used to assist GSA undergraduate Student Associates, as well as graduate Student Members, traveling to GSA meetings. For information and deadlines, contact your section secretary.

Cordilleran—Bruce Blackerby,
(209) 278-2955, bruceb@zimmer.csufresno.edu

Rocky Mountain—Kenneth Kolm,
(303) 273-3932. kkolm@mines.colorado.edu

North-Central—Robert Diffendal, Jr.,
(402) 472-7546, rfd@unlinfo.unl.edu

Northeastern—Kenneth Weaver,
(410) 554-5532, kweaver438@aol.com

South-Central—Rena Bonem,
(817) 755-2361, bonemr@baylor.edu

Southeastern—Harold Stowell,
(205) 348-5098, hstowell@wgs.geo.us.edu

1998 Annual Meeting Field Trips

The 1998 GSA Annual Meeting in Toronto will provide an exciting set of field trips. The theme of the meeting, "Assembly of a Continent," is in part a reference to the focus on the Canadian Lithoprobe program that will be highlighted by GSA 1998. Two transects and two other excursions through the Grenville province of the Precambrian shield will be directly related to Lithoprobe seismic transects. Scientists involved in the Paleozoic paleontology and stratigraphy will provide several trips that will show the world some of their most recent, even current, results. Southern Ontario is a major population center, and hydrology, environmental geology, Quaternary geology, and geomorphology are important public as well as scientific concerns. Several trips will provide an opportunity to discover the results of the work done in response to these concerns. One of them will focus on the Oak Ridges moraine, a massive accumulation of mid-continental glacial sediments that dominate the north shore of Lake Ontario. The Niagara escarpment, another spectacular geomorphologic feature of southern Ontario, will also be featured in many of the trips. A Niagara Falls trip will explore their importance in the history of geological thought. Come, learn, or update your knowledge about the geology of this part of North America. Most trips, but not all, will begin and end in Toronto. The following list of trips is tentative and subject to change. Further details will be given in the April issue of *GSA Today.*

Chert, Corn, Environmental Change, and Prehistoric Land Clearance: Three Geoarchaeological Studies on the Niagara Escarpment. Ronald F. Williamson, Peter L. Storck, and Robert I. MacDonald.
From Front to Interior: A Southern Ontario Transect of the Grenville Province from Sudbury, Ontario, to the Adirondacks, New York. J. A. Davidson and Mike Easton.
Geology of the Grenville Central Metasedimentary Belt of Ontario and Quebec. Mike Easton and Louise Corriveau.
Ground-water Experimental Field Sites at the Base Borden Research Site and Other Sites of Interest in the Waterloo Area. Dave Rudolph.
History of Geology Trip to Niagara Falls. Keith Tinkler.
Hydrogeology and Late Quaternary History of Point Pelée National Park, Ontario. Allan Crowe, John Coakley, and C. J. Ptacek.
Late Grenvillian Horizontal Extension and Vertical Thinning of Proterozoic Gneisses, Central Ontario. Wilfried M. Schwerdtner.
Paleozoic Stratigraphy and Coal Geology. Cortland Eble and Blaine Cecil.
Regional Quaternary Geology and Hydrogeology of the Oak Ridges Moraine Area–Greater Toronto Area, Southern Ontario. D. Sharpe, P. Barnett, H. Russel, L. Dyke, M. Hinton, R. Gerber, and T. Brennand.
Silurian and Devonian Stratigraphy of the Niagara Escarpment. Carlton Brett and Brian Pratt.
Stratigraphy, Sedimentology, and Paleocommunities of the Black River and Trenton Limestone Groups (Ordovician), East of Lake Simcoe, Ontario. Mike Brookfield, El Gadi, Derek Armstrong, Dave Rudkin, and Carlton Brett.
***Sponsored by the Society of Economic Geologists*—Western Quebec Grenville Transect.** Jacques Martignole.
Gold Deposits of Northern Sonora Mexico. Kenneth F. Clark.

For further information, contact 1998 Field Trip Co-Chairs **Pierre-Yves F. Robin,** (905) 828-5419, fax 905-828-3717, probin@erin.utoronto.ca, and **Henry Halls,** (905) 828-5363, fax 905-828-3717, hhalls@erin.utoronto.ca, both at Dept. of Geology and Erindale College, University of Toronto, 3359 Mississauga Road, Mississauga, Ontario L5L 1C6, Canada. ■

TORONTO 1998 Annual Meeting

General Chairs: ***Jeffrey J. Fawcett,*** *University of Toronto,*
Peter von Bitter, *Royal Ontario Museum*

Technical Program Chairs:
Denis M. Shaw, *Dept. of Geology, McMaster University, Hamilton, Ontario L8S 4M1, Canada, shawden@mcmail.cis.mcmaster.ca*
Andrew Miall, *Dept. of Geology, University of Toronto, 22 Russell St., Toronto, Ontario M5S 3B1, Canada, miall@quartz.geology.utoronto.ca*

Due date for symposia and theme proposals: ***January 2, 1998***

Call for Field Trip Proposals:
We are interested in proposals for single-day and multi-day field trips beginning or ending in Toronto, and dealing with all aspects of the geosciences. Please contact the Field Trip Chairs listed below.

Pierre Robin, *Dept. of Geology, University of Toronto, Erindale Campus, Mississauga, Ontario L5L 1C6, Canada, probin@erin.utoronto.ca*

Henry Halls, *Dept. of Geology, University of Toronto, Erindale Campus, Mississauga, Ontario L5L 1C6, Canada, hhalls@erin.utoronto.ca*

TORONTO MINI-CALENDAR

1997

November 1—Theme Proposal Information in November *GSA Today.* Electronic Theme/Symposia Proposal Form Available on the GSA Web Site
December 1—Continuing Education Proposals Due to GSA

1998

January 2—Theme and Symposia Proposals Due to Technical Program Chair
April 1—Call for Papers Published and Distributed
May 1—Electronic Abstract Submittal Form Available on GSA Web Site
June 1—Registration and Lodging Information printed in June *GSA Today*
July 13—Abstracts Deadline
September 13—Preregistration and Housing Deadline

Call For

CONTINUING EDUCATION COURSE PROPOSALS

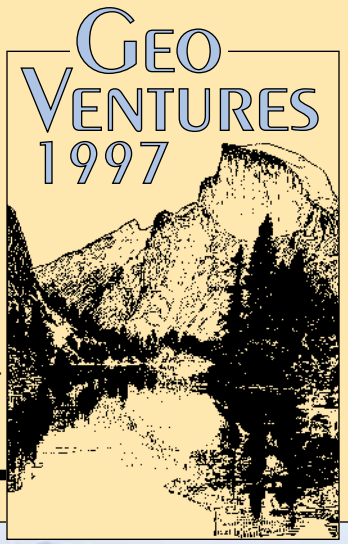
Due December 1, 1997

The GSA Committee on Continuing Education invites those interested in proposing a GSA-sponsored or cosponsored course or workshop to contact GSA headquarters for proposal guidelines. Continuing Education courses may be conducted in conjunction with all GSA annual or section meetings. We are particularly interested in receiving proposals for the 1998 Toronto Annual Meeting or the 1999 Denver Annual Meeting.

Proposals must be received by December 1, 1997. Selection of courses for 1998 will be made by February 1, 1998. For those planning ahead, we will also consider courses for 1999 at that time.

For proposal guidelines or information, contact: Edna Collis, Continuing Education Coordinator, GSA headquarters, 1-800-472-1988, ext. 134, ecollis@geosociety.org.

MEMORIES . . . THE 1997 GSA GEOVENTURES PROGRAM



offered five programs unrelated to the annual or section meetings. The total of 125 participants, ranging in age from 20 to 79, represented a vast range of interests and backgrounds.

This educational program serves professionals who enjoy their geology and the company of other geologists in a field setting. GeoVentures are a special benefit created for members, but are open to guests and friends also.

GEOVENTURES is the overall name for adult educational and adventure experiences of two kinds: GeoHostels and GeoTrips. Both are known for superior scientific leadership. Fees for both are low to moderate (relative to the destination, length, time of year, and number of participants). GeoHostels are usually five-day, campus-based programs. GeoTrips are anywhere from one to three weeks in length, and the itinerary covers a wide variety of destinations.

GEOTRIP
ITALY'S VOLCANOES

17 participants • May 9–21, 1997

Leaders: *Haraldur Sigurdsson, Graduate School of Oceanography, University of Rhode Island*
Mauro Rosi, Department of Geology, University of Pisa, Pisa, Italy

"Our trip to Italy with Haraldur and Mauro was outstanding. Even my wife, Jan, who seldom accompanies me on geological tours, concurs. I liked the length, emphasis, places visited, lodging, and food. Don't change a thing," said Dave MacKenzie of Denver, Colorado.

ITALY GANG. PHOTO COURTESY OF GILES ALLARD.

CANYONLANDS GANG. PHOTO BY SUE TANGES.

GEOTRIP
ARCHES, CANYONLANDS, AND CATARACT CANYON

18 participants • May 30–June 7, 1997

Leader: *Jack Campbell, Department of Geology, Fort Lewis College, Durango, Colorado*

"The best geology and maybe the best trip ever! No worries, great sites, geology, and food!" wrote Mike and Mingo Galenski, Thornton, Pennsylvania.

GEOHOSTEL
GEOLOGY AND THE MONSOON: SKY ISLANDS AND MINING CAMPS OF SOUTHEASTERN ARIZONA

23 participants • August 2–7, 1997

Leaders: *Timothy Lawton and Nancy McMillan, New Mexico State University, Las Cruces*

SKY ISLANDS GANG. PHOTO BY NANCY MCMILLAN.

"Tim and Nancy did an outstanding job presenting the geology, selecting sites, and keeping everything organized. They should be encouraged to lead more GeoHostels," wrote Bob Beringer, Ventura, California.

CLASSIFIED ADVERTISING

Published on the 1st of the month of issue. Ads (or cancellations) must reach the GSA Advertising office one month prior. Contact Advertising Department (303) 447-2020, 1-800-472-1988, fax 303-447-1133, or e-mail:acrawfor@geosociety.org. Please include complete address, phone number, and e-mail address with all correspondence.

Classification	Per Line for 1st month	Per line for each addt'l month (same ad)
Situations Wanted	$1.75	$1.40
Positions Open	$6.50	$5.50
Consultants	$6.50	$5.50
Services & Supplies	$6.50	$5.50
Opportunities for Students		
first 25 lines	$0.00	$2.35
additional lines	$1.35	$2.35
Code number: $2.75 extra		

Agencies and organizations may submit purchase order or payment with copy. Individuals must send prepayment with copy. To estimate cost, count 54 characters per line, including all punctuation and blank spaces. Actual cost may differ if you use capitals, centered copy, or special characters.

Positions Open

TENURE-TRACK POSITION
BRIGHAM YOUNG UNIVERSITY

The Department of Geology at BYU invites applications for a tenure-track position beginning 1 September 1998.

The successful candidate will have a Ph.D., dedication to excellent teaching, and demonstrated research ability. Specializations to be considered include structural geology/tectonics (including seismic interpretation), igneous/metamorphic petrology, quantitative geomorphology/GIS-GPS. A candidate with experience in two of these fields is strongly preferred.

Hiring will be at the academic rank of assistant or associate professor, depending on qualifications. Review of applicants will begin on 1 January 1998 and will continue until the position is filled.

Applicants should send a curriculum vitae and the names and e-mail addresses of three referees to: Eric H. Christiansen, Faculty Search Committee, Department of Geology, Brigham Young University, Provo, UT 84602 (e-mail: eric_christiansen@byu.edu).

BYU is an equal opportunity employer. Preference is given to members of the sponsoring Church of Jesus Christ of Latter Day Saints.

FACULTY POSITION
ENVIRONMENTAL STABLE ISOTOPE GEOCHEMISTRY
Geological Sciences / Ohio State University

The Department of Geological Sciences invites applications for one tenure-track position at the assistant professor level, or higher, to begin as early as September 1998. A Ph.D. in geological sciences or related field is required. Candidates should have a strong record of funded research, refereed publications, a commitment to teaching, and collaboration with colleagues in other areas of specialization. The successful candidate will be expected to develop an independent research program in paleoclimatic reconstruction, work closely with the Ohio State ice-core paleoclimate research program (including the elemental and isotopic composition of trapped gases in ice cores or atmospheric isotope geochemistry), and participate broadly with Department research programs. Teaching will involve courses at introductory and advanced levels.

The Department of Geological Sciences has 24 full-time faculty and approximately 70 graduate students. The Department is well equipped with laboratory and computing equipment and is occupying newly renovated laboratory, classroom, and office space. The successful candidate will be expected to maintain strong research ties with the Byrd Polar Research Center and with faculty in Geological Sciences and other departments and disciplines, e.g., Department of Chemistry and Atmospheric Sciences. Also,the successful candidate will be expected to generally participate in the Ohio State University Environmental Sciences initiative.

To apply, send a curriculum vitae, statements of research and teaching interests, and names of three referees to Search Committee Chair, Department of Geological Sciences, 155 South Oval Mall, Columbus, OH 43210. The search committee will begin reviewing applications January 1, 1998, and continue until a suitable candidate is hired. The Ohio State University is an Equal Opportunity, Affirmative Action Employer. Women and minorities, Vietnam-era veterans, and disabled veterans and individuals with disabilities are encouraged to apply.

WESTERN OREGON UNIVERSITY

The Division of Natural Sciences and Mathematics announces the availability of two tenure-track, Assistant Professor positions in Geology to begin September 16, 1998. Each position requires a Ph.D. in Geology in the designated specialty area. Candidates must demonstrate a strong commitment to teaching, conducting field trips and research at the undergraduate level. Evidence of published research and computer expertise is highly desirable.

Position #1 requires a specialization in volcanology or petrology to teach introductory geology and upper-division courses in mineralogy, petrology, structural geology, and mineral resources.

Position #2 requires a specialization in paleontology with research interest in the Pacific Northwest to teach introductory earth science and upper-division courses in paleontology, sedimentation, and stratigraphy.

Application: send application letter, curriculum vitae, three current letters of reference and graduate transcripts by December 15, 1997, to: Dr. Arlene Courtney, Chair, Natural Sciences and Mathematics Division, Western Oregon University, Monmouth, OR 97361, (503) 838-8206, fax 503-838-8072.

An affirmative action, equal opportunity employer, Western Oregon University encourages applications from women, persons from culturally diverse backgrounds, and individuals with disabilities.

Classifieds *continued on p. 38*

GeoHostel

Mount St. Helens and Mount Rainier

31 participants • June 21–26, 1997

Leaders: *Richard B. Waitt, U.S. Geological Survey, Cascades Volcano Observatory*
Patrick T. Pringle, Washington Department of Natural Resources

"Both leaders were excellent with geology and with people," wrote Dan Barker of Austin, Texas.

Mount St. Helens and Mount Rainier Gang. Photo by Edna Collis.

Yellowstone gang. Photo by passing tourist.

GeoHostel

Geology of the Yellowstone-Beartooth Country, Montana and Wyoming

35 participants • July 19–24, 1997

Leaders: *Robert Thomas and Sheila Roberts, Western Montana College, Dillon*

"Rob and Sheila did an excellent job—even the non-geologists (like me) learned in spite of ourselves," commented Pat Scott, Red Bluff, California.

 continued from p. 37

FACULTY POSITIONS
GROUND-WATER HYDROGEOLOGY
AND VOLCANOLOGY
STATE UNIVERSITY OF NEW YORK AT BUFFALO

The Department of Geology invites applications for two tenure-track faculty positions in hydrogeology and volcanology at the Assistant Professor level starting September 1998. The successful candidates will demonstrate a potential for research which will complement our existing programs in environmental geology and volcanology. Teaching duties for the hydrogeology position will involve hydrogeology courses at the undergraduate and graduate levels. Teaching duties for the volcanology position could be in the area of undergraduate geophysics, petrology or structural geology, with resarch that focuses on active volcanoes. The salary and the initial University contribution to the candidates' research equipment will be very attractive. Successful candidates must have the Ph.D. degree as of the date of appointment. Apply with a statement of teaching and research goals and a curriculum vitae, including published research, grant support, and names of at least three references to: Dr. John C. Fountain, Chair, Search Committee, Department of Geology, State University of New York at Buffalo, 876 Natural Sciences Complex, Buffalo, NY 14260-3050. We will begin evaluating applicants on December 20, 1997.

The State University of New York is an Equal Opportunity/Affirmative Action Employer and encourages applications from women and minorities.

TENURE-TRACK FACULTY POSITION IN
HYDROGEOLOGICAL SCIENCES
DEPARTMENT OF GEOSCIENCES
THE PENNSYLVANIA STATE UNIVERSITY

The Department of Geosciences at Penn State seeks an individual in the field of hydrogeology, for a tenure-track faculty position to be filled at any level. Rank, salary, and tenure-status will be commensurate with prior experience and qualifications.

We seek an outstanding scientist and educator in any area of hydrogeology which emphasizes subsurface fluid flow. Examples of interest include, but are not restricted to, contaminant transport, basinal fluid flow, multi-phase flow, fluid-flow/tectonics interactions, unsaturated zone flow, and hydraulic properties and their scaling relationships.We are particularly interested in individuals whose research couples observation with theory, and whose research is of both an applied and fundamental nature.

The successful candidate will join a large, dynamic and well-equipped department dedicated to innovative teaching and research, which seeks a national and international leadership role in Hydrosciences. Opportunities exist for campus-wide collaborative research and teaching in the Hydrosciences. Apppointment as an affiliate of the Earth System Science Center and the Center for Environmental Chemistry and Geochemistry are possible.

Applicants should demonstrate a history of, or potential for, funded research and high-quality teaching. A Ph.D. is required at the time of appointment. Applications should include a complete resume, examples of published work, a statement outlining teaching and research interests and the names and addresses of at least four (4) individuals who could provide references. Send application materials to: Head, Department of Geosciences, 503 Deike Bldg., The Pennsylvania State University, University Park, PA 16802.

The search process begins immediately and will continue until suitable candidates are identified.

An Affirmative Action/Equal Opportunity Employer. Women and minorities are encouraged to apply.

VISITING POSITION IN QUATERNARY SOILS
UNIVERSITY OF IOWA

The Department of Geology, University of Iowa, seeks a Visiting Professor, who is an outstanding teacher and researcher in the area of Quaternary studies, with focus on soils and associated surficial materials. The appointment will begin in August 1998 and extend for 2 years, with the possibility of starting January 1998 for 2.5 years. Teaching responsibilities will involve at least four courses per year. These will include two upper-level undergraduate/graduate courses: Modern and Ancient Soils, and Glacial and Pleistocene Geology, and one of our general education courses (Earth History and Resources). Other courses would depend on the candidate's expertise and departmental needs, and may include a portion of Remote Sensing. The successful candidate should have a Ph.D. and be active in research that will complement ongoing Quaternary research and surficial-process programs in the Department. Women and minorities are encouraged to apply. Applicants should send a complete resume (including a bibliography and statement of teaching and research interests) and have three letters of recommendation sent to: Dr. Richard G. Baker, Search Committee Chair, Department of Geology, University of Iowa, Iowa City, Iowa 52242-1379 (phone: 319-335-1827; fax: 319-335-1821; e-mail rgbaker@blue. weeg.iuowa.edu). Final evaluation of the applicants will begin on December 1, 1997, and continue until the position is filled. The University of Iowa is an affirmative action-equal opportunity employer.

ASSISTANT PROFESSOR, GEOLOGY
BALL STATE UNIVERSITY, MUNCIE, INDIANA

Tenure-track position available August 21, 1998, with interests in environmental geochemistry/geology. Responsibilities include: teaching courses in ground water geochemistry or sedimentary petrology/stratigraphy, and environmental field methods along with courses in general education, such as physical or environmental geology and oceanography, developing a program of reserach; advising student research at graduate and undergraduate levels. Area of research is open but should enhance the department's offerings and research in the above areas or combined with engineering geology, glacial deposits, karst, paleoclimatology, or geoscience education. Additional information about the position may be obtained by communicating through the web site (http://www.geology.bsu. edu) or by visiting with department faculty at GSA in Salt Lake City. Minimum qualifications: doctoral degree; ABD's will be considered if all requirements for the Ph.D. are met by August 21, 1998; some college teaching and/or professional experience with teaching interest in geochemistry or sedimentary petrology/stratigraphy and environmental field methods. Preferred qualifications: doctorate in geology with specialty in environmental geochemistry; demonstrated teaching abilities and effective interaction with other faculty and students on individual projects and research; records supporting quality of teaching, research, and/or professional performance; interest in teaching in several of the areas listed above and in the summer five-week field mapping course currently taught in South Dakota and Wyoming; experience and knowledge in geoscience education methods. Send statement of teaching and research interests, including specific courses of interest and ways that research might be developed to include students, especially undergraduates; vitae; names of at least three references; and transcript of highest degree earned to: Chairperson of Search Committee, Department of Geology, Ball State University, Muncie, IN 47306. Review of applications will begin December 3, 1997, and continue until the position is filled.

Ball State University is an equal opportunity, affirmative action employer and is strongly and actively committed to diversity within its community.

CHAIR, GEOSCIENCES
UNIVERSITY OF NEBRASKA-LINCOLN

The Department of Geosciences, University of Nebraska-Lincoln, invites applications and nominations for the position of department chair. The successful candidate will be responsible for promoting the growth and stature of the department, budgetary and personnel matters, developing teaching schedules, and alumni development. The chair must also guide the instructional and outreach activities of the department, and provide appropriate service to the University. The successful candidate should be a senior geoscientist with a record of internationally recognized, externally funded research. Evidence of effective leadership in academic administration or in funding agencies will be a positive factor. Candidates should have a research specialty that bridges departmental strengths in hydrogeology, meteorology and climatology, micropaleontology, Quaternary geology and geomorphology, remote sensing and GIS, sedimentology, and vertebrate paleontology.

Screening of applications will begin on December 15, 1997, and continue until the position is filled. Potential candidates should send a letter of interest, curriculum vitae, and the names of 5 references. Send nominations and applications to: Dr. Richard M. Kettler, Department Chair Search, College of Arts and Sciences, 1223 Oldfather Hall, University of Nebraska-Lincoln, Lincoln, NE 68588-0312. Phone: (402) 472- 2663; fax: 402-472-4917; e-mail: rkettler@unlinfo.unl.edu.

The University of Nebraska-Lincoln is committed to a pluralistic campus community through Affirmative Action and Equal Opportunity and is responsive to the needs of dual career couples. We assure reasonable accommodation under the Americans with Disabilities Act; contact Richard Kettler for assistance.

FACULTY POSITION IN
NEOTECTONICS / STRUCTURAL GEOLOGY
SAN FRANCISCO STATE UNIVERSITY

The Department of Geosciences invites applications for a tenure-track faculty position at the assistant professor level in Neotectonics/Structural Geology, beginning in August 1998. The position requires a Ph.D. in geology and a strong commitment to excellence in both teaching and research. Some background in teaching is necessary and experience in industry or government agency in engineering geology is required. The successful candidate will have prime responsibility for teaching undergraduate and graduate courses in structural geology, neotectonics and plate tectonics, and will share responsibility for courses in engineering geology. We seek someone to work with local environmental firms and agencies and to assist in expanding our new graduate program in Applied Geosciences.

To apply, send curriculum vitae including a statement of teaching and research interests, and names and addresses of three references to: John Monteverdi, Department of Geosciences, San Francisco State University, 1600 Holloway Avenue, San Francisco, CA 94132.

Applications must be postmarked by January 15, 1998. For more information, contact the Department of Geosciences web site, http://tornado.sfsu.edu/geosciences/geosciences.html.

San Francisco State University is an Equal Opportunity/Affirmative Action employer.

ENVIRONMENTAL GEOSCIENTIST
AMHERST COLLEGE

The Department of Geology at Amherst College seeks applications for a tenure-track position at the level of Assistant Professor, to begin in the fall semester of 1998. Possible fields of expertise include one or more of the following: aqueous geochemistry, biogeochemistry, glacial geomorphology, hydrogeology, paleoclimatology, paleoecology, and/or surficial geology. Teaching responsibilities will include participation in the Department's introductory courses, an intermediate-level course that focuses on environmental and surficial processes, and an advanced level undergraduate course in the candidate's specialty. Amherst College has opportunities to teach in interdisciplinary programs. Geology faculty also supervise undergraduate research projects.

Candidates should have a strong interest in undergraduate teaching as well as an ongoing program of research. A Ph.D. is required and post-doctoral experience is desirable.

Amherst College provides competitive start-up funds in support of research. In addition, if the successful candidate is a woman, she will be appointed the Clare Boothe Luce Assistant Professor of Geology. Through the generosity of the Henry Luce Foundation, and under the terms of the will of Clare Boothe Luce, Amherst is able to offer dedicated research support to the Clare Boothe Luce Professor for a period of five years.

Submit a resume, three letters of recommendation, and a brief statement of your research interests to: Professor Tekla A. Harms, Department of Geology, Amherst College, Amherst, MA 01002-5000 (taharms@amherst.edu). Review of applications will begin on January 1, 1998, but applications will be accepted until a pool of qualified candidates is identified. Amherst College is an equal opportunity/affirmative action employer. Women, minorities, and persons with disabilities are particularly encouraged to apply.

SURFICIAL PROCESSES
INFORMATION SYSTEMS MANAGEMENT
BOWLING GREEN STATE UNIVERSITY

The Department of Geology seeks to fill a tenure-track position in surficial processes and information systems management starting in August 1998. Areas of specialization are open, but coastal geomorphology, glacial geomorphology, and pedology fit well with existing department strengths. Teaching assignments might include introductory classes, geomorphology, and a graduate-level class in the candidate's specialty. In addition, participation in the summer geology field camp course would be desirable. The successful candidate would also be expected to maintain an active research program, supervise M.S. thesis projects, and contribute to the department's program in environmental geology (GIS, remote sensing, hydrogeology, and engineering geology) and to an emerging program in information systems management. Department facilities include: remote sensing/GIS laboratory (Sun & Silicon Graphics workstations), geochemistry laboratory (AAS, SEM, XRD), sedimentology/ hydrology laboratory, mineral kinetics laboratory, geophysical equipment (magnetometer, gravity meter, resistivity, shallow seismic,

GPS), optical petrology laboratory, sample preparation facilities, sediment core facility, and field vehicles.

A Ph.D. is required. Applications (including a complete resume, statement of teaching and research interests, and three original letters of recommendation) should be sent to: Chair, Surficial Processes Search Committee, Dept. of Geology, Bowling Green State University, Bowling Green, Ohio 43403. Applications must be received no later than January 1, 1998. BGSU is an AA/EEOC employer. Applicants from under-represented/protected groups are urged to apply.

ASSISTANT PROFESSOR POSITION IN GEOMORPHOLOGY

The Department of Geology and the Center for Environmental Sciences & Education at Northern Arizona University solicit applications for a tenure-track, Assistant Professor position in geomorphology, to begin in August 1998. The position is a joint appointment between two academic units in the College of Arts & Sciences.

Applicants must have a Ph.D. in Geological Sciences. The successful candidate will be a process-oriented and quantitative geomorphologist with research experience in neotectonics, geochronology, climatology, and ecosystem-level processes. Because NAU is committed to serving the rural, Hispanic, and Native American populations of the Colorado Plateau and Southwest, experience with diverse cultures is desirable.

Primary teaching responsibilities will be courses in geomorphology and climatology. Additionally, the successful applicant will teach introductory core courses in Geology and Environmental Sciences on a rotating basis, and will develop undergraduate and graduate courses in his/her specialty. He/she will be expected to seek external funding and establish an active research program in geomorphology centered around the Colorado Plateau and the desert Southwest.

Applicants for this position should send a letter outlining teaching and research interests, curriculum vitae and names, addresses (including e-mail), and telephone numbers of five references. Send to Chair, Screening Committee, Department of Geology, Box 4099, Northern Arizona University, Flagstaff, Arizona 86011. The search will remain open until the position is filled; however, the screening committee will begin reviewing applications on December 1, 1997. Visit our web site at http://www.nau.edu. The Northern Arizona University community is composed of faculty, staff, and students from a wide range of cultural backgrounds. Applicants should have the experience and commitment necessary to work with such a diverse population.

CALIFORNIA, BERKELEY 94720-4740. University of California, Berkeley, tenure-track Assistant Professor position, starting 1 July 1998, for a Physical Geographer/ Earth Scientist with primary research in geomorphology and environmental change. A commitment to a high rate of scholarly productivity and excellence in classroom and field methods teaching is expected. Applicant must have Ph.D. or completed dissertation. Submit letter of application, vitae, and complete list of publications, and the names of three references and addresses, by January 12, 1998. Apply: Richard Walker, Chair, Department of Geography.

The University of California is an Equal Opportunity, Affirmative Action Employer.

NEAR-SURFACE (APPLIED) GEOPHYSICS
SIMON FRASER UNIVERSITY

The Earth Sciences Program is seeking to fill a tenure-track position at the Assistant Professor level in the area of near-surface (applied) geophysics. The ideal candidate is a geophysicist with an established research program in the application of seismic reflection, electrical methods, three-dimensional imaging, ground penetrating radar or electromagnetic techniques to problems in the shallow subsurface, preferably with relevance to environmental geoscience issues. The successful candidate must have a commitment to both undergraduate and graduate education as well as to developing a funded research program. For detailed information about this position refer to the Program's home page: http://www.sfu.ca/earth-sciences.

A Ph.D. is required at the time of appointment and the successful candidate will be eligible, preferably, for professional registration in BC (APEGBC). The appointment will commence in September 1998. In accordance with Canadian Immigration this advertisement is directed to Canadian citizens and Permanent Residents. Simon Fraser University is committed to the principle of equity in employment and offers equal employment opportunities to qualified applicants. This position is subject to final budgetary approval. Applicants should send a curriculum vitae, a letter describing current and near-term research interests and copies of appropriate reprints; an e-mail address, a fax number, and names of at least three referees by January 1, 1998 to: Dr. Michael C. Roberts, Director, Earth Sciences Program, Simon Fraser University, Burnaby, BC, Canada V5A 1S6. Phone (604) 291-4657; fax 604-291-4198; mroberts@sfu.ca.

NORTHWESTERN UNIVERSITY
COLLEGE OF ARTS AND SCIENCES

The Department of Geological Sciences invites applications for a senior faculty position. We seek a distinguished scientist of high professional standing who will complement and augment our research, graduate, and undergraduate programs. Our web page: http://www.earth. nwu.edu.

To ensure full consideration, applications should include a curriculum vitae, copies of significant publications, names of at least three professional references, and be received by January 5, 1998.

Address applications to: Search Committee, Dept. of Geological Sciences, 1847 Sheridan Road, Northwestern University, Evanston, IL 60208-2150, Fax number: 847-491-8060, e-mail: search@earth.nwu.edu.

Women and members of minority groups are encouraged to apply. Northwestern is an affirmative action and equal opportunity employer.

PROFESSOR OF GEOBIOLOGY

The Department of Earth, Atmospheric, and Planetary Sciences at MIT invites qualified candidates to apply for a new faculty position in Geobiology. The level of the appointment will depend on qualifications. We seek an outstanding biologist deeply interested in both research and teaching who has specific expertise in the interactions between organisms and geologic, hydrologic, oceanic, or atmospheric processes. Of particular interest are individuals who specialize in ecosystem dynamics or evolutionary/ developmental biology. The successful candidate will be an individual who focuses on theory and quantitative analysis but who also knows in depth and uses observations. One or more of the current programs at MIT in the earth, atmospheric, hydrologic, oceanic, biological, climatic, and planetary sciences are expected to provide a signficant and welcome resource to the new faculty member for interdisciplinary studies.

Interested scientists should send a curriculum vitae, a one-page description of research plans, and the names of three professional references to: Prof. Thomas H. Jordan, Head, Department of Earth, Atmospheric, and Planetary Sciences, Massachusetts Institute of Technology, Bldg. 54-926, Cambridge, MA 02139-4307, or by e-mail: thj@mit.edu; fax: 617-253-8298. MIT is an Equal Opportunity/Affirmative Action Employer. MIT is a non-smoking environment.

ENVIRONMENTAL GEOLOGY
SURFICIAL PROCESSES — GEOHYDROLOGY
UNIVERSITY OF MICHIGAN

The Department of Geological Sciences has requested permission to fill a tenure-track position at the Assistant Professor level, or in exceptional cases, at a higher level, to begin September 1998. We seek applicants with broad research interests in: The physical or chemical aspects of geohydrology; a quantitative understanding of Earth surface processes; and/or environmental geochemistry. We expect the applicant to develop a vigorous research program and to teach at both the graduate and undergraduate levels, including involvement in our new Environmental Geology degree program. Regular participation in introductory earth science courses is expected. A Ph.D. is required. Interested persons should send a curriculum vitae, names of five persons from whom the Department may request letters of recommendation, and brief statements of their research and teaching interests to: Prof. Eric J. Essene, Search Committee Chair, Department of Geological Sciences, University of Michigan, Ann Arbor, MI 48109-1063 (e-mail: essene@umich.edu). Applications should be received by December 31, 1997. The University of Michigan is an affirmative action, equal opportunity employer.

Services & Supplies

ALBORAN SCIENCE PUBLISHING. Have you seen our posters on *Societal Benefits of Geoscience?* Thumbnails and orders forms are printed in *GSA Today* (May '97, p. 36/37) and *AAPG Explorer* (April '97, p. 58). Order Now!

LEATHER FIELD CASES. Free brochure, SHERER CUSTOM SADDLES, INC., P.O. Box 385, Dept. GN, Franktown, CO 80116.

ALBORAN SCIENCE PUBLISHING. Want to better your understanding of stress and strain? Try *Principles of Rock Mechanics* by R. Weijermars, 1997, 238 line drawings, 67 photos, 193 exerc. sol., 360 pages (8.5 x 11", flexicover). Excellent reviews. Strongly recommended. At $27.95 you cannot afford to miss this successful textbook/lab book. Order forms are printed in *GSA Today* (April '97, p. 11) and *AAPG Explorer* (May '97, p. 28). You can also contact us by fax (Netherlands): 31 20 3640 145, or phone: 31 20 3640 331. Order Now!

Opportunities for Students

Visiting Fellows and Students/Institute for Rock Magnetism. Applications are invited for visiting fellowships (regular and student) lasting for up to 10 days during the period from March 1, 1998, through August 31, 1998.

Topics for research are open to any field of study involving fine particle magnetism, but preference will be given to projects relating magnetism to geological or environmental studies, or to fundamental physical studies.

A limited number of travel grants of $500 are available to researchers who can demonstrate no existing financial resources. No funds are available for per diem expenses. Application forms and information necessary for proposal preparation may be obtained from IRM manager Mike Jackson at the address below, or on the Web at http://www.geo.umn.edu/orgs/irm/irm.html.

Short proposals (two pages, single-spaced text plus two forms and necessary figures and tables) are due by December 12, 1998, for consideration by the Institute's Review and Advisory Committee. Successful applicants will be notified in early February 1998. Proposals should be sent to: Facilities Manager, Institute for Rock Magnetism, University of Minnesota, 291 Shepherd Laboratories, 100 Union St. SE, Minneapolis, MN 55455-0128, 612-624-5274; fax: 612-625-7502.

California Institute of Technology. Postdoctoral Fellowships in Geological and Planetary Sciences. The California Institute of Technology announces two fellowships in earth and planetary sciences: The O.K. Earl Postdoctoral Fellowship, and the Texaco Postdoctoral Fellowship. These awards are from funds endowed by Orrin K. Earl, Jr., and by the Texaco Philanthropic Foundation. Each fellowship carries an annual stipend of $36,000 and offers a research expense fund of $1,000 per year and one-way travel to Pasadena. The duration of each appointment will normally be for two years, contingent upon good progress in the first year, and beginning with the 1998–99 academic year. Fellows are eligible to participate in Caltech's health and dental program.

These fellowships have been established to support the research of scientists typically within two years after receipt of the Ph.D. The intent of the program is to identify and support innovative and creative work in the earth and planetary sciences, with particular emphasis on interdisciplinary work. Applicants with training in physics, chemistry, biology or computer sciences are urged to apply. The Caltech faculty is currently active in geobiology, geochemistry, geology, geophysics, petrology, seismology, and atmospheric and planetary sciences. It is expected that each fellowship holder will be hosted by a division professor (designated by the division chairman) who will contribute to the fellowship support both financially and by providing intellectual guidance.

Application forms may be obtained via the division home page on the Internet http://www.gps.caltech.edu or by writing to Prof. E. M. Stolper, Chair, Division of Geological and Planetary Sciences, Mail Code 170-25, California Institute of Technology, Pasadena, California 91125, or by e-mail to Marcia Hudson: marcia@gps.caltech.edu.

Completed applications with references should arrive at Caltech by Friday, December 19, 1997.

Fellowship candidates will automatically be considered for other available postdoctoral positions at Caltech in their fields of interest.

Caltech is an Affirmative Action/Equal Opportunity Employer. Women, minorities, veterans, and disabled persons are encouraged to apply.

GSA ON THE WEB

Visit the GSA Web Site at **http://www.geosociety.org.**
From our home page you can link to many information resources. Here are some highlights:

The new **News Notes** page gives information on newsworthy events and includes links to sites with more details.

On our **Membership** page you'll learn about the GSA Employment Service, find out how to become a GSA Campus Representative, or learn how to get forms to join GSA as a professional or as a student. You'll also find information here on how to nominate a GSA Member to Fellowship standing.

Try out the **Meetings** site for a first look at the 1998 Annual Meeting in Toronto, with links to key Toronto Web sites.

From the **Publications** heading, you can visit the GSA Bookstore, where you'll find prices on DNAG publications slashed by 50% (and GSA Member discount still applies). You'll find two Treatise volume revisions, a new 1998 calendar celebrating *Geology's* 25th year, an Explore Kilauea multi-media CD-ROM, a new Reviews in Engineering Geology volume, and several new memoirs and special papers. There's a general page with information for contributors, details on copyright permissions, a free geologic time scale, and more. Don't forget the *GSA Data Repository*—you can download valuable supplementary materials relating to articles in *GSA Bulletin* and *Geology.* As always, you'll find abstracts of all articles in those journals posted monthly.

In the **Education** section, read about GSA's educational programs, including PEP (Partners for Education Program), and the Earth and Space Science Technological Education Project (ESSTEP). Find out about GSA's environment and public policy activities in the **Institute for Environmental Education** section, including updates on the GSA Congressional Science Fellowship program, the Roy J. Shlemon Applied Geology Mentor Program, and the U.S. Geological Survey–National Biological Service scientific opportunities workshop.

Under **Foundation** you will find information on the Foundation and the current annual giving campaign, a list of trustees and officers, and several ways to make a planned gift.

See the **Administration** section for information on GSA Medals and Awards, research grants, and other general information about GSA. You can also link to the pages for GSA Sections and Divisions for specific information on each of these.