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INSIDE

Gold Degassing and Deposition at Galeras Volcano, Colombia

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Figure 1. The active cone within the Galeras crater looking west on January 25, 1993; the inner crater is about 500 m in diameter, and the cone height is about 150 m. Large andesite blocks as much as 5 m high were mostly vented during the July 16, 1992, explosion of the plug dome. Small fragments of hydrothermally altered vent breccia are also found on the cone. Deformes Fumarole (200 °C) is the highly focused magmatic gas plume on the left edge of the inner crater.

ABSTRACT

Analyses of hydrothermally altered rocks, vein ore, 1992–1993 andesite, 200–360 °C fumarole discharges, and fumarole sublimates show that Galeras volcano has deposited Au in past hydrothermal events and that solidified andesite and magmatic volatiles contain Au at levels of about 0.015 mg/kg and 0.04 mg/kg, respectively. Although the S in Galeras magma is relatively reduced, shallow decompression releases gases containing SO_2 that disproportionate with water to form H_2SO_4-rich fluids. The hydrothermal environment in country rocks surrounding the magmatic conduit is best described as "high-sulfidation" and provides favorable conditions for deposition of Au, Cu, and other metals; it is entirely possible that a gold-enargite deposit has already formed during the complex hydrothermal evolution of Galeras. Flux estimates for SO_2 discharged by the volcano and for SO_4 discharged by large acid springs flanking the volcano indicate that Galeras is releasing 0.5 kg/d Au to the atmosphere and is probably depositing >0.06 kg/d (>20 kg/yr) Au inside the volcanic edifice. If such flux rates remained continuous, a moderate-sized precious-metal deposit (>200 t contained Au) would form in only 10 ka.

INTRODUCTION

Throughout history, no metal has been more desired or described than gold (Boyle, 1987). Economic geologists have long recognized the association of precious metal deposits and exhumed volcanoes. Epithermal gold deposits associated with obvious volcanism are now broadly classified as low-sulfidation (adularia-sericite) types, in which the principal mineralizing fluid is meteoric water, and high-sulfidation (acid-sulfate or alunite-kaolinite) types, in which the primary fluid is magmatic water (Heald et al., 1987; Hedenquist, 1987; Rye, 1993). Geologic and geochemical characteristics of high-sulfidation Au deposits have been recently tabulated by White (1991). Such deposits generally contain substantial Cu as enargite and other sulfosalts and develop in relatively acid environments where alunite, kaolin, pyrophyllite, and diaspore may be stable (Knight, 1977). High-sulfidation deposits most commonly form in the higher levels of stratovolcanos and flow-dome complexes of andesitic to rhyolitic composition (Sillitoe and Bonham, 1984), although the largest bulk-mineable gold deposit of this type occurs in a maar-diatreme complex (Vennemann et al., 1993). Degassing shallow magma is presumed to be the primary source of S, Cl, F, Cu, and Au responsible for acidification, alteration, and ore formation in high-sulfidation deposits (Brimhall and Ghiorso, 1983; Giggenbach, 1992; Rye, 1993; Hedenquist et al., 1993).

The highly active Colombian volcano, Galeras (Figs. 1, 2), provides an ideal setting in which to better understand these processes. We have analyzed samples of rocks, veins, sublimates, acid springs, and high-temperature fumarole discharges (≤360 °C) from the volcano. Our results show that Au and Cu not only were deposited in past hydrothermal events, but are degassing from shallow magma. In this paper we discuss geochemical processes involved with Au transport from magma into hydrothermal fluid, calculate flux rates of Cu and Au associated with recent eruptions and acid spring discharges, and speculate on the present formation of gold-enargite deposits at Galeras.

GALERAS VOLCANO

Galeras volcano (4200 m) is a composite andesitic stratovolcano located in the northern Andes volcanic chain of southern Colombia (Fig. 2). Galeras is historically the most active volcano in Colombia, having erupted many times since first observed by Europeans in 1554. After 40 yr of dormancy, Galeras became active in March 1988, and its close proximity to the city of Pasto (300,000 people) led to its eventual choice as a "Decade Volcano" (Muñoz et al., 1993; Stix et al., 1993). A small but catastrophic explosion on January 14, 1993, killed six scientists

Galeras *continued on p. 244*

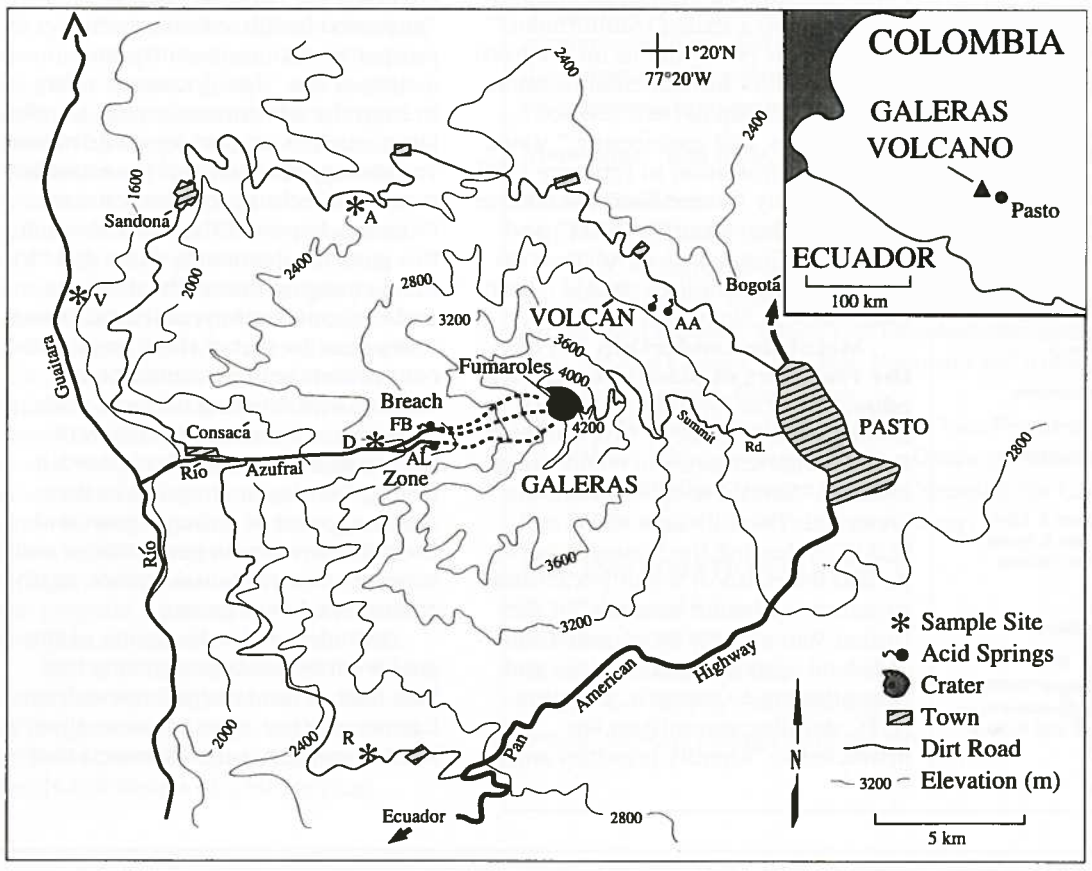

Figure 2. Map of Galeras volcano region, Colombia, showing significant features. Symbols: A = dated olivine andesite flow (0.686 ± 0.012 Ma); R = dated biotite rhyolite tuff (0.288 ± 0.034 Ma); D = altered porphyritic dacite; V = gold-bearing quartz-dolomite-sulfide-sulfosalt vein; AA = Aguas Agrias springs; AL = Alicamancha springs; FB = Fuente Blanca springs.

IN THIS ISSUE

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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. In future issues, Washington Report will present summaries of agency and interagency programs, track legislation, and present insights into Washington, D.C., geopolitics as they pertain to the geosciences.

Science in the National Interest

"This country must sustain world leadership in science, mathematics, and engineering if we are to meet the challenges of today ... and of tomorrow." (President William J. Clinton, in the introduction to "Science in the National Interest—Policy Statement")

"Science reveals new worlds to explore, and by implication new opportunities to seize and new futures to create." (Vice President Al Gore, Forum on Science in the National Interest, February 1994)

The new Clinton science policy is "a vision statement superior to any I have seen in my experience ..." (Rep. George E. Brown, Jr. [D—CA], chairman of the House Science, Space, and Technology Committee, August 4, 1994 [quoted in the August 5, 1994 Washington *Post*])

On August 3, 1994, the Clinton administration released "Science in the National Interest—Policy Statement," the first formal executive science policy statement issued since the Carter administration. The statement sets forward five goals for "our stewardship of science in the national interest." These are:

1. to maintain leadership across the frontiers of scientific knowledge;
2. to enhance connections between fundamental research and national goals;
3. to stimulate partnerships that promote investments in fundamental science and engineering and effective use of physical, human, and financial resources;
4. to produce the finest scientists and engineers for the 21st century; and
5. to raise the scientific and technological literacy of all Americans.

To reach the five goals, "Science in the National Interest" states that the "Administration proposes a coherent, integrated set of policies and will work to refine and implement them in concert with the Congress, state and local governments, academia, industry, the research and educational communities, and our citizens. We are all stakeholders in the scientific enterprise, and we now must focus on a shared commitment."

This new policy builds on the overarching goal for fundamental research, "world leadership in basic science, mathematics, and engineering," stated by the administration in February 1993 and the newly formed National Science and Technology Council (NSTC) and President's Committee of Advisors on Science and Technology (PCAST), both established in November 1993.

Maintain Leadership Across the Frontiers of Scientific Knowledge. This goal "will serve the NSTC as the principal guide to investment in fundamental science and engineering research." Several specific actions are presented. These include NSTC and PCAST evaluating the "research portfolio and the status of the physical infrastructure needed for research" in the United States, partly by coordination of federal agency responsibilities and commitments to research. The nine NSTC standing committees are instructed to "identify priorities and prepare technical information, implementation plans, and milestones and measures of progress in support of NSTC priorities."

The policy statement also directs that if U.S. researchers are to "sustain leadership and strengthen participation in collaborative scientific endeavors, we must increase our level of interaction with colleagues in other countries." This cooperation includes sharing of costs as well as sharing the results of research. Specifically mentioned are "engaging the scientific communities of the Americas" as an outgrowth of the North American Free Trade Agreement and development of international data standards. Specifically stated is the long-term goal of raising the total national research and development outlay (both civilian and defense) to 3% of the gross domestic product. Currently, research and development represents 2.6% of the gross domestic product (civilian, 1.9% and defense, 0.7%). "Science in the National Interest" states that basic research, "the venture capital" of our national enterprise, is only 0.27% of the gross domestic product.

Enhance Connections Between Fundamental Research and National Goals. The statement identifies our national goals as "improved health, environment, prosperity, national security, and quality of life." The document refers to steps the administration has already taken, such as support for an Advanced Technology Program and the establishment of a Technology Reinvestment Program. As part of the effort to reach this goal, the document states that "in these changing times" the missions and the contributions of federal laboratories must be part of the strengthened connections between fundamental research and evolving national goals. Therefore, a cross-agency review of these national laboratories is needed, paying "particular attention to their role in support of national goals and their effectiveness in performance and support of fundamental science, mathematics, and engineering."

Included in the discussion of this goal are statements recognizing that "the fruit of fundamental research initiatives may not ripen for some time." Most important is the statement that "we cannot allow a short-term mission focus to compromise development of the intellectual capital vital to our Nation's future."

Stimulate Partnerships that Promote Investments in Fundamental Science and Engineering and Effective Use of Physical, Human, and Financial Resources. The document states that successful private sector industrial participation in fundamental research results from "an appropriate fiscal and budgetary environment, a stable science-based regulatory system, a global trade environment which encourages commercialization of technology, and intellectual property protection." Similarly, academia's participation is based on "stable policies on research funding, establishing equitable policies for financing the construction, renovation, and modernization of educational and research facilities, and modernizing the costing principles for academic buildings and equipment." The statement declares that the Clinton administration will work "in partnership with universities and the private sector to modernize our research infrastructure." Between $10 billion and $11 billion are identified as needed for the "repair and renovation of existing academic research space" and to meet "high priority scientific instrumentation needs." Although "Science in the National Interest" states that there is a "continuing need for government programs to modernize our research infrastructure," it does not indicate how or how soon these costs will be met.

Produce the Finest Scientists and Engineers for the 21st Century. Although the statement declares that "American colleges and research universities are unmatched in their ability to provide advanced education and to enrich it through forefront research," I was unable to find a clear description of how this ability will translate into the needed scientists and engineers of the 21st century. The document states, "Our goal is to maintain this excellence and to encourage the ongoing reexamination of advanced education in our colleges and universities." But the "how" is missing. Aside from a statement that the NSTC will produce a "human resources development policy for sustaining excellence and promoting diversity in the science and technology workforce," what is presented are general statements about "engaging the talents of our diverse population," "mentoring of individuals in underrepresented groups," and a request to "all Federal grantees to engage creatively in the process."

Raise Scientific and Technological Literacy of all Americans. The document states that "We must improve the U.S. educational system to give our children an understanding and an appreciation of science and the opportunity to compete successfully for high quality jobs and to lead productive lives." To achieve this, the Clinton administration has proposed "Goals 2000: Educate America," an initiative calling for systematic reform of elementary and secondary education. Also mentioned is the national information infrastructure and the need to "educate our children for the twenty-first century workplace in a twenty-first century setting."

On this account, the administration is already making progress. The text of "Science in the National Interest" was available on the Internet within 24 hours of its official release. ■

IEE Annual Environmental Forum To Focus on Crucial Environmental Issues Related To Hazards and Habitat

Fred A. Donath, Executive Director, GSA Institute for Environmental Education

As an educational interface between the geological community and the public on matters of the environment, and mindful of its charge to promote the "application of geology to the wise use of Earth," the GSA Institute for Environmental Education has selected several crucial issues for its third Annual Environmental Forum, to be presented Sunday, October 23, in Seattle. IEE is joined in this effort by the GSA Geology and Public Policy Committee. The forum is entitled *Crucial Environmental Issues: Fear and Loathing at the Leading Edge*. Speakers will address four topics: earthquakes and seismic hazard analysis, geologic factors affecting habitat loss and modification, low-level radioactive waste disposal, and contaminant hydrogeology.

The first speaker in this year's IEE forum points out that earth science professionals have even broader social responsibilities than such critical roles as: the discovery and conservation of natural resources; predicting, warning, and advising of natural hazards; and advising on the impacts of human activities. William Dietrich, a Pulitzer Prize–winning journalist with the *Seattle Times*, notes that science and technology are the dominant driving forces of modern civilization, shaping enormous environmental and social change. As society becomes more complex, scientists are increasingly pressed to contribute to decision making. Science, in turn, is dependent on taxpayer support and understanding. Polls show an astounding public ignorance, misunderstanding, and distrust of science. Dietrich believes that, broader and more subtly, geologists have a crucial role to play in sharing their perspective on issues of critical importance: In comparing the human life span and history of civilization with the history of Earth, what does this length of time imply for the rate of change we now see? To what extent is our livable environment the product of geology, and what does this tell us about the chance of life on other planets? What do geology and paleontology say about the fate of past life, and what are the implications for us? How does modern geology differ from creationism, and what does that imply? How does science differ from other thought systems? Geologists must talk to a broader audience than each other, bringing their knowledge to everyday decision making.

Ian P. Madin of the Oregon Department of Geology and Mineral Industries (ODGMI) discusses earthquake hazards in the Pacific Northwest, which in years past had generally been considered to be minor for Oregon and Washington. During the 1980s, however, this perception was changed by seismologists and geological research. Demonstration of the occurrence of past megathrust earthquakes related to the Cascadia subduction zone represents a triumph of field geology applied to seismic hazard analysis. Seismic threats from intraplate earthquakes up to M 7.5, crustal earthquakes up to M 6.5, and subduction earthquakes up to M 8.5 or larger are now widely recognized. Still, the frequency, magnitude, and location of individual seismic sources are poorly understood. Recognizing that much earthquake damage is related to site-dependent enhancement of vibratory ground motion, ODGMI began in 1990 to map hazardous sites in the Portland, Oregon, urban area. Archival subsurface data were used to develop a 3-D digital model of the entire geologic column above bedrock for eight quadrangles. Numerous boreholes and cone penetrometer profiles provided geotechnical data that were used with the geologic model for computer analysis of liquefaction, landslide, and amplification potential. Published maps for a technical audience show the individual hazards; a combination map for the general public shows the relative hazard posed by all three. These maps are being used for GIS-based damage and loss modeling, as well as for aiding public and private officials with siting and zoning decisions.

> ***Geologists have a crucial role to play in sharing their perspecitve on issues of critical importance.***

Shoreline erosion, wetland loss, pollution of coastal waters, modification of fresh water and sediment inflow, resource extraction, recreational and industrial development, storm protection measures, and transportation system construction are among the activities that impact coastal ecosystems. Charles G. Groat of the Center for Coastal, Energy, and Environmental Resources at Louisiana State University points out that utilization of research-derived understanding of processes that shape natural coastal systems is neither automatic nor routine in dealing with the impacts of planned or already implemented activities. Good science is only one element in coastal management decision making, and, unfortunately, it commonly is a minor one. Among the reasons for this are entrenched government agency practices, resistance to having "professor types" involved in agency business, emotion-based positions on the issues by public interest groups, and social, political, and economic factors that tend to outweigh concerns for the natural systems in activities that involve contentious resource uses and ecosystem modifications. The development of a long-range plan and individual projects for the $50 million per year coastal restoration program under way in Louisiana provides a good example. After initial agency resistance to the organized involvement of university scientists and use of current research results that challenged long-standing ecosystem management practices advocated by participating federal agencies, the scientific community won a long struggle to become an active force in the program, shaping the comprehensive plan along natural systems lines.

David R. Montgomery of the University of Washington believes that one of the great social crises of the coming millennium will be reconciling the needs and desires of a burgeoning human population with the health and stability of ecological systems. The recent adoption of ecosystem management strategies to address aspects of the underlying issues provides new opportunities for the geological sciences. The decline of the Pacific salmon illustrates this. Long-term geologic processes influence regional habitat characteristics, control rates and extents of catastrophic events that extirpate populations, and govern long-term ecological changes that create and destroy habitat. Temporal variability of stream discharge and channel bed scour affect different life history stages of salmon over annual time scales; spatial variability in these processes influences how salmon use channel habitat. At finer spatial and temporal scales, the intrusion of sand and silt into spawning gravels influences the development of embryos during incubation in stream beds. Hence, understanding of the production and delivery of sediment off a landscape is crucial to addressing the causes of and potential for fine sediment intrusion into stream beds. Geologic insight into such issues can guide strategies for habitat restoration, species recovery programs, and implementation of ecosystem management. The spatial and temporal patterns of geological, geomorphological, hydrological, and geochemical processes form the physical template upon which aquatic and terrestrial ecosystems develop. Thus, understanding of ecological processes sufficient to guide ecosystem management requires a strong foundation in the essential role of the geological sciences in addressing ecosystem degradation and management, issues commanding an increasing proportion of our society's time and resources.

An environmental issue that can evoke strong public reaction is the disposition of low-level radioactive waste. One segment of the population is fearful that radionuclides cannot be disposed of safely; another is fearful that opposition to anything "nuclear" will prevent a reasoned solution, jeopardizing medical research that involves the use of radioisotopes and ultimately leading to loss of life. William W. Otterson, Director of the University of California, San Diego, CONNECT Program in Technology and Entrepreneurship, addresses challenges and consequences related to this issue. He points out that since the low-level radioactive waste disposal site at Barnwell, South Carolina, was closed to "out-of-compact" waste on July 1, 1994, biotech companies, hospitals, laboratories, and universities located in all but a few states

IEE *continued on p. 251*

ENERGY AND THE ENVIRONMENT:

APPLICATION OF GEOSCIENCES TO DECISION MAKING

1995 U.S. Geological Survey McKelvey Forum
Washington, D.C., February 13–16, 1995

ISSUES:

- What are the energy resources of the future based on scientific, technologic, economic, environmental, and sociopolitical factors?
- How does the natural occurrence of oil, gas, and coal impact the atmosphere, water quality, and climate changes?
- What are the environmental effects of energy resource development?
- How is geological information used in formulating regulatory policy?

SPECIAL FEATURE:

A highlight of the Forum will be a panel discussion on the technologic, economic, political, and social aspects of energy resources of the future, and their impact on the environment. Panel members will state their positions and field questions from the moderator, other panel members, and the audience.

Moderator: Ken Bode, Host of *Washington Week in Review*

Panel Members:

Mr. Thomas Bechtel, Director, Morgantown Energy Technology Center, U.S. Department of Energy
Mr. Daniel Becker, Chief, Global Warming and Energy Program, Sierra Club
Mr. Michael German, Senior Vice President, American Gas Association
Gen. Richard Lawson, President, National Coal Association
Dr. Jeremy Leggett, Greenpeace
Dr. Dale Nesbitt, Economist and Senior Vice President, Decision Focus, Inc.
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Galeras *continued from p. 241*

who were participating in an international workshop to study Galeras.

Recent eruptive history, tectonic setting, and bedrock geology of Galeras have been described previously (Calvache and Williams, 1992; Stix et al., 1993; Murcia and Cepeda, 1991). Although much is known about the eruptive history of the past few thousand years, little is known about the earlier volcanic events. Two $^{40}Ar/^{39}Ar$ dates we obtained for a thick andesite flow on the lower north flank of the volcano and for a widespread rhyolite tuff beneath the southern flows of the summit (A and R in Fig. 2) suggest that most of the present edifice has formed since 0.7 Ma. This volcanic pile overlies Precambrian metamorphic rocks to the south and Cretaceous ophiolites and subordinate Miocene sedimentary rocks to the north.

The summit of Galeras displays several nested craters (1–2 km wide) that have undergone sector collapse, forming a breach zone to the west. The breach zone is drained by the Río Azufral (Sulfur River). Within this crater area is an active cone with a central vent about 500 m in diameter at the east end of an andesite flow erupted in 1866 (Figs. 1 and 3). A plug dome grew in the central vent during 1991 but was destroyed by a violent explosion on July 16, 1992 (Stix et al., 1993). The explosion of January 1993 produced ash containing fragments of fresh andesite and hydrothermally altered rocks from the conduit. The fresh lavas and ash are porphyritic, calc-alkaline andesites (57–59 wt% SiO_2) containing phenocrysts of plagioclase, clinopyroxene, orthopyroxene, magnetite, ilmenite, and sparse resorbed olivine. A variety of textures including sieve texture and reverse zoning in plagioclase and reverse zoning and mantling of one pyroxene by another suggest that mixing of similar batches of basaltic andesite and andesite was an important process in development of the Galeras magma chamber (Stimac and Pearce, 1992). Stix et al. (1993) demonstrated that the solidified andesite is relatively rich in Cl and F, but depleted in S. The andesite from the plug dome contains <1% metasedimentary xenoliths composed of quartz, biotite, cordierite, and banded pyrrhotite (Goff et al., 1993).

High- and low-temperature fumaroles (60–360 °C in early 1993) discharge near the margins of the active central vent (Fig. 1). The hottest fumarole (Besolima, 340–360 °C) produces vapor containing 90 mol% H_2O. The $\delta D/\delta^{18}O$ and ^3H values of this water show that it is 80% magmatic water and 20% meteoric water <1 yr old precipitated on the crater (Goff et al., 1993). The noncondensible gases consist of 75.3% CO_2, 12.3% SO_2, 5.2% H_2S, 3.7% HCl, 0.4% HF, 2.3% H_2, 0.5% N_2, 0.03% CO, and 0.000% O_2 (all mol%). Carbon, sulfur, and helium isotope results show that the fumarole gases are primarily magmatic in origin (Williams et al., 1993; F. Goff and G. McMurtry, unpub. data). Warm acid springs (≤29 °C) of SO_4-Cl–rich composition discharge from the eastern flank (Aguas Agrias group) and western breach zone (Río Azufral groups) of the volcano at elevations of 2400 to 2800 m. The Río Azufral springs issue from and just below the contact of 1866 lava and underlying andesitic flows and volcaniclastic deposits. The $\delta D/\delta^{18}O$ and ^3H values of acid spring waters show that they are composed of >95% meteoric water ≤20 yr old (Goff et al., 1993). The geologic setting and geochemistry of the acid springs that are the source of the Río Azufral show many similarities to the Loowit hot springs in the breach zone of Mount St. Helens (Shevenell and Goff, 1993).

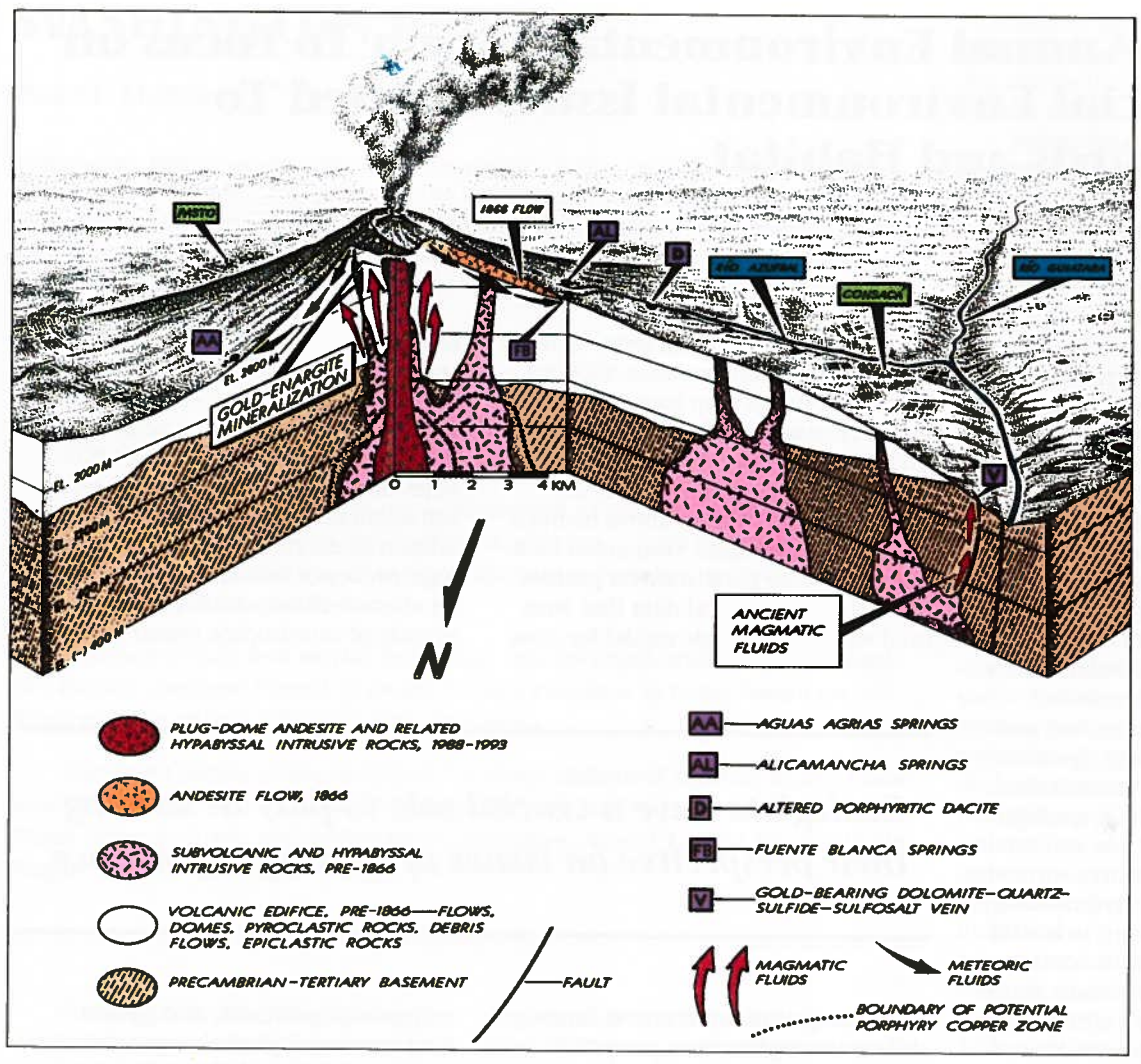

Figure 3. Modified cutaway perspective drawing of Galeras volcano (viewed from the north) showing the basic geology and configuration of a shallow hydrothermal system. Magmatic volatiles mix with young, near-surface groundwaters to form acid springs (Goff et al., 1993). Magmatic fluids discharging inside the volcano create high-sulfidation conditions favorable for deposition of Au and Cu (Hedenquist et al., 1993). Altered rocks around the volcano's conduit probably show chemical and mineral zonations typical of "acid-sulfate" precious-metal deposits as described by White (1991) and Rye (1991); such deposits are commonly associated with deeper, coeval, porphyry copper mineralization. Ancient magmatic fluids derived from a proto-Galeras intrusion are envisioned as responsible for bonanza gold mineralization now exposed on the western flank of Río Guitara. Vertical exaggeration at the Galeras summit is about 1.5x.

GOLD AND ASSOCIATED METALS

Samples described herein were collected during the three-week period after the explosion of January 1993. Chemical analyses of Au and related metals from Galeras rock and fluid samples were performed by two different laboratories (methods are given in Table 1). Mineral phases and compositions were determined by petrographic microscope, X-ray diffraction (XRD), scanning electron microscope (SEM), and electron microprobe. Small fragments of hydrothermally altered andesite breccia litter the active cone and surrounding areas and probably represent country rock encircling the magmatic conduit, which was excavated during past explosions. The breccia is replaced by quartz, gypsum, anhydrite, alunite, and pyrite (5–10 mode %) and has up to 2.5 mg/kg (ppm or g/t) Au. Outcrops of intensely altered, quartz-plagioclase porphyritic lava (dacite?) representing older Galeras volcanism are exposed along the Río Azufral about 2 km west of the Fuente Blanca springs (D in Fig. 2). Alteration minerals consist of quartz, sericite, chlorite, and pyrite, and specimens of this rock contain minor Au (0.2 mg/kg).

A spectacular but previously undescribed (Murcia and Cepeda, 1991), gold-bearing, quartz-dolomite-sulfide-sulfosalt vein cuts Miocene sedimentary and Quaternary (?) volcaniclastic rocks 16 km west of the Galeras summit (V, Fig. 1). The vein, where exposed by a small "glory hole" on the east side of the Río Guaitara, trends northwest and is up to 3 m wide; its length and depth remain to be determined. Dolomite, the earliest vein-forming phase, is partially replaced by finely crystalline quartz along with sericite, a trace of chlorite, and localized traces of hematite. Ore minerals consist of pyrite, chalcopyrite, tetrahedrite, enargite, and sphalerite as well as megascopically visible, late-stage electrum (85%–91% Au, Fig. 4). Grab samples of ore from this vein run about 20 mg/kg Au, whereas high-grade chunks contain up to 270 mg/kg Au (7.8 oz/t)! Ion microprobe analyses of coexisting pyrite yield concentrations of 0.5–0.8 mg/kg Au (see Larocque et al., 1994, for analytical parameters). The youngest vein-forming phase is kaolin, deposited in small vugs following gold precipitation.

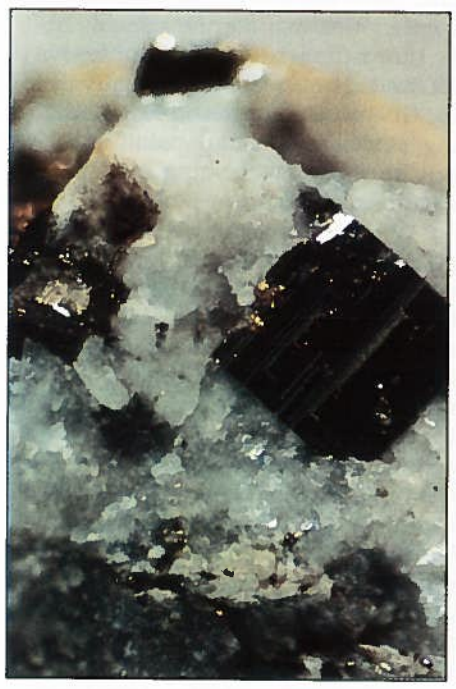

Figure 4. A 0.32 mm electrum nugget perched on a striated pyrite cube in a quartz matrix from a vein 16 km west-northwest of the Galeras summit (field of view is 0.68 cm wide). Associated minerals include chalcopyrite, tetrahedrite, enargite, and sphalerite. (Photo by Wes Martin, Salt Lake City.)

Figure 5. Photomicrograph of coexisting magnetite-pyrrhotite-Cu, Fe monosulfide in a clinopyroxene phenocryst from the July 1992 Galeras andesite (reflected light, Nomarski lens, 0.18 µm field of view).

Fluid inclusions in samples of the early dolomite are large (commonly 20 µm) and abundant, but they are exceedingly sparse and small (mostly <3 µm) in the sulfide-, sulfosalt-, and gold-stage replacement quartz. Fifteen primary inclusions trapped during crystal growth (Roedder, 1984) in dolomite yield homogenization temperatures (T_h) ranging from 116 to 132 °C (mean = 129 °C). Five primary inclusions in quartz have T_h between 163 and 173 °C (mean = 168 °C). The local geologic setting and youth of the host rocks require that at this level of exposure, these two vein minerals and accompanying metallic phases were precipitated at relatively shallow depth, perhaps 1 km or less. Accordingly, the corresponding reconnaissance T_h values for our samples approximate true entrapment temperatures (Roedder and Bodnar, 1980). The data suggest that the quartz, sulfides, sulfosalts, and gold were deposited at temperatures slightly below the typical range for high-sulfidation precious-metal systems (200–300 °C; e.g., Hayba et al., 1985). This tentative conclusion is consistent with the abundant relict presence of vein dolomite, a carbonate that would readily dissolve in the acidic solutions characterizing high-sulfidation deposits.

A sublimate sample consisting mostly of soluble sulfates and sulfur

continued on p. 245

TABLE 1. CHEMICAL ANALYSES OF GOLD AND RELATED ELEMENTS IN ROCKS, SUBLIMATE, MAGMATIC FLUID, SULFUR, AND ACID SPRING WATERS, GALERAS VOLCANO, COLOMBIA

Sample no.	Description	Au (ppm)	Ag (ppm)	Cu (ppm)	Pb (ppm)	Zn (ppm)	As (ppm)	Hg (ppm)	Sb (ppm)	Se (ppm)	Comments
Various Rocks and Sublimate											
F93-7(B)	Pyritic breccia	2.59±15%	<0.2	34	17	6	35	0.044	<5	—	50 g sample
F93-7(L)	Pyritic breccia	0.40±0.4	19	33	14	10	20	<0.05	<1	7	100 mg fragment
F93-11(B)	Altered dacite	0.22±15%	<0.2	20	30	64	86	0.02	<5	—	50 g sample
F93-11(L)	Altered dacite	0.15±0.07	13	18	36	56	80	<0.05	<1	0.1	100 mg fragment
F93-15(B)	Gold vein, ore	22.3±10%	7.3	430	20	220	165	<0.01	156	—	50 g sample
F93-15(L)	Gold vein, high-grade	269±13	30	300	15	210	190	<0.05	—	0.7	100 mg fragment
F93-16(L)	Fumarole sublimate	0.03±0.02	5.5	21	3.4	32	44	0.8	<1	24	250 mg sample
F93-21b(B)	Xenolith, bulk	0.048±25%	<0.2	345	6	18	<5	0.174	<5	—	45 g sample
F93-21b(L)	Xenolith, pyrrhotite	<0.05±0.05	45	1390	6	52	30	<0.14	<1	25	50 mg separate
Fresh Andesite											
F93-17(B)	7/92 2-px andesite	0.030±25%	<0.2	28	2	38	5	<0.01	<5	—	50 g split of XRF sample
F93-21a(B)	7/92 2-px andesite	0.015±50%	<0.2	25	3	34	<5	<0.01	<5	—	50 g split of XRF sample
Ave. of 4(B)	7/92 2-px andesite	0.016	<0.2	30	3	35	5	<0.01	<5	—	—
F93-3(B)	1/93 andesite ash	0.007±50%	<0.2	31	5	25	<5	<0.01	<5	—	50 g split of XRF sample
Magmatic Fluid and Sulfur											
GV93-33(L)	Deformes Fumarole	<0.05±0.05	—	0.19	—	—	116	0.04	0.010	0.022	T = 207 °C; total discharge
GV93-33(L)	Deformes Fumarole	23±11	34	40	<10	<60	57	23	11	55	T = 207 °C; sulfur ppt
GV93-35(L)	Besolima Fumarole	<0.05±0.05	—	0.38	—	—	165	0.01	0.010	<0.001	T = 358 °C; total discharge
GV93-35(L)	Besolima Fumarole	3±2	3	115	5	<20	290	26	26	240	T = 358 °C; sulfur ppt
GV93-36(L)	Besolima Fumarole	0.07±0.05	—	0.23	—	—	152	0.05	0.014	<0.001	T = 342 °C; total discharge
GV93-36(L)	Besolima Fumarole	9±3	6	70	7	<20	400	<1?	23	180	T = 342 °C; sulfur ppt
Acid Springs and River											
GV93-5(L)	Agua Agrias #2	<0.002±0.002	<0.001	0.12	0.005	1.09	0.090	0.001	<0.001	<0.001	T = 29.0 °C; pH = 2.3
GV93-6(L)	Agua Agrias #1	<0.002±0.002	<0.001	0.06	<0.002	0.87	0.004	<0.001	<0.001	<0.001	T = 27.4 °C; pH = 2.5
GV93-20(L)	Fuente Blanca	<0.002±0.002	<0.001	0.05	<0.002	0.08	<0.05	—	<0.001	<0.001	T = 21.8 °C; pH = 4.8
GV93-24(L)	R. Azufral, F. Blanca	<0.002±0.002	<0.001	0.05	<0.002	0.10	0.05	—	<0.001	<0.001	T = 19.7 °C; pH = 4.4

Note: B after sample number indicates analysis by Bonder-Clegg (Sparks, NV); Au by fire assay; Hg by cold vapor AA; others by ICP. L after sample number indicates analysis by P. Trujillo and D. Counce (LANL); Au, Ag, Cu, Pb, and Zn by graphite furnace AA after dissolution in aqua regia and HF (if needed); As, Hg, Sb, Se by hydride generator method.

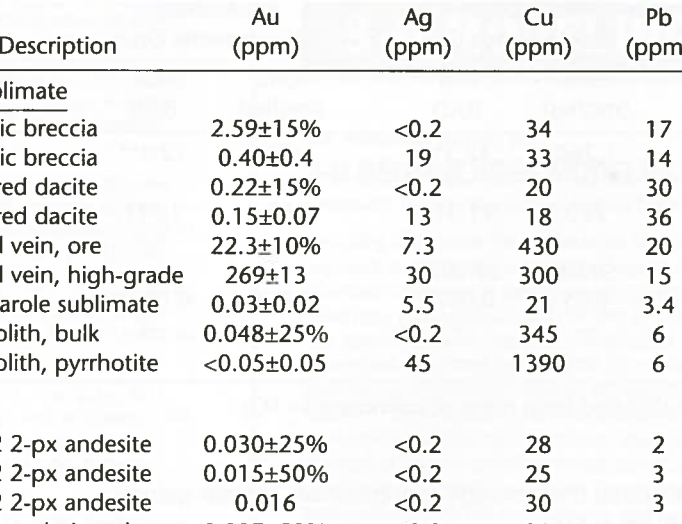

Figure 6. Plot of log f_{O_2} vs. temperature showing redox conditions of 1992 Galeras andesite. Although only sulfide phases are present in the solidified andesite, shallow decompression of magma causes released volatiles to become SO_2-rich with falling temperature. Conditions for the Bandelier Tuff (Valles caldera) are from Warshaw and Smith (1988). MSH = 1980–1986 Mount St. Helens dacite; P = 1991 Pinatubo dacite (modified from Rutherford, 1993; Rye, 1993).

Galeras *continued*

from Deformes Fumarole (200 °C) contains detectable Au. A bulk sample of metasedimentary xenolith from 1992 Galeras andesite also contains detectable Au, although a pyrrhotite separate does not. Ion-microprobe analysis of the pyrrhotite indicates that Au content is <0.050 mg/kg. Most of these samples contain Cu, Ag, and varying amounts of relatively volatile As, Hg, Sb, and Se. Contents of Cu are generally greater than those of Pb and Zn, a feature common to high-sulfidation Au deposits (White, 1991).

Four samples of fresh andesite from the July 1992 explosion contain an average of 0.016 mg/kg Au, whereas the ash from January 1993 contains 0.007 mg/kg Au. One sample of andesite (analyzed twice) contains 0.030 ± 0.002 mg/kg Au. For comparison, Mount Erebus anorthoclase phonolite contains 0.023 mg/kg Au (Kyle et al., 1990). These values are considerably higher than the mean value of 0.00054 mg/kg Au recently reported for a suite of 23 "relatively silicic intermediate rocks" (Connors et al., 1993) and suggest that Au content in any given magma is highly unpredictable, or possibly that extremely young, fresh specimens quenched near their vents have Au contents more representative of initial values.

Total discharge samples of magmatic fluid from high-temperature fumaroles were collected through Ti tubing into special evacuated glass bottles filled with ~100 ml of 4N NaOH (Trujillo et al., 1987; Fahlquist and Janik, 1992). After the gases were determined, splits of the caustic solutions were analyzed for selected metals. Results indicate that the magmatic fluid contains Au at levels of ≤0.07 mg/kg (≤0.07 g/t). Magmatic fluids were also condensed in glass tubes immersed in crushed ice and water. Some elemental S precipitates during condensation and partially scavenges metals, particularly volatile elements, Cu, and Au. Although the S analyses are not quantitative (about 0.009 to 0.035 g S precipitates from 50 ml of condensate), the S analyses verify that Au is present in the magmatic fluid at concentrations >0.006 mg/kg. In contrast, the acid springs flanking Galeras contain <0.002 mg/kg Au and low levels of the other metals.

MAGMATIC AND HYDROTHERMAL CONDITIONS

The temperature of July 1992 Galeras andesite magma during eruption was 1000 ± 50 °C, determined from both two-pyroxene and Fe-Ti oxide geothermometry (Lindsley and Anderson, 1983; Ghiorso and Sack, 1991), and the log f_{O_2} was –10.8 to –9.7. Coexisting blebs of magnetite, pyrrhotite (Fe[0.96]S), and Cu, Fe monosulfide in clinopyroxene phenocrysts place the log f_{S_2} at –0.7 to –0.9 (Toulmin and Barton, 1964) and show that the S in the magma was relatively reduced (Fig. 5). Many arc magmas straddle the SO_2-H_2S boundary, whereas continental ignimbrites like the Bandelier Tuff tend to lie well below this boundary (Fig. 6), although the state of S in any given magma will be controlled by temperature, pressure, melt composition, and total S (Hattori, 1993). Magmatic vapors released from solidifying andesite in the conduit (and, previously, the plug dome) undergo rapid decompression, causing H_2S to partially convert to SO_2 (Fig. 6; Rye, 1993). As a result, the magmatic vapors become oxidizing (high-sulfidation). Below temperatures of 400 °C, SO_2 disproportionates in the presence of water to H_2SO_4 and H_2S (Rye, 1993); thus, an extremely acid environment develops around the magmatic conduit.

We have not identified a separate Au-rich phase in Galeras andesite, but it is most likely carried in sulfide phases and magnetite in the magma (Connors et al., 1993) as well as the xenoliths. During shallow degassing, some Au partitions from magma into vapor and is probably transported as $HAu(SH)_2$ (Giggenbach, 1992) or AuS (Symonds and Reed, 1993). The solubility of the first phase in SO_2-rich vapor at 400 °C (Fig. 7) is compatible with Au values that we measured in the total discharge samples (≤0.07 mg/kg).

Although many tons of magmatic volatiles are lost to the atmosphere at Galeras (Stix et al., 1993), SO_4-rich acidic fluids invade and attack country rocks around the conduit, as evidenced by hydrothermally altered rocks around the vent and in exploded ejecta. A probable path line (1) for present Galeras hydrothermal fluid (Fig. 7) shows that the solubility of Au decreases dramatically going from submagmatic conditions around the conduit to conditions represented by the acid springs on the flanks of the volcano. Most of the Au is precipitated in rocks such as the pyritic breccia (Table 1) surrounding the conduit. Another path line (2) shows that the Au-bearing

Galeras *continued on p. 246*

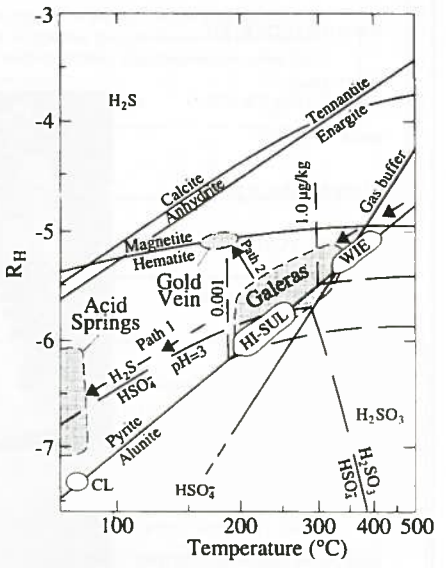

Figure 7. Redox potential ($R_H = f_{H_2}/f_{H_2O}$) vs. temperature (modified from Giggenbach, 1992). The heavy line designated "gas buffer" represents magmatic fluid ($H_2S + H_2SO_3$), and Au solubilities are in µg/kg of $HAu(SH)_2$. Open envelopes show conditions for White Island "acid-sulfate" ejecta (WIE), for typical acid crater lakes (CL), and for high-sulfidation Cu-Au deposits (HI-SUL) as defined by Hedenquist et al. (1993). Shaded envelopes show probable conditions surrounding the conduit within Galeras, the range of conditions represented by the acid springs, and conditions represented by the Au vein west of Galeras. Path 1 shows a probable transition from magmatic fluid to the acid springs. Falling temperature causes Au deposition in the region surrounding the conduit. Path 2 shows a hypothetical transition from high-sulfidation conditions to conditions represented in the gold vein during progressive neutralization of fluid.

Galeras *continued from p. 245*

quartz vein west of Galeras could be generated by progressive neutralization of metal-rich acidic solutions from earlier magma-hydrothermal events in the evolution of the volcano.

The position of the gas buffer, compositions and temperatures of fumarole discharges, and coexisting phases in the pyritic breccia require that conditions around the conduit are very close to the pyrite-alunite join (Fig. 7). The envelope marked "HI-SUL" (Fig. 7) represents high-sulfidation Cu-Au deposits as defined by Hedenquist et al. (1993) and implies that such deposits must have alunite, which, of course, many do. As the name suggests, however, high-sulfidation conditions are defined by the oxidation state of S (and the resulting acidity of the hydrothermal fluid). Extremely sharp chemical and mineral zonations typically are present in the exhumed conduits and fracture networks of high-sulfidation deposits (White, 1991). Deposition of Au and Cu under high-sulfidation conditions can take place without formation of alunite, and enargite can form in environments considerably less acid than those forming alunite.

FLUX RATES

Since 1988, emissions of SO_2 at Galeras have often exceeded 2000 t/d (maximum about 5500 t/d) but have generally decreased since early 1990 to values of typically 500 t/d (Stix et al., 1993; Fischer et al., 1994). No Cu/SO_2, Au/SO_2, or other metal ratios have been determined in the aerosols at Galeras. The concentration of Cu in the total discharge of three fumarole samples is 0.19 to 0.38 mg/kg (average 0.27 mg/kg). Although as much as 0.07 mg/kg Au apparently occurs in discharge samples, the average Au/Cu ratio of the S precipitates indicates an average Au content of 0.04 mg/kg. We realize that changes occur with time in the relative proportions of gases in Galeras fumarole discharges (Fischer et al., 1994), but these changes are small relative to water. Thus, we can calculate the approximate flux rates of selected constituents from the volcano assuming constant ratios of these constituents to SO_2 (Table 2). A constant flux of 500 t/d and concentration of 38,000 g/t SO_2 from Besolima Fumarole are used. The results show that very large amounts of CO_2, H_2S, and HCl are discharged with SO_2 and water. Nearly 2 t/d As are also discharged. Flux rates of Cu, Au, and Hg are roughly 3.6, 0.5, and 0.4 kg/d.

TABLE 2. CONCENTRATONS AND FLUX RATES OF SELECTED CONSTITUENTS IN ACTIVE CRATER PLUME AND ACID SPRINGS, GALERAS VOLCANO, COLOMBIA

Constituent	Galeras Volcano,* active crater		Río Azufral† Fuente Blanca Gp.		Río Azufral§ Alicamancha Gp.		Agua Agrias# Springs 1 and 2	
	conc. (mg/kg)	flux (t/d)	conc. (mg/kg)	flux (t/d)	conc. (mg/kg)	flux (t/d)	conc. (mg/kg)	flux (t/d)
SO_2	38,000	500	1,260	42.3**	650	12.4**	~4,500	~0.3**
H_2S	8,700	115	—	—	—	—	—	—
HCl	6,800	89	220	11.3††	58	1.7††	~575	~0.04††
CO_2	160,000	2,100	—	—	—	—	—	—
As	144	1.89	≤0.05	≤0.0025	—	—	≤0.09	≤4x10-6
Cu	0.27	0.0036	0.05	0.0025	0.008	0.0002	~0.09	~4x10-6
Au	0.04	0.0005	—	—	—	—	—	—
Hg	0.03	0.0004	—	—	—	—	—	—

* Flux of 500 t/d assumed; other fluxes calculated from ratios of unknowns to SO_2.
† Estimated discharge is 50,000 t/d.
§ Estimated discharge is 30,000 t/d.
# Estimated discharge is 80 t/d; fluxes calculated from average concentrations of both springs.
** Measured analyte is SO_4; flux is recalculated as SO_2.
†† Measured analyte is Cl; flux is recalculated as HCl.

Although Au measurements in gases and aerosols are lacking at most volcanoes, the Au concentrations determined in the total discharge at Galeras are about four times higher than measured at White Island, a similar calc-alkaline volcano (Le Cloarec et al., 1989). The flux rate of Au at Mt. Erebus can be as much as 0.1 kg/d when the SO_2 flux is only 20 t/d (Meeker et al., 1989). Concentrations of Cu at Galeras are about five times higher than at White Island in comparable fumarole discharges, but Le Cloarec et al. (1989) have measured considerably higher flux rates of Cu in the aerosols (300 kg/d).

It is interesting to calculate the flux of magmatic volatiles into the Río Azufral, which drains approximately 99% of Galeras acid spring waters from remote locations 4.5 km west of the active crater (Fuente Blanca and Alicamancha). We determined approximate flow rates of 50 and 30 x 10^3 t/d for the two main branches of the Río Azufral fed by these springs, whereas the total flow rate of the Aguas Agrias group is merely 80 t/d. The SO_4 and Cl in these springs are derived from magmatic volatiles (SO_4/Cl recalculated as SO_2/Cl is similar to SO_2/Cl of fumarole discharges) even though, as at Mount St. Helens, the waters are dominantly meteoric (Shevenell and Goff, 1993; Goff et al., 1993). The flux of SO_2 and Cl from the Río Azufral springs is about 55 and 13 t/d or about 10% of the flux discharged at the volcano summit, assuming the latter is 500 t/d SO_2. By comparison, the measured discharge of thermal fluid into Loowit Creek, Mount St. Helens, was 18 x 10^3 t/d in 1989 (Shevenell and Goff, 1993), and the fluxes of SO_2 and Cl were 6.2 and 10.1 t/d, respectively.

The flux of Cu into the Río Azufral (2.5 kg/d) is actually larger than would be expected from the Cu/SO_2 ratio in the fumarole discharges. Hedenquist et al. (1993) noted similar findings in the acid springs of White Island and suggested that additional Cu was provided by isochemical dissolution of rock by acid waters. On the other hand, Au concentrations in the acid springs of Galeras are <0.002 mg/kg. Using an equivalent SO_2 flux of 55 t/d for all acid springs and a ratio for Au/SO_2 of 1.05 x 10^{-6} in the magmatic fluid, at least 0.06 kg/d or 20 kg/yr Au are being deposited in the hydrothermally altered volcanic rocks inside the volcano. If sustained, flux rates of this magnitude can produce moderate-sized Au deposits (>100 t contained Au) in geologically short periods of time (a few thousand years or less).

CONCLUSIONS

The temporal variation of Au concentration in the crater fumaroles and flux rate of magmatic volatiles in the acid springs are unknown, but Galeras has erupted often during the last few thousand years and has supplied magmatic components to the acid springs for at least several hundred years. At present, the volcano vents 0.5 kg/d Au to the atmosphere (based on SO_2 flux of 500 t/d) and is probably depositing at least 0.06 kg/d Au in altered rocks around the magmatic conduit (Fig. 3). Depositional conditions are best described as high-sulfidation and are similar to conditions described in classic "acid-sulfate," gold-enargite deposits within exhumed volcanoes (e.g., White, 1991; Rye,1993). The Au contents of hydrothermally altered rocks and veins in the volcanic edifice indicate that magmatic fluids have episodically deposited Au (as well as other metals) over many thousands of years, perhaps the past 700 ka.

Note Added in Proof: The leachate from dolomite in the gold-bearing vein west of Galeras was dated by M. Murrell (LANL) using the $^{234}U^{230}Th$ disequilibrium method. Although the observed disequilibrium is only a few percent, it is clearly resolved using mass spectrometry. Given the usual assumptions about closed system behavior and low initial ^{230}Th, the apparent age of this sample is 520 ka (+110, –60; 2σ).

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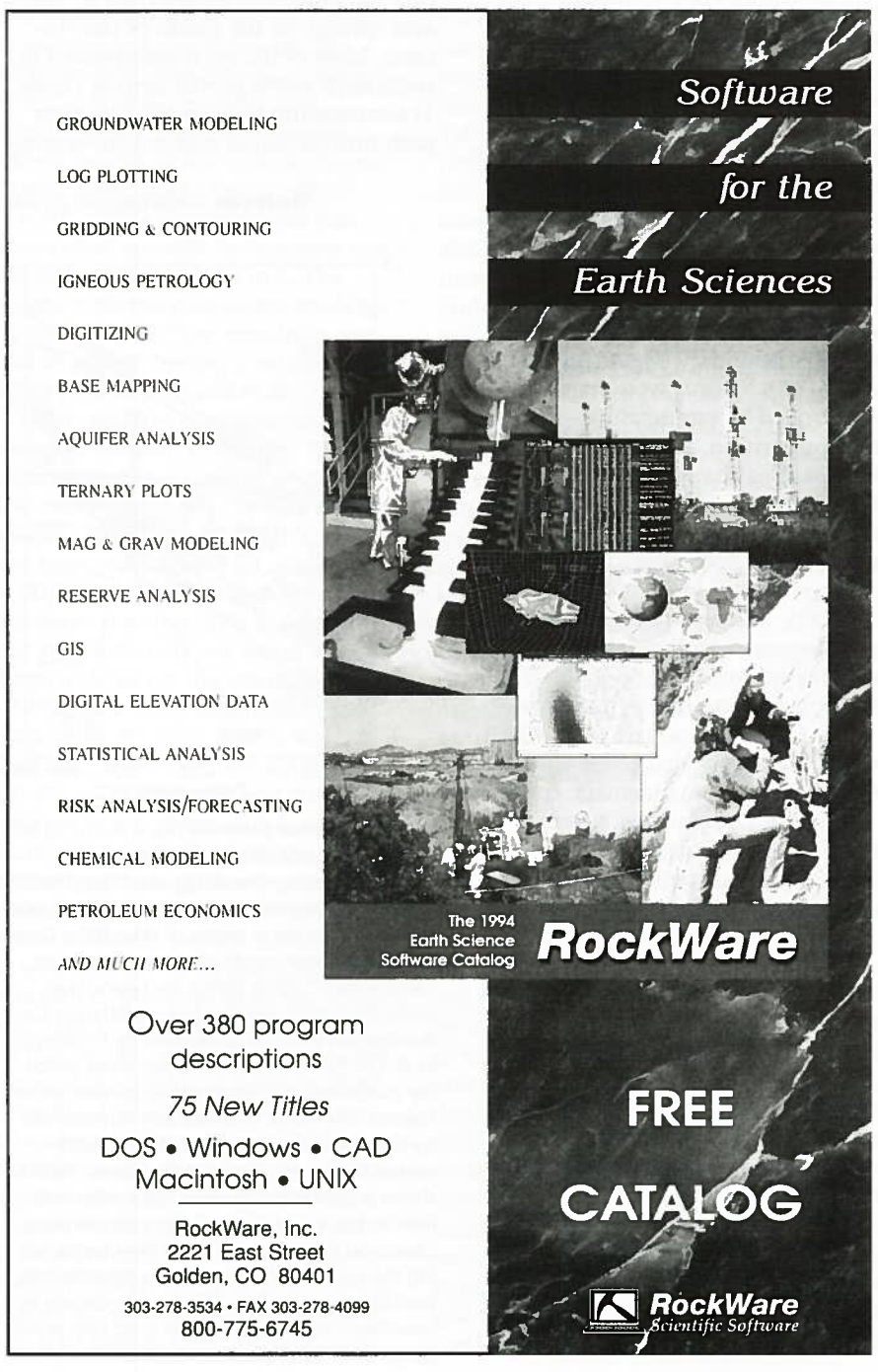
Galeras *continued on p. 247*



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Penrose Conference Report

Effects of Triple Junction Interactions at Convergent Plate Margins

Conveners:
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The typical view of the subduction of oceanic lithosphere is as a two-dimensional process dominated by underflow of oceanic lithosphere, refrigeration of the fore arc, and presence of calc-alkaline magmas along a linear chain situated 70–150 km above the downgoing plate. However, Delong et al. (1979) noted that all trenches must ultimately interact with a spreading center, and the resultant triple junction interaction must profoundly influence the geologic evolution of the plate boundary. Thus, triple junction interactions should be distinct geologic "events," yet the characteristics of such events are not well understood. Despite the unequivocal requirement for ancient triple junction interactions, only a few pre-Tertiary tectonic systems are related to triple junction interaction. This is undoubtedly not a true representation of the geologic record but is an artifact of the ignorance of the geologic community of the distinctive characteristics of these events in ancient rocks. In pre–late Mesozoic rocks, where plate-tectonic records are absent, most "events" at convergent margins are commonly synonymous with orogenesis, as either inferred collisional events or contractional events driven by changes in plate motion. Thus, an important challenge for earth scientists is recognition of characteristic features of triple junction interactions, and the fingerprinting of ancient systems.

Because of these general problems, a Penrose Conference was held April 21–26, 1994, in Eureka, California, to bring together earth scientists from a variety of disciplines to determine what, if any, are the distinguishing features of different classes of triple junction interactions. This conference was a joint GSA Penrose Conference and JOI/USSAC workshop. Our primary goal was to bring together groups working on ancient and present-day systems. The 80 participants included 20 international participants from seven countries and 14 students.

The meeting began with a field trip showing on-land effects of the Mendocino triple junction in the vicinity of Eureka, California, and it focused on neotectonics of the Cape Mendocino region. The field trip demonstrated the structural complexities and the scale of the tectonic processes associated with the triple junction region. Many spirited discussions set the stage for the meeting to follow. All of the participants were impressed by the magnitude of the complex compressional deformation in the vicinity of the triple junction and phenomenal rates of uplift documented by Holocene marine terraces as well as dead intertidal organisms associated with 1992 seismicity.

The second and third days of the conference were devoted to presentations of both modern and ancient triple junction interactions. As a direct extension of the field trip, the meeting began with continued discussion of the Mendocino triple junction. Discussion began by reviewing the general tectonic features and the geodynamics of the region including (1) the development of a slab window with supporting evidence from tomographic images, (2) the unique geometry in which the transform grows by conversion of a trench to a transform, and (3) the three-dimensional complexities of the system that are closely linked to the evolving thermal structure and the potential decoupling of the upper crust relative to the lower crust and upper mantle. Volcanism associated with the slab window lagged behind the actual triple junction because of a time lag in upwelling processes in the wake of the migrating triple junction. A surprising result from the Mendocino seismic experiment that began in 1993 was evidence for a bright reflection just north of the projected position of the triple junction. This observation, together with an interpretation of underplated oceanic crust in areas to the south of the triple junction, led to an interesting discussion of slab windows at the site of the triple junction. Other critical points from this region include the three-dimensional complexities of structures recognized offshore from the triple junction; the problem of positioning the triple junction as a recognizable feature in earthquake records; preliminary global positioning system data suggesting large horizontal motions well inboard from the position of the inferred triple junction, an observation that was underscored by geologic evidence showing a large area of complex distributed deformation that varied with time; and the anomalous thermal signature of the King Range region compared to the region around Cape Mendocino.

An important challenge for earth scientists is recognition of characteristic features of triple junction interactions.

The Woodlark Basin contains the best modern example of ridge subduction entirely within oceanic plates. This region is the most seismically active in the world and has an unusual abundance of island-arc volcanoes. In addition, there is unusual near-trench magmatism with rhyodacite volcanoes in the trench, and the locus of island-arc magmatism has shifted outward with time. Many distinctive geochemical signatures such as high–Na-Ti basalts and high-Mg andesites are associated with ridge subduction throughout the Pacific Ocean. Another modern example of ridge subduction is in western Mexico, as documented by the apparent on-land effects of the Rivera–Cocos–North American triple junction; effects include complex rifting of the submarine part of the fore arc, which apparently does not extend on land and may be associated with propagating rift systems related to the triple junction.

The most well known example of ridge subduction occurs in southern Chile. Ridge subduction has been migrating northward to its present site near the Taitao Peninsula. Several unique geologic features are the offshore Taitao Ridge, the onshore Taitao Ophiolite, the Liquine Ofqui fault system, and the Golfo de Penas basin and gap in the island-arc volcanics. The associated accretionary prism also reflects the ridge interaction as the width of the fore arc varies, its surface is rough, and tectonic erosion apparently accelerated as the triple junction approached a given site. In addition, there are many thermal effects that increased hydrothermal activity, as documented by "hot jets" of fluid, abnormally high levels of cementation at shallow levels, and changes in magnetic mineralogy. A controversial point was whether the effects of ridge subduction may be seen in the outboard plate, because there appear to be unusual magmas in four ridge segments offshore from the Chile triple junction. The site of ridge subduction can be traced onshore by several means, including a large east-west gravity anomaly, a gap in seismicity, a lack of back-arc basins, a time-transgressive structural history in the back-arc region, different mean elevations, ages of arc volcanics, style of deformation, and presence of slab melts seen in the back-arc region.

Two convergent margins, Japan and Alaska, show relatively clear effects of ancient triple junction migrations. Conference sessions on these began with an overview of the Miocene Shimanto accretionary prism. Inferred plate reconstructions for the Miocene imply subduction of the Shikoku ridge. However, it was also proposed that all of the Miocene events were in fact the result of an arc collision, a controversial model that excited considerable debate but that underscored the problem of clearly recognizing the effects of a triple junction interaction in the ancient record. These discussions were then extended to the older, late Mesozoic–early Cenozoic history of the Japanese margin, where Japanese scientists have accumulated a large database suggestive of a prolonged interaction between the East Asia convergent margin and the Kula-Pacific ridge. One approach was to compile fossil ages and radiometric ages to construct "At/t" diagrams for the Japanese margin. This showed multiple periods of interaction between the convergent margin and zero-age oceanic crust. In addition, age data from the East Asian arc and cooling ages in the Ryoke belt showed a surprising reduction in ages from south to north, ranging from ca. 100 Ma to ca. 50 Ma. This, together with observations of the metamorphic history, suggest that the Ryoke belt, a type area for low-*P* metamorphism, was not an arc terrane, but may represent a fore-arc assemblage that was subjected to extensive heating and magmatic activity related to late Mesozoic subduction of the Kula-Pacific spreading center. Other signatures of ancient Japanese ridge subduction are changes in fabrics recorded in accretionary melanges related to a switch in plate motion, greenstones incorporated in an accretionary prism as both dikes and volcanics, and an Early Cretaceous metamorphic assemblage on Hokkaido that contained unusual ophiolitic assemblages.

The southern Alaska fore arc has a suite of fore-arc plutons and has been linked to early Cenozoic interaction with the Kula-Farallon spreading center. The fore-arc plutonic belt has a distinct age progression and a complex structural history closely tied to injection of a suite of dikes. This may require unusual ridge geometry to accommodate the apparently rapid age progression. The most unusual feature of the Tertiary event is a low-*P*–high-T metamorphic belt developed within part of the fore-arc system. This metamorphic belt, the Chugach metamorphic complex, reaches upper amphibolite facies at pressures <400 MPa, is associated with voluminous granitoids with isotopic signatures suggestive of a composite source including a MORB component plus anatectic melts of accretionary prism sedimentary rocks, and shows a complex structural history with an early history of orogen-parallel motions along a low-angle ductile shear zone followed by dramatic telescoping during peak metamorphism. Other important associations in this region are fore-arc strike-slip systems, Resurrection Bay ophiolite, and gold mineralization within the fore-arc assemblages. In contrast, the Early Cretaceous Alaskan fore-arc plutonic belt may represent a process different from ridge subduction—melting along a young subduction zone. Several other regions such as the Juneau goldfield and Island Mountain massive sulfide deposit in northern California may also be linked to ridge subduction. The session ended with two proposals for Paleozoic ridge-trench interaction in the eastern Klamath Mountains and eastern Australia.

The fourth day of the meeting began with a model of plate motion and a direct implication that most triple junctions have inherent instabilities related to constantly changing plate motions. Next, possible analogues in the Archean were considered. One intriguing idea that was proposed is that with higher heat flow in the Archean, there were 68 triple junctions, creating a scenario analogous to Southeast Asia. In addition, theoretical models of thermal histories of Archean oceanic plates suggest that occurrences of tonalite-trondhjemite-granite suites are not a unique signature of Precambrian ridge subduction. Formal presentations concluded with more coverage of modern examples, including the change from ridge collision to passive-margin sedimentation in the Antarctic Peninsula. This was documented by changes in uplift seen as sedimentary unconformities, an increase in hydrothermal activity, and cessation of arc volcanism at 20 Ma. In the back arc of the Antarctic Peninsula, there is evidence for alkaline volcanics that do not have any geochemical evidence for subduction influence. In this region, there was a 5 m.y. gap between the predicted opening of the slab window and the generation of magmatism. The final example covered the complex microplate interactions at the Pacific–Explorer–North American triple junc-

Penrose *continued on p. 249*

Penrose *continued from p. 248*

tion near the Queen Charlotte Islands. This presentation underscored the complex microplate interactions that accompany most ridge-subduction events as well as the development of unusual volcanic assemblages developed on the downgoing plate in advance of the triple junction.

The group then split into a series of smaller discussion groups to consider five topics. A morning session took up the topics of thermal manifestations, basin development, and ophiolite associations. The thermal manifestations session devoted considerable discussion to the diversity of possible effects, such as significant thermal distinctions among triple junctions with slab windows versus those without, and problems of determining whether heat transport is dominated by fluid advection or conduction. The role of heat transport by magmas produced extensive discussions, in particular on the inhibition of adiabatic decompression melting in a subducting system and the importance of basaltic underplating compared to conductive heating. Basin development discussions centered on problems of shifting depocenters, unconformities indicating migrating uplifts, and basin development due to fore-arc structural evolution. A session on ophiolite associations led to stimulating discussions of what may be critical to identify ancient triple junction interactions. These systems seem to show a distinctive geochemical signature of MORBs contaminated by sedimentary components. In addition, there are structural and lithologic assemblages typical of fore-arc regions clearly associated with the ophiolite and a stratigraphic cover sequence, indicating volcanism in close proximity to an existing convergent margin. All of these relations may be critical in recognizing ancient examples of ridge subduction. An afternoon session took up the topics of petrogenetic and structural signatures. The petrogenetic discussions focused mostly on igneous signatures that may be caused by triple junction interactions. These may include (1) a gap in volcanic stratigraphy and/or location of volcanoes; (2) a change from arclike volcanism to MORB/OIB volcanism as the slab window is opened; (3) parautochthonous N-MORB or contaminated N-MORB in the fore arc; (4) volcanics with slab melt components such as high Sr, Zr, and La/Yb, and isotope signatures indicative of MORB; and (5) alkaline magmatism in the back arc. None of these criteria will uniquely identify a triple junction interaction; however, they should make earth scientists consider this possibility. The structural-tectonic discussions initially centered on variations among different classes of triple junctions. Kimura reminded the group that, on the basis of observations from Japan and Alaska as well as the potential for Archean interactions, the process of ridge subduction may be a major overlooked mechanism in the construction of continental crust. The most distinctive structural characteristic of a triple junction interaction was an event that migrated in time and was associated with one or more of the following characteristics: (1) abrupt changes in the kinematics of deformation; (2) migration of magmatic provinces and their thermal manifestations; (3) dynamic fore-arc sedimentation that records rapid lateral migration of sedimentary sources and basins; and (4) juxtaposition of rocks within the accretionary stack with a characteristic decrease in the age interval of sediments reflecting approach of zero-age lithosphere. Clearly these characteristics can be produced by other structural processes, and extreme caution should be used in simple application of these generalizations, but recognition of several of these characteristics should be a strong indicator of the presence of a triple junction process.

In summary, there are many variables that control the particular signatures of each triple junction interaction. This results in a wide range of possible effects that may be used to document these events. One of the important variables is the geometry of the triple junction. Other variables include the lithology, kinematics, and amount of accreted material in the upper plate. The resultant features almost all record temporal and spatial variations in a variety of features such as kinematics, age and chemistry of magmatism, fluid circulation and hydrothermal mineralization in the fore arc, uplift and subsidence in the margin, directions of paleocurrents, and age of pelagic sediments. Other diagnostic features may include high-temperature–low-pressure metamorphism, near-trench magmatism, and ophiolite emplacement.

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Penrose Conference Scheduled

Mesozoic Evolution of the Cordilleran Continental Margin in Central and Southern California

October 6–11, 1995

A Geological Society of America Penrose Conference, "Mesozoic Evolution of the Cordilleran Continental Margin in Central and Southern California," will be held October 6–11, 1995, in Tehachapi, California.

Since the advent of the theory of plate tectonics, the western United States Cordillera has been central to models of the spatial and temporal evolution of ocean-continent convergent plate margins. These models evolved from the classic association of trench, fore-arc basin, magmatic arc, and foreland fold-thrust belt that characterizes the Late Jurassic and Cretaceous of central California. This classic association of plate margin structural elements is obscure or inapplicable, however, when considered in a broader spatial and temporal context. It is difficult to apply to the earlier Mesozoic evolution of the margin, where structural elements are obscured by younger tectonism, or to the Mesozoic of southern California, where elements of the classic convergent margin association are superimposed or absent. Further complicating interpretation of the spatial association of structural elements is the recognition of contemporaneous and/or subsequent margin-parallel slip.

The focus of this conference is on the spatial and temporal evolution of the Mesozoic Cordilleran margin in central and southern California (about 33°–37°N). Our goal is to bring together workers interested in interpreting the plate tectonic, structural, stratigraphic, magmatic, and metamorphic history of this region. This part of the Cordilleran margin is of particular importance because it was constructed across a preexisting, tectonically modified, passive margin of the Proterozoic North American craton. This structural setting suggests three key subjects for the conference: (1) What tectonic processes initially formed the west-facing convergent margin? (2) What effects did the location of the older continental edge and associated along-strike variation in crustal thickness or character have on convergent margin processes? (3) To what extent have magmatic and tectonic accretion led to continental crustal growth? Our objective is to foster links among the many ongoing studies of convergent margin processes that are applicable to this region, which we believe will lead to new insights into the growth and modification of continental crust at convergent continental margins.

Participation in the conference will be limited to 80 persons. Participation for some graduate students will be partially subsidized. The registration fee is expected to be about $525 or less. Formal invitations will be mailed no later than May 1, 1995.

Co-conveners of the conference are: ***Andrew P. Barth,*** Department of Geology, Indiana/Purdue University, Indianapolis, IN 46202-5132, (317) 274-1243, E-mail: ibsz100@indyvax.iupui.edu; ***Jason B. Saleeby,*** California Institute of Technology, Pasadena, CA 91125, (818) 395-6141, E-mail: jason@legs.gps.caltech.edu; and ***J. Douglas Walker,*** University of Kansas, Lawrence, KS 66045, (913) 864-7711, E-mail: jdwalker@ukanvm.cc.ukans.edu.

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For further information, contact Andrew Hudson, Program Director, The Center for Field Research, 680 Mt. Auburn St., Box 403, Watertown, MA 02272; (617) 926-8200; fax 617-926-8532; E-mail: ahudson@earthwatch.org.

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Las Positas College
Los Angeles City College
Los Angeles Harbor College
Los Angeles Valley College
Mendocino College
Merced College
Miracosta College
Napa Valley College
Naval Postgraduate School
Ohlone College
College of the Redwoods
Riverside City College
Sacramento City College
Saddleback Community College
San Bernardino Valley College
University of San Diego
San Joaquin Delta College
San Jose City College
Santa Barbara City College
Sonoma State University
Southwestern College
Ventura College
Yuba Community College

Nevada
University of Nevada
Wassuk College

Oregon
Central Oregon Community College
Clatsop Community College
Willamette University

Washington
Green River Community College
Olympic College
Tacoma Community College
Whitworth College
Yakima Valley College
British Columbia
Capilano College
Cariboo College
University of Victoria

ROCKY MOUNTAIN SECTION

Colorado
Colorado Northwestern Community College
Pikes Peak Community College
United States Air Force Academy

Idaho
College of Southern Idaho

Montana
Eastern Montana College
Flathead Valley Community College
Northern Montana College
Rocky Mountain College

New Mexico
New Mexico Highlands University
College of Santa Fe
Western New Mexico University

North Dakota
Dickinson State College

South Dakota
Augustana College

Wyoming
Casper College

Alberta
Athabasca University
University of Lethbridge
Mount Royal College
Northern Alberta Institute of Technology
Southern Alberta Institute of Technology
Saskatchewan

NORTH-CENTRAL SECTION

Illinois
University of Chicago
Columbia University
Concordia University
Elgin Community College
College of Lake County
Lincoln Land Community College
Northeastern Illinois University
Northwestern University
Principia College
Wabash Valley College

Indiana
Holy Cross College
Indiana University at Kokomo
Indiana University—Indianapolis
Vincennes University Junior College

Iowa
Drake University

Michigan
Adrian College
Central Michigan University
Charles Stewart Mott Community College
Concordia College
Gogebic Community College
Henry Ford Community College
Lansing Community College
Macomb Community College—Warren
Northern Michigan University
Schoolcraft College
St. Clair County Community College
Washtenaw Community College
Wayne State University

Minnesota
Anoka-Ramsey Community College
Concordia College
Itasca Community College
Mesabi Community College
Southwest State University
College of St. Thomas
Willmar Community College

Missouri
Central Methodist College
St. Louis Community College at Florissant Valley
St. Louis Community College at Forest Park
Stephens College
William Jewell College

Nebraska
University of Nebraska at Kearney

Ohio
Ashland University
Central State University
Kent State University, Tuscarawas
Muskingum College
Oberlin College
Ohio University—Lancaster
Shawnee State University
University of Dayton

Wisconsin
Milwaukee Area Technical College
Mount Senario College
Northland College
University of Wisconsin—Extension
University of Wisconsin—Marathon County
University of Wisconsin—Platteville
University of Wisconsin—Stevens Point

Ontario
University of Guelph
University of Ottawa
Sir Sandford Fleming College

Campus Reps *continued on p. 251*

Is the Annual Student Forum a Good Idea?

Initiated by Past President Bob Hatcher during the Boston GSA meeting late last year, the Student Forum highlighted the problem that led to the recent bylaw change to afford graduate students the opportunity to become full voting GSA members, beginning in 1995, without increase in dues or fees. (For background, refer to the article on page 183 in the July 1994 issue of *GSA Today*). Council was able to act so expeditiously in part because Hatcher effectively championed the logic that underpinned the Council decision to broaden participation in Society affairs by student members.

From Boston in 1993 to Seattle in 1994—students on the opposite coast will soon have the opportunity to express their views about GSA affairs directly to outgoing GSA President Bill Dickinson and incoming GSA President Dave Stephenson. In planning for the second annual forum, Dickinson said, "I am confident that we have done the right thing and laid the basis for a more dynamic and responsive Society in the future. Is the annual Student Forum a good idea? You bet it is. Even if nothing else ever comes of it, highlighting the problem that led to the recent bylaw change was a signal service to GSA."

The 1994 President's Student Forum will be held on *Wednesday, October 26,* at the Washington State Convention and Trade Center from 4:00 to 5:30 p.m., during the GSA Annual Meeting in Seattle.

Students who cannot attend the forum in Seattle and who wish to express an opinion about GSA affairs directly to GSA officers may write to the GSA Executive Director, P.O. Box 9140, Boulder, CO 80301.

CALL FOR PAPERS

Planetary Geoscience Student Paper Award

The Award

Planetary geologist Stephen E. Dwornik established the award in 1991 to provide encouragement, motivation, and recognition to outstanding future scientists. Two awards are given annually, each winner receiving a citation and $500. The program is administered through the Planetary Geology Division of the Geological Society of America. The GSA Foundation manages the award fund. Arrangements for travel by the recipients to the awards ceremony at NASA headquarters in Washington, D.C., are handled by the Planetary Geology and Geophysics Program, NASA.

Criteria

Students who are U.S. citizens and are enrolled in a college or university at any level of their education in the field of planetary geosciences may submit abstracts for the Student Paper Award. Student applicants must be the senior author of the abstract, and the paper may be presented orally or in a poster session. Papers will be judged on the quality of the scientific contribution, including methods and results; clarity of material presented; and methods of delivery, oral or display. Two awards are given: one for the best oral presentation, the other for the best poster presentation.

To Apply

The application form and instructions may be found in the Call for Papers for the 1995 Lunar and Planetary Science Conference, March 13–17, to be held in Houston, Texas. Only one abstract per student will be considered.

Deadline for application and abstracts is December 23, 1994.

Campus Reps *continued from p. 250*

SOUTH-CENTRAL SECTION

Arkansas
University of Central Arkansas
College of the Ozarks
Southern Arkansas University

Kansas
Cowley County Community College
University of Kansas

Oklahoma
Northeastern Oklahoma A&M College
Northeastern State University
Phillips University

Texas
Angelo State University
Del Mar College
Houston Community College System
Kilgore College
Laredo Junior College
Lee College
Odessa College
San Antonio College
South Plains College
Tarrant County Junior College
University of Texas—Pan American
Texas Christian University

NORTHEASTERN SECTION

Connecticut
University of Bridgeport
Central Connecticut State University
Southern Connecticut State College
United States Coast Guard Academy

Delaware
University of Delaware—College of Marine Studies

Maine
University of Maine at Presque Isle
University of Maine

Maryland
Catonsville Community College
Frostburg State University
Montgomery College—Rockville

Massachusetts
Bentley College
Berkshire Community College
Greenfield Community College
Harvard University
University of Massachusetts at Boston—Harbor Campus
North Adams State College
Worcester State College

New Hampshire
New England College
Plymouth State College

New Jersey
Fairleigh Dickinson University
Glassboro State College
Trenton State College
Union County College
Upsala College
William Paterson College

New York
Adelphi University
Adirondack Community College
Broome Community College
Columbia University
Hudson Valley Community College
Lehman College (CUNY)
Long Island University—Brooklyn Campus
Long Island University—C. W. Post College
Manhattan College
Molloy College
Nassau Community College
Onondaga Community College
Roberts Wesleyan College
St. Lawrence University
SUNY—College at Buffalo
SUNY—College at Purchase
SUNY—Maritime College
SUNY at Albany
United States Military Academy
Utica College of Syracuse University

Pennsylvania
Drexel University
Elizabethtown College
Gannon University
Lycoming College
Mansfield University
Montgomery County Community College
Pennsylvania State University—Altoona Campus
Pennsylvania State University—Erie
Pennsylvania State University—Monaca
Susquehanna University
Thiel College
York College of Pennsylvania

Rhode Island
Community College of Rhode Island
Providence College
Rhode Island College
Roger Williams College

Vermont
Castleton State College
Middlebury College
University of Vermont

New Brunswick
University of New Brunswick
University of New Brunswick—Saint John

Nova Scotia
St. Mary's University
University College of Cape Breton

Quebec
Concordia University
Ecole Polytechnique
Université du Quebec
Université du Quebec à Rimouski
Université du Quebec à Trois Rivières

SOUTHEASTERN SECTION

Alabama
University of Alabama—Dauphin Island
University of Montevallo

Florida
Broward Community College
University of Central Florida
Eckerd College
Edison Community College
Florida Keys Community College
Gulf Coast Community College
Hillsborough Community College
Miami-Dade Community College (New World Center)
Nova University
Okaloosa-Walton Junior College
Pensacola Junior College
St. Petersburg Junior College
St. Petersburg Junior College—Clearwater
Stetson University
Tallahassee Community College

Georgia
Emory University—Oxford College
Gainesville Junior College
Georgia Southwestern College
Gordon College
Kennesaw College
Mercer University
Shorter College
Valdosta State College

Kentucky
Berea College
Henderson Community College
Morehead State University
Northern Kentucky University

Louisiana
Nicholls State University
Northwestern State University

Mississippi
Millsaps College

North Carolina
Catawba College
University of North Carolina—Asheville
North Carolina Agricultural & Tech State University
North Carolina Central University
South Carolina
Coker College
Winthrop University
Wofford College

Tennessee
Rhodes College

Virginia
Emory & Henry College
Hampton University
Lynchburg College
Northern Virginia Community College
Virginia State University
Virginia Western Community College

West Virginia
Glenville State College
Potomac State College
West Virginia University—Parkersburg ■

IEE *continued from p. 243*

have had no place to send low-level radioactive wastes. Doctors diagnose and treat disease with radioisotopes. Researchers use radioisotopes to study chemical and biological processes in cells—from marking the process as experimental pharmaceuticals are metabolized by the body, to being "tipped" onto antibodies as a potential "magic bullet" for treatment of certain solid tumors. Biological and medical research depends on radioimmunoassays to detect tiny quantities of biological chemicals. He asks, "Does anyone seriously argue that these activities are not important?" Storing existing low-level radioactive waste, and that currently being generated, at local sites such as parking lots and basements is clearly not the best solution. Properly located and evaluated sites are needed, and the quality of the social debate over siting and resulting decisions can be improved by the active involvement of environmental and geological professionals.

Fred A. Donath of the GSA Institute for Environmental Education notes that confusion among the public about differences between low-level and high-level waste, public perception of risk, and disagreement among experts, along with misleading and self-serving statements of special interests, can all contribute to the strong public reaction over disposition of low-level radioactive waste. Such reaction can hamper efforts to locate a geologically acceptable environment in which to put the waste, and this can create situations that constitute even greater public risk. Geoscientists can help correct such situations by heightening public understanding of the relevant geoscience and of the geological approach to inquiry. Radionuclides placed in either a storage or disposal environment can come into contact with humans only if they are released from that environment and transported; the predominant scenario for transport to humans involves ground water. The potential hazard thus depends primarily upon the amount and rate of supply of radionuclides to the ground water; the pathways and rate of ground-water movement; and the degree of geochemical retardation imposed by the geologic media. Release is dependent on the nature of containment (waste form, containers, engineered barriers), and is best evaluated by other scientists. The configuration and composition of geologic units, distribution of heterogeneities within them, and hydraulic potentials—which dictate the pathways, flow rates, and geochemical interactions—are the purview of the geoscientist. The selection and assessment of possibly suitable sites for low-level radioactive waste must consider the containment system, the performance of the existing geologic system, and the probable future performance of the geologic system—taking into consideration evolutionary change and potentially disruptive events. The *probability* of radiation exposure to humans depends upon the release and transport processes and pathways; the *consequences* of an exposure is a matter for the medical community to evaluate. The *risk* to the public is the product of the *probability* of an exposure occurring and the *consequences* if that exposure were to occur. The public needs to understand these simple concepts if it is to make rational choices among low-level radioactive waste storage and disposal options.

Ground-water contamination studies typically include technical, legal, and socioeconomic components. As a consequence, hydrogeologists are thrown into an interdisciplinary milieu that involves working together with engineers, risk analysts, toxicologists, microbiologists, economists, and lawyers. Hydrogeological site characterization must serve the needs of engineering design within a set of constraints posed by complex regulatory-compliance issues, strong social pressures, and an adversarial legal setting. It is under such circumstances that the hydrogeologist must help decide such issues as which remedial alternative is the best, whether additional data will aid a decision in a cost-effective way, and what level of societal risk reduction must be achieved. R. Allan Freeze, whose engineering firm in White Rock, British Columbia, is intimately involved with such deliberations, discusses ethical conundrums related to: the responsibility of the hydrogeologist to protect the health and safety of the public in a regulated environment; the role of scientists in the adversarial legal environment; the pursuit of objective truth by the usual scientific process compared with that arrived at by the legal system; the levels of societally acceptable uncertainty and risk; and the role of value systems and social biases in environmental decision making. As an example of these types of issues, hydrogeologists recognize that mass removal of contaminants from aquifers in many instances is neither currently feasible nor cost-effective. Containment is feasible, but it implies perpetual care of contaminated sites. Freeze asks: What is the socially optimal course of action in this situation, and does the current adversarial style of interaction between regulators and site owner-operators lead to socially optimal decisions?

In the closing paper of the forum, Richard R. Parizek of the Pennsylvania State University comments on changing factors that influence the approach to ground-water contamination. Formerly, economic activities were undertaken without regard to environmental impacts or deferred costs. Space and natural resources were abundant, financial gains were measures of success, and diverse land and material use practices caused widespread and costly damage to water and other natural resources. Although continuing efforts to define and clean up existing pollutants are necessary, these must be viewed in terms of geologic uncertainties, the value of resources being restored, and awareness of cost limitations and time frames required. In many instances, the containment of pollutants and use of institutional controls will be more realistic than site cleanup. This runs against political and other commitments to restore the environment, but competing demands for finite resources will require a scaling down of restoration efforts and expectations. Population pressures and an expanding list of polluting compounds, coupled with finite resources and our desire to maintain our standard of living, will pose significant educational, technical, political, and resources management challenges in the future. Earth scientists must have a more prominent role in the decision process if we are to minimize adverse environmental consequences. Pollution prevention, working within the carrying capacity of the land, adoption of an environmental ethic, innovative technologies, continued need for highly educated individuals, and an informed public will be required to meet future environmental goals.

The formal presentations by these speakers will be followed by a panel discussion and questions from the audience. ■

GSAF UPDATE

Robert L. Fuchs

Retirement Planning? Consider a Gift Annuity

Retirement is one of life's major milestones—from work overload to work underload, from responsibility and authority to less of each, from a regular employer paycheck to a regular government check supplemented, one hopes, by payments from pension plans, IRAs, and investments. Paying the bills and maintaining lifestyles at a time of reduced income is a problem that faces senior GSA members who see this milestone approaching in the next five to ten years. At a time of concern over the future direction of major government entitlement programs, solutions to this problem deserve the attention of those in the final employment years before retirement.

We all have a good idea of where the bills will be coming from after retirement. The sources of future income are varied, and each individual situation will be unique to that retiree, depending on employment, planning, saving, investment, and a myriad of lifetime factors. Social Security is the most ubiquitous source of retirement income, providing support to nearly everyone. But no one really believes that a comfortable living is possible solely from these monthly payments, which lately have begun to be reduced by taxes. Probably every GSA member has some form of savings or a financial estate to supplement Social Security. Employer pension plans are common, including such variations as profit sharing, 401-K, and contributory savings plans. In addition, those planning for the future are investing to build up taxable and tax-free dividend and interest income, and may purchase annuities of various types and attributes.

The *charitable gift annuity* and a modification known as the *deferred payment gift annuity* can provide retirement income, while at the same time augmenting the endowment of the GSA Foundation. In the creation or purchase of such an annuity, money passes from a donor to a charitable institution, and this generates some attractive tax benefits that are over and above the lifetime payments to the donor, or to the donor and spouse. These benefits are twofold—a charitable gift income tax deduction in the year that the annuity is purchased, plus partially tax-free payments for a period of time after annuity payments begin. The deferred annuity differs from the foregoing in that payments to the annuitant commence at some preselected future date, for example at age 65. This is a particularly effective retirement planning tool for those now employed who don't need the current income but will in 10 or 15 years.

A GSA member, age 50, purchases an annuity from the Foundation with a gift of $10,000 in 1994. The terms of the annuity specify that quarterly payments of $312.50 ($1250 per year) will be made to the member or spouse for the balance of their lives, commencing on the donor's 65th birthday.

Two tax benefits are generated by this gift. First, there is an income tax deduction of $6539 this year. Second, $34 of each quarterly annuity payment ($137.50 per year) is a tax-free return of principal for 25.1 years. The offsetting of tax deduction and income by a number of years is an intriguing aspect of the charitable gift annuity. The tax deduction takes place at a time of higher income, when such a deduction can be very helpful in lowering the member's annual tax bill. The payments come at a time of lower income, when the money is most needed.

An additional wrinkle can make this type of gift even more attractive from the tax standpoint. If the donor gives appreciated securities directly to the Foundation instead of cash, the capital gains tax that would have to be paid on the profit in these securities if they were sold is deferred. In essence, by purchasing a charitable gift annuity in this manner, the money that you would pay to the government in taxes remains available to earn income for you over a period of years.

Thus, in carefully structuring the purchase of an annuity from the Foundation, a GSA member can achieve several benefits—income for life, a partially tax-free income stream, a current tax deduction, and the deferral of capital gains tax if the gift is made in the form of appreciated securities. Is the gift annuity or its deferred counterpart something that you should be considering in your retirement planning? The Foundation can help you answer that question by providing an analysis specific to your circumstances. Please call the Foundation office at (303) 447-2020, ext. 154, or mail the accompanying coupon to GSA. ■

Donors to the Foundation—July 1994

Doris M. Curtis Memorial
F. Eyolf Bronner

Shirley J. Dreiss Memorial
Gail Bakker
Ronaldo I. Borja
Jeffrey S. Hanor
Marcia F. Hubbard
June A. Oberdorfer
Fred M. Phillips
Robert W. Ritzi
Haresh C. Shah*
Water Resources Center*

Dwornik Planetary Geoscience Award
Jay F. Piper

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Women In Science
Marilyn Quas

*Century Plus Roster (gifts of $150 or more).

GEOSTAR
Supporting The Advancement of Research

GSA Foundation
3300 Penrose Place
P.O. Box 9140
Boulder, CO 80301
(303) 447-2020

☐ Enclosed is my contribution in the amount of $_____ for
☐ Foundation Unrestricted ☐ GSA Unrestricted
☐ _____ Fund

☐ Please add my name to the Century Plus Roster (gifts of $150 or more).

☐ A charitable gift annuity might be a good idea for me. I'm doing some retirement planning and would like a copy of the booklet entitled *The Charitable Gift Annuity.*

PLEASE PRINT

Name _____

Address _____

City/State/ZIP _____

Phone _____

IMPORTANT NOTICE

VISIT FOUNDATION BOOTH #633 IN SEATTLE.
1994 DONORS ARE ELIGIBLE FOR A PRIZE DRAWING.

CALL FOR NOMINATIONS

1997 National Awards
(*Deadline: April 30, 1995*)

Nominations for the national awards described below are being solicited for 1997. Each year GSA members have been invited to participate by recommending possible candidates.

Those who wish to make nominations are urged to do so by sending BACKGROUND INFORMATION and VITAE, and specifying the award for which the candidate is being submitted by **April 30, 1995,** to the GSA External Awards Committee, P.O. Box 9140, Boulder, CO 80301, (303) 447-2020, fax 303-447-1133. The nomination process is coordinated by AGI on behalf of its member societies, and a roster of candidates will be finalized by the AGI Member–Society Council at its Spring 1996 meeting for nomination to the respective offices sponsoring the national awards.

William T. Pecora Award

The Pecora Award, sponsored jointly by NASA and the Department of the Interior, is presented annually in recognition of outstanding contributions of individuals or groups toward the understanding of Earth by means of remote sensing.

The award recognizes contributions of those in the scientific and technical community as well as those involved in the practical application of remote sensing. Consideration will be given to sustained or single contributions of major importance to the art or science of the understanding of Earth through observations made from space.

National Medal of Science

The medal is awarded by the President to individuals "deserving of special recognition by reason of their outstanding contributions to knowledge in the physical, biological, mathematical, engineering, or social and behavioral sciences."

There are now many younger American scientists and engineers who may be reaching a point where their contributions are worthy of recognition. The committee is giving increasing attention to these individuals as well as to those outstanding women and minority scientists who deserve recognition.

Vannevar Bush Award

The Vannevar Bush Award is presented from time to time to a person who, through public service activities in science and technology, has made an outstanding contribution toward the welfare of mankind and the nation.

The award is given to a senior statesman of science and technology and complements the NSF's Alan T. Waterman Award, which is given to a promising young scientist. The two awards are designed to encourage individuals to seek the highest levels of achievement in science, engineering, and service to humanity.

The nomination should be accompanied by a complete biography and a brief citation summarizing the nominee's scientific or technological contributions to our national welfare in promotion of the progress of science.

Alan T. Waterman Award

The Waterman Award is presented annually by the NSF and National Science Board to an outstanding young researcher in any field of science or engineering supported by NSF.

Candidates must be U.S. citizens or permanent residents and must be 35 years of age or younger, *OR* not more than five years beyond receipt of the Ph.D. degree by December 31 of the year in which nominated.

Candidates should have completed sufficient scientific or engineering research to have demonstrated, through personal accomplishments, outstanding capability and exceptional promise for significant future achievement.

Remember: BACKGROUND INFORMATION and VITAE of nominated candidates should be sent by **April 30, 1995,** to the GSA External Awards Committee, P.O. Box 9140, Boulder, CO 80301.

Call for Nominations for 1995 Penrose and Day Medals and Honorary Fellows

Nominations for GSA's Penrose and Day Medals and for Honorary Fellowships of the Society are due at headquarters by ***February 1, 1995***. Members and Fellows of the Society are encouraged to participate in this important process by nominating candidates for these high honors.

Penrose Medal

The Penrose Medal was established in 1927 by R.A.F. Penrose, Jr., to be awarded in recognition of eminent research in pure geology, for outstanding original contributions or achievements that mark a major advance in the science of geology. The award is made only at the discretion of the Council. Nominees are selected by the Council, may or may not be members of the Society, and may be from any nation. Penrose's sole objective in making the gift was to encourage original work in purely scientific geology. **Scientific achievements should be considered rather than contributions in teaching, administration, or service. Mid-career scientists who have already made exceptional contributions should be given full consideration for the award.**

Day Medal

The Day Medal was established in 1948 by Arthur L. Day to be awarded annually, or less frequently, at the discretion of the Council, for outstanding distinction in contributing to geologic knowledge through the application of physics and chemistry to the solution of geologic problems. Day's intent was to recognize outstanding achievement and inspire further effort, rather than reward a distinguished career. **Scientific achievements should be considered rather than contributions in teaching, administration, and service.**

Honorary Fellows

Geologists who have distinguished themselves in geological investigations or in notable service to the Society may be elected as Honorary Fellows. In practice, nearly all candidates are non–North Americans who live and work outside of North America. The most noteworthy exceptions were astronauts.

Most Honorary Fellows have been elected after many years of outstanding and internationally recognized contributions to the science.

Nominations *continued on p. 254*

PENROSE MEDAL, DAY MEDAL, OR HONORARY FELLOWSHIP

THE GEOLOGICAL SOCIETY OF AMERICA
Nomination for Penrose Medal, Day Medal, or Honorary Fellowship
(please circle one)

NAME OF CANDIDATE:

ADDRESS: Telephone: _____

REQUIRED INFORMATION (Please attach)

BIOGRAPHICAL INFORMATION

Suggested sources: *American Men and Women of Science*
Who's Who in America
GSA Service Record (obtainable from headquarters)
Other

SUMMARY OF SCIENTIFIC CONTRIBUTIONS TO GEOLOGY

Not more than 200 words.

SELECTED BIBLIOGRAPHY

No more than 20 titles.

LETTERS OF SUPPORT

Nominations for any one of these three awards MUST BE SUPPORTED by signed letters from five (5) GSA Fellows or Members in addition to the person making the nomination. The letters may be attached to this form or may be sent to the Executive Director separately. Supporting letters must discuss the original research and scientific advances of the candidates. Please also verify all other supporting data.

Name of person making the nomination: _____

Address: _____

Date: _____ Signature: _____

Letters of support will be submitted by:

1. _____
2. _____
3. _____
4. _____
5. _____

RETURN TO: Executive Director
The Geological Society of America
P.O. Box 9140
Boulder, CO 80301
(303) 447-2020

DEADLINE: Completed nomination materials must be received by ***February 1, 1995***.

Nominations *continued from p. 253*

How To Nominate

To ensure thorough consideration by the respective committees, please submit for each candidate a brief biographical sketch, such as used in *American Men and Women of Science* and *Who's Who in America*, a summary of the candidate's scientific contributions to geology that qualify the individual for the award, and a selected bibliography of no more than 20 titles.

A nomination for any one of these three awards MUST BE SUPPORTED by signed letters from each of five (5) GSA Fellows or Members in addition to the person making the nomination. The letters may be attached to the nomination form or may be sent to the Executive Director separately. For Honorary Fellow nominations, please *verify degrees received, publications, positions held, etc.* The names of unsuccessful candidates proposed to the Council by the respective committees will remain for consideration by those committees for three years. FOR THOSE STILL UNDER CONSIDERATION, IT IS RECOMMENDED THAT AN UPDATED LETTER OF RENOMINATION BE SENT TO THE EXECUTIVE DIRECTOR.

The deadline for receipt of nominations at the office of the Executive Director is ***February 1, 1995***.

Please use the form on page 253 for submitting the name of a candidate for any one of the awards.

Recipients of the awards to date are listed below. ■

About the Honorary Fellow Program

On page 253 you will find a form to be used in nominating candidates for Honorary Fellowship in the Geological Society of America. Each year this honor is bestowed on non–North Americans who live and work outside of North America and have distinguished themselves in geological investigations or in notable service to the Society. Under exceptional circumstances, North Americans have been named Honorary Fellows. This amendment to the bylaws was made in 1969 when the Apollo II astronauts who first walked on the moon were elected.

The program was established by the GSA Council in 1909, and since then, except during a few war years, one or more Honorary Fellows have been elected annually. Most Honorary Fellows have been elected after many years of outstanding and internationally recognized contributions to the science. At present there are 59 living geologists who have received this honor.

The Council of the Society encourages the membership to submit names of qualified candidates for this honor. In preparing a nomination, it is imperative that the original research and scientific advances of the candidate be stressed. All supporting data, especially degrees received, publications, positions, etc., should also be verified by the nominator. Use the form on page 253 for nominating a candidate for Honorary Fellowship. ■

GSA Medalists and Honorary Fellows

Richard A. F. Penrose, Jr., Medalists

1927 Thomas Chrowder Chamberlin
1928 Jakob Johannes Sederholm
1929 *No award given*
1930 Francois Alfred Antoine Lacroix
1931 William Morris Davis
1932 Edward Oscar Ulrich
1933 Waldemar Lindgren
1934 Charles Schuchert
1935 Reginald Aldworth Daly
1936 Arthur Philemon Coleman
1937 *No award given*
1938 Andrew Cowper Lawson
1939 William Berryman Scott
1940 Nelson Horatio Darton
1941 Norman Levi Bowen
1942 Charles Kenneth Leith
1943 *No award given*
1944 Bailey Willis
1945 Felix Andries Vening-Meinesz
1946 T. Wayland Vaughan
1947 Arthur Louis Day
1948 Hans Cloos
1949 Wendell P. Woodring
1950 Morley Evans Wilson
1951 Pentti Eskola
1952 George Gaylord Simpson
1953 Esper S. Larsen, Jr.
1954 Arthur Francis Buddington
1955 Maurice Gignoux
1956 Arthur Holmes
1957 Bruno Sander
1958 James Gilluly
1959 Adolf Knopf
1960 Walter Herman Bucher
1961 Philip Henry Kuenen
1962 Alfred Sherwood Romer
1963 William Walden Rubey
1964 Donnel Foster Hewett
1965 Philip Burke King
1966 Harry H. Hess
1967 Herbert Harold Read
1968 J. Tuzo Wilson
1969 Francis Birch
1970 Ralph Alger Bagnold
1971 Marshall Kay
1972 Wilmot H. Bradley
1973 M. King Hubbert
1974 William Maurice Ewing
1975 Francis J. Pettijohn
1976 Preston Cloud
1977 Robert P. Sharp
1978 Robert M. Garrels
1979 J Harlen Bretz
1980 Hollis D. Hedberg
1981 John Rodgers
1982 Aaron C. Waters
1983 G. Arthur Cooper
1984 Donald E. White
1985 Rudolf Trümpy
1986 Laurence L. Sloss
1987 Marland P. Billings
1988 Robert S. Dietz
1989 Warren Bell Hamilton
1990 Norman D. Newell
1991 William R. Dickinson
1992 John Frederick Dewey
1993 Alfred G. Fischer
1994 Luna B. Leopold

Arthur L. Day Medalists

1948 George W. Morey
1949 William Maurice Ewing
1950 Francis Birch
1951 Martin J. Buerger
1952 Sterling Hendricks
1953 John F. Schairer
1954 Marion King Hubbert
1955 Earl Ingerson
1956 Alfred O. C. Nier
1957 Hugo Benioff
1958 John Verhoogen
1959 Sir Edward C. Bullard
1960 Konrad B. Krauskopf
1961 Willard F. Libby
1962 Hatten Schuyler Yoder
1963 Keith Edward Bullen
1964 James Burleigh Thompson, Jr.
1965 Walter H. Munk
1966 Robert M. Garrels
1967 O. Frank Tuttle
1968 Frederick J. Vine
1969 Harold C. Urey
1970 Gerald J. Wasserburg
1971 Hans P. Eugster
1972 Frank Press
1973 David T. Griggs
1974 A. E. Ringwood
1975 Allan Cox
1976 Hans Ramberg
1977 Akiho Miyashiro
1978 Samuel Epstein
1979 Walter M. Elsasser
1980 Henry G. Thode
1981 Donald L. Turcotte
1982 Eugene M. Shoemaker
1983 Harmon Craig
1984 Wallace S. Broecker
1985 Freeman Gilbert
1986 E-an Zen
1987 Don L. Anderson
1988 Claude J. Allègre
1989 Dan McKenzie
1990 William S. Fyfe
1991 Ian Carmichael
1992 Susan Werner Kieffer
1993 Hugh P. Taylor, Jr.
1994 David Walker

Young Scientist Award (Donath Medalists)

1989 Mark Cloos
1990 Leigh Handy Royden
1991 Brian Philip Wernicke
1992 John Peter Grotzinger
1993 Michael Gurnis
1994 An Yin

Honorary Fellows

Edwin "Buzz" Aldrin
Neil Armstrong
Jean A. Aubouin
Krzysztof Ludwik Birkenmajer
Roland Brinkmann
George Malcolm Brown
S. Warren Carey
Maria Bianca Cita
Michael Collins
William Compston
Douglas Saxon Coombs
Gabriel Dengo
Kingsley C. Dunham
Stanislaw Dzulynski
François Ellenberger
Hans Füchtbauer
William S. Fyfe
Augusto Gansser
David Headley Green
Francisco Hervé
Dorothy Hill
Kenneth J. Hsü
Jiqing Huang
Valdar Jaanusson
Emilie Jäger
Ihsan Ketin
Teiichi Kobayashi
Hans Laubscher
Henno Martin
Michael W. McElhinny
German K. Müller
Mervyn Silas Paterson
Leo Y. Picard
Wallace S. Pitcher
Jean Piveteau
Isabella Premoli-Silva
Desmond A. Pretorius
B. P. Radhakrishna
Hans Ramberg
Victor A. Ramos
John G. Ramsay
Alfred Rittmann
Alexander B. Ronov
Rupert W. R. Rutland
Kristján Sæmundsson
Rushdi Said
Hitoshi Sakai
Mircea Sandulescu
Harrison Hagan Schmitt
Eugen Seibold
Ali Mehmet Celal Şengör
Ahti J. Simonen
Boris Sergeevich Sokolov
Richard L. Stanton
Rashid A. Khan Tahirkheli
Bernard P. Tissot
Livio Trevisan
Rudolf Trümpy
Guangzhi Tu
Harry B. Whittington
Alwyn Williams
Yang Zun-yi

Help Direct GSA's Future

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

Nominations for 1996 officers and councilors must be received at GSA headquarters no later than **FEBRUARY 15, 1995.**

Please send nominations and back-up material to Administrative Department, Geological Society of America, P.O. Box 9140, Boulder, CO 80301.

CALL FOR NOMINATIONS

1995 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 1995 award will be presented at the autumn AASG meeting to be held during the GSA Annual Meeting in New Orleans. Members of the selection committee are Chairman Frank E. Kottlowski, New Mexico Bureau of Mines and Mineral Resources; John P. Kempton, Illinois Geological Survey; and Diane L. Conrad, Vermont Division of Geology and Mineral Resources.

CRITERIA FOR NOMINATION

Nominations can be made by anyone, on the basis of the following criteria:

(1) paper must be selected from GSA or state geological survey publications,

(2) paper must be selected from those published during the preceding three full calendar years, (3) nomination must include a paragraph stating the pertinence of the paper, (4) **nominations must be sent to Executive Director, GSA, P.O. Box 9140, Boulder, CO 80301. Deadline: March 31, 1995.**

BASIS FOR SELECTION

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

1994 AWARD RECIPIENT NAMED

The 1994 award will be presented at the GSA Annual Meeting in Seattle to Ronald W. Hoenstine and Ed Lane, Florida Geological Survey, for their paper *Environmental Geology and Hydrogeology of the Gainesville Area, Florida,* Special Publication No. 33 (1991), Florida Geological Survey. The report deals with a wide range of environmental geology aspects, including land-use planning, resource management, and geologic hazards (such as karst subsidence and ground-water contamination), and is easily understood by nonscientists.

Call for Nominations for 1995 Young Scientist Award (Donath Medal)

The Young Scientist Award was established in 1988 to be awarded to a young scientist (35 years 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 1995, only those candidates born on or after January 1, 1960, are eligible for consideration. In choosing candidates for the Young Scientist Award, scientific achievement and age will be the sole criteria. Nominations for the 1995 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.

Nominations for the 1995 Young Scientist Award must be received at GSA headquarters by ***February 1, 1995***. Use the form below for submitting the name of a candidate for the Young Scientist Award. ■

Call for Nominations for 1995 GSA 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. Letters of nomination and any supporting information should be addressed to Executive Director, GSA, P.O. Box 9140, Boulder, CO 80301. ■

Deadline for nominations for 1995 is March 1, 1995.

Recipients to date:

1988	*Campbell Craddock*
	Robert D. Hatcher, Jr.
	Eldridge M. Moores
	William A. Thomas
1990	*William B. Heroy, Jr.*
1991	*Dorothy M. Palmer*
1992	*A. R. (Pete) Palmer*
1993	*Michel T. Halbouty*
1994	*F. Michael Wahl*

1995 YOUNG SCIENTIST AWARD (DONATH MEDAL)

THE GEOLOGICAL SOCIETY OF AMERICA
Nomination for 1995 Young Scientist Award (Donath Medal)

NAME OF CANDIDATE:

Date of birth: _____

For the year 1995, only those candidates born on or after January 1, 1960, are eligible for consideration.

ADDRESS:

REQUIRED INFORMATION (Please attach)

BIOGRAPHICAL INFORMATION

Provide in a format similar to that found in *American Men and Women of Science, Who's Who in America.*

SUMMARY OF SCIENTIFIC CONTRIBUTIONS TO GEOLOGY

Not more than 200 words.

SELECTED BIBLIOGRAPHY

No more than 10 titles.

LETTERS OF SUPPORT

Nominations for the Donath Medal MUST BE SUPPORTED by signed letters from five (5) scientists in addition to the person making the nomination. The letters may be attached to this nomination form or may be sent to the Executive Director separately.

Name of person making the nomination: _____

Address: _____

Date: _____ Signature: _____

Letters of support will be submitted by:

1. _____
2. _____
3. _____
4. _____
5. _____

RETURN TO: Executive Director
The Geological Society of America
P.O. Box 9140
Boulder, CO 80301
(303) 447-2020

DEADLINE: Completed nomination materials must be received by ***February 1, 1995***.

Preliminary Announcement and Call for Papers

SOUTHEASTERN SECTION, GSA 44th Annual Meeting

Knoxville, Tennessee
April 6–7, 1995

The Southeastern Section of the Geological Society of America will meet in Knoxville, Tennessee. The meeting will be hosted by the Department of Geological Sciences at the University of Tennessee, Knoxville, in cooperation with the Oak Ridge National Laboratory and the Tennessee Division of Geology.

SETTING

Knoxville is situated in the Valley and Ridge province of eastern Tennessee, northwest of the Great Smoky Mountains and east of the Cumberland Plateau. The city is home to the main campus of the University of Tennessee and is just a few miles from Oak Ridge, the site of Oak Ridge National Laboratory, and from Gatlinburg, the gateway to Great Smoky Mountains National Park. The Southeastern Section meeting will be held in the downtown Knoxville Hilton Hotel, which is within walking distance of the university, numerous restaurants, and the 1982 World's Fair site. Knoxville is easily reached by car via interstate highways I-40, I-75, and I-81, or by air through McGee-Tyson Airport.

CALL FOR PAPERS

Papers are invited for presentation in oral technical sessions, symposia, theme sessions, and poster sessions. Although papers dealing with all aspects of the southeastern or Appalachian regions of the United States are especially encouraged, papers dealing with other regions will be welcome. All oral presentations will be limited to 20 minutes, including five minutes for discussion. Poster sessions will be set up for four hours, and authors will be available for two hours to discuss their work. Abstracts not accepted for symposia (invited) or theme (volunteered) sessions will be considered for regular technical sessions.

REGISTRATION

Preregistration deadline: March 3, 1995

Please preregister for lower registration fees and to assist the local committee in planning. On-site registration will also be available. A reduced registration fee will be offered to students and to precollege teachers. Field trip participants must register for the meeting.

Preregistration will be handled by GSA headquarters. Registration forms will appear in the January 1995 issue of *GSA Today.*

ABSTRACTS

Abstract deadline: December 16, 1994

Abstracts for all sessions must be submitted camera-ready on official 1995 GSA abstract forms. These forms are available from Abstracts Coordinator, Geological Society of America, P.O. Box 9140, Boulder, CO 80301, (303) 447-2020, or E-mail: ncarlson@geosociety.org.

An original and five copies of all abstracts (volunteered and invited) should be sent to Robert D. Hatcher, Jr., Department of Geological Sciences, University of Tennessee, Knoxville, TN 37996-1410. We encourage participants in symposia and theme sessions to send an *extra* copy to the convener of the session. Abstracts will be reviewed for information content, format, and originality. GSA rules prohibit individuals from presenting more than one volunteered abstract, although they can be coauthors on additional volunteered abstracts. Abstracts submitted for symposia are not affected by this limitation.

FIELD TRIPS

Both premeeting and postmeeting field trips will be offered. For details about particular field trips, contact the field trip leaders listed. For general questions concerning field trips, contact William Dunne, Department of Geological Sciences, University of Tennessee, Knoxville, TN 37996-1410, (615) 974-6005, E-mail: bill@tanasi.gg.utk.edu.

Premeeting

1. **Geology and Hydrology of the Department of Energy's Oak Ridge Reservation and Associated Waste Management Issues** (1 day, $30; maximum participants, 40), RaNaye Dreier, Peter Lemiszki, and Steven Stow, Environmental Sciences Division, Oak Ridge National Laboratory, P.O. Box 2008, Oak Ridge, TN 37831-6036, (615) 574-7422, E-mail: rdo@stc10.ctd.ornl.gov.
2. **Deformation Processes Related to Emplacement of the Rabun Granite in the Eastern Blue Ridge, Georgia and North Carolina** (2 days, $180; maximum participants, 25), Robert Hatcher, Department of Geological Sciences, University of Tennessee, Knoxville, TN 37996-1410, (615) 974-2366, E-mail: bobmap@utkvx.utk.edu.

Postmeeting

3. **Waulsortian-like Bioherms of Maury and Fort Payne Formations, Tennessee** (2 days, $120; maximum participants, 24), Frank Stapor and Larry Knox, Department of Earth Sciences, Tennessee Technological University, Box 5062, Cookeville, TN 38505, (615) 372-3121.
4. **Late Silurian–Early Devonian Sedimentary Facies and Biotas from the Southern North American Craton, Tennessee** (2 days, $100; maximum participants, 20), Thomas Broadhead, Department of Geological Sciences, University of Tennessee, Knoxville, TN 37996-1410, (615) 974-6002, E-mail: broadhea@utkvx.utk.edu, and Mike Gibson, University of Tennessee, Martin.
5. **Stratigraphic and Structural Relationships in the Western Blue Ridge of Tennessee and North Carolina** (2 days, $125; maximum participants, 24), Mark Carter, Robert Hatcher, Steven Martin, and Don Geddes, Department of Geological Sciences, University of Tennessee, Knoxville, TN 37996-1410, (615) 974-2366, E-mail: bobmap@utkvx.utk.edu.
6. **The Grandfather Mountain Formation (Neoproterozoic) of Northwestern North Carolina: Clast Provenance and Architecture of Five Coarsening-Upward Sequences,** Michael Neton, Geological and Environmental Services (GES) Inc., 701 Cherokee Boulevard, Suite G, Chattanooga, TN 37405-3303, (615) 756-8020, and Loren Raymond, Appalachian State University.
7. **Understanding the Evolution and Sequence Stratigraphy of a Cambrian Platform Carbonate Succession, Southern Appalachians** (1 day, $40; maximum participants, 24), Kenneth Walker, Department of Geological Sciences, University of Tennessee, Knoxville, TN 37996-1410, (615) 974-6017, E-mail: kwalker@freddy.gg.utk.edu.
8. **Coal Geology in Kentucky and West Virginia** (2 days, $135; maximum participants, 20), James Hower and Cortland Eble, Center for Applied Energy Research, 3572 Iron Works Pike, Lexington, KY 40511-8433, (606) 257-0261.

SYMPOSIA

Eleven symposia are already planned for the meeting, and individuals with suggestions for additional symposia are encouraged to contact Robert Hatcher, Department of Geological Sciences, University of Tennessee, Knoxville, TN 37996-1410, (615) 974-2238, E-mail: bobmap@utkvx.utk.edu. Please contact respective conveners for information about the symposia listed below.

1. **Sequence Stratigraphic Contrasts and Diagenesis of Lower Paleozoic Carbonates.** Krishnan Shrinivasan and Kenneth Walker (University of Tennessee), (615) 974-6017, E-mail: kwalker@freddy.gg.utk.edu.
2. **Deformation Processes Associated with Plutons.** Robert Hatcher (University of Tennessee) and Richard Law (Virginia Tech), (615) 974-2366, E-mail: bobmap@utkvx.utk.edu.
3. **Energy and the Environment in the Next Century.** Otto Kopp (University of Tennessee), (615) 974-6399, E-mail: otto_kopp.rocks@freddy.gg.utk.edu.
4. **Disturbance-driven Ecosystems and Biotic Change.** Michael Gibson (University of Tennessee, Martin) and Douglas Jones (University of Florida Natural History Museum), (901) 587-7430.
5. **Hydrogeology.** Bill Sanford (Oak Ridge National Laboratory), (615) 574-7301.
6. **Geology of Appalachian Coals.** James Hower (University of Kentucky Center for Applied Energy Research), (606) 257-0261.
7. **Symposium on Effective Teaching at the Introductory Level.** John Wagner (Clemson University), (803) 656-3438.
8. **Quantitative Assessments of Metamorphism: Pressure, Temperature, *P-T-t,* Reaction Progress, and Fluid-Rock Interactions.** Loren Raymond (Appalachian State University) and Robert Tracy (Virginia Tech), (704) 262-3049.
9. **Communicating Geologic Information with Decision Makers and the Public in the Southeast.** Dan Walker and Jeffrey Reid (North Carolina Geological Survey), and Stephen Stow (Oak Ridge National Laboratory), (615) 594-7830.
10. **Paleosols and Paleokarst of the Southeastern U.S.: Genesis and Implications.** Michael Caudil and Steven Driese (University of Tennessee), (615) 974-2366.
11. **Great Ideas from Great Professors: Tips for Teaching Introductory Geology.** Molly Miller (Vanderbilt University) and Gail Russell (University of Southern Mississippi), (615) 322-2976.
12. **Mercury Transport and Transformation in the Subsurface.** Ralph Turner (Oak Ridge National Laboratory), (615) 574-7856, and Kula Misra (University of Tennessee).

THEME SESSIONS

Several theme sessions (all papers volunteered) are already planned, as indicated below. Individuals interested in convening a theme session should contact Robert Hatcher, Department of Geological Sciences, University of Tennessee, Knoxville, TN 37996-1410, (615) 974-2238, E-mail: bobmap@utkvx.utk.edu.

1. **Paleogene Paleontology of the Southeast.** Jon Bryan (Okaloosa-Walton Community College) and Richard Fleugeman (Ball State University), (904) 729-5376.
2. **The Contributions of Strain to the Formation of the Appalachian Foreland Thrust Belts.** William Dunne (University of Tennessee), (615) 974-6005, E-mail: bill@tanasi.gg.utk.edu.

POSTER SESSIONS

Four half-day poster sessions are planned; we encourage poster contributions because they permit extended discussions. Please indicate your preference for a poster session on the GSA abstract form.

The Council for Undergraduate Research will sponsor a student poster session, to showcase senior theses and other undergraduate research projects. First authors must be undergraduate students and are responsible for the bulk of the research, preparation of posters, and presentation of the results. For more information, contact Jack Beuthin, University of Pittsburgh, Johnstown, (814) 269-2945.

SPECIAL LECTURE

The Environmental Sciences Division of Oak Ridge National Laboratory will sponsor a special lecture at the conclusion of technical sessions on Thursday, April 6, at 5:30 p.m. John A. Cherry of the University of Waterloo Centre for Groundwater Research will present a lecture entitled "Field-scale Experimental Studies of Contaminant Behavior in Groundwater." This special presentation will focus on important environmental issues and will be of interest to a broad spectrum of geoscientists and educators. Cherry is coauthor of a widely used textbook on ground water and is the recipient of the GSA Meinzer Award and the AGU Horton Award for his hydrogeology research.

EARTH SCIENCE EDUCATION PROGRAMS

Undergraduate students are invited to participate in a poster session sponsored by the Council for Undergraduate Research (see POSTER SESSIONS above).

Two symposia dealing with teaching introductory-level geology, sponsored by the National Association of Geology Teachers and the GSA Geoscience Education Division, are also planned (see SYMPOSIA above).

Southeastern *continued on p. 257*

Preliminary Announcement and Call for Papers

NORTH-CENTRAL and SOUTH-CENTRAL SECTIONS, GSA Joint Annual Meeting

Lincoln, Nebraska
April 27–28, 1995

It has been a number of years since a Geological Society of America section meeting has been held in Nebraska. Much progress in understanding all facets of the geology of the midcontinent has been made since the last meeting was held in Lincoln. These were the reasons why geologists in Nebraska and Kansas offered to host a joint section meeting in Lincoln, Nebraska, in 1995.

The North-Central and South-Central sections of the Geological Society of America will meet in the Nebraska Center for Continuing Education and the East Campus Student Union on the East Campus of the University of Nebraska, Lincoln, in Lincoln, Nebraska. The meeting will be hosted by the Conservation and Survey Division (Nebraska Geological Survey), the Department of Geology, and the University of Nebraska State Museum of the University of Nebraska, Lincoln, the Geography and Geology Department of the University of Nebraska, Omaha, the Nebraska Geological Society, the Omaha office of Woodward-Clyde Consultants, and the Department of Geology, Kansas State University. Societies that will meet in conjunction with the combined section meeting include the Pander Society; North-Central and South-Central sections of the Paleontological Society; Texas, Mid-Continent, and North-Central sections of the National Association of Geology Teachers; and Great Lakes and Midcontinent sections of the Society for Sedimentary Geology.

All meeting rooms are handicapped accessible. Many local hotels and motels have rooms available for visitors with special needs. Registration and housing materials in the Final Announcement will include instructions for registrants with disabilities.

Smoking is not allowed in any building on the University of Nebraska, Lincoln, campus including the meeting and hotel rooms at the Nebraska Center for Continuing Education or in any university vehicle. Smoking is allowed outside of buildings.

CALL FOR PAPERS

Technical sessions will include all topics listed on the GSA abstract form. Papers, poster sessions, theme sessions, and symposia on these and other subjects (including all symposia listed below) are solicited. Special sessions focused on specific themes or subjects will also be arranged by the local program committee after review of the abstracts. The time usually allotted for oral presentations will be 15 minutes followed by 5 minutes for discussion. In accord with the intention of GSA to broaden its focus and membership, sessions related to aspects of environmental geology and hydrogeology will be featured at the meeting. A special symposium on earth science educational activities at the college and university level and a forum on K–12 education are planned. University credit may be granted through the University of Nebraska Division of Continuing Studies to K–12 teachers for participation in postmeeting field trips and satisfactory completion of a paper on ways to incorporate things learned on the trip into the curriculum.

REGISTRATION

Preregistration Deadline: March 24, 1995

Preregistration by mail will be handled by the Geological Society of America Meetings Department, P.O. Box 9140, Boulder, CO 80301-9140. On-site registration will be held in the Nebraska Center for Continuing Education on Wednesday, April 26, 5:00 p.m.–9:00 p.m., on Thursday, April 27, 7:30 a.m.–5:00 p.m., and on Friday, April 28, 7:30 a.m.–11:30 a.m.

Preregistration fees will be $45 for professional GSA members, or members of associated societies participating in this meeting, and $15 for GSA student members. For those not affiliated with GSA or the associated societies, preregistration will be $50 for professionals, $20 for students, and $10 for K–12 teachers. On-site registration will be $10 more for professionals and students. Please take advantage of the lower registration fees and **register by March 24.**

SYMPOSIA

The following symposia have been organized. Authors are encouraged to contact the individual symposium organizers for information.

1. **Cyclic Sedimentation in Carboniferous and Permian Strata of North America: Sequence Stratigraphy, Biostratigraphy, and Paleoecology.** Darwin R. Boardman II and Arthur Cleaves, School of Geology, Oklahoma State University, Stillwater, OK 74078-0451, (405) 744-5315, fax 405-744-7841.
2. **Geoarchaeological Research in Fluvial and Eolian Depositional Environments.** Rolfe Mandel, 1730 SW High St., Topeka, KS 66604-3121, (913) 235-1647.
3. **Quaternary Eolian Deposits of the Midcontinent: Loess, Sand, and Ash.** E. Arthur Bettis III, Iowa DNR, Geological Survey Bureau, 123 N. Capitol St., Iowa City, IA 52242-1319, (319) 335-1590, fax 319-335-2754, E-mail: abettis@GSBTH-PO.UIowa.edu; James B. Swinehart, 113 Nebraska Hall, University of Nebraska, Lincoln, NE 68588-0517, (402) 472-7529, fax 402-472-2410, E-mail: jbs@unlinfo.unl.edu; and Brian Carter, Department of Agronomy, Oklahoma State University, Stillwater, OK 74078, (405) 744-6414.
4. **Remote Sensing and GIS for Water-Quality Assessment.** Donald Rundquist, 113 Nebraska Hall, University of Nebraska, Lincoln, NE 68588-0517, (402) 472-7536, fax 402-472-2410.
5. **Perspectives on Urban Geology: Principles, Educational Needs, and Case Studies.** Perry Wigley, 113 Nebraska Hall, University of Nebraska, Lincoln, NE 68588-0517, (402) 472-3471, fax 402-472-2410, E-mail: pwigley@unlinfo.unl.edu; Priscilla Grew, 302 Adm, University of Nebraska, Lincoln, NE 68588-0433, (402) 472-3123; and William Wayne, Department of Geology, University of Nebraska, Lincoln, NE 68588-0340.
6. **College-related Earth Science Educational Activities for K–12 Schools.** Robert Pinker, Johnson County Community College, 12345 College at Quivira, Overland Park, KS 66210-1299, (913) 469-3894; and David Gosselin, 113 Nebraska Hall, University of Nebraska, Lincoln, NE 68588-0517, (402) 472-8919, fax 402-472-2410, E-mail: gosselin@unlinfo.unl.edu.
7. **Ogallala Group and Younger Neogene Geology.** R. F. Diffendal, Jr., 113 Nebraska Hall, University of Nebraska, Lincoln, NE 68588-0517, (402) 472-7546, fax 402-472-2410, E-mail: rfd@unlinfo.unl.edu.
8. **Chemical Dispersions in Hydrologic Systems.** Sambhudas Chaudhuri, Department of Geology, Kansas State University, Manhattan, KS 66506-3201, (913) 532-6724, fax 913-532-5159, E-mail: ksuncsc@ksuvm.bitnet.
9. **Geology of the Garbage Heap: Waste Sites and Waste Sitting.** Sanford S. Kaplan, Department of Geology, University of Nebraska, Lincoln, NE 68588-0340, (402) 472-6213, E-mail: skaplan@unlinfo.unl.edu; and Page C. Twiss, Kansas State University, Manhattan, KS 66506-3201, (913) 532-6724, E-mail: pctwiss@ksuvm.bitnet.
10. **Modern and Ancient Lake Environments of the Great Plains.** David C. Gosselin, 113 Nebraska Hall, University of Nebraska, Lincoln, NE 68588-0517, (402) 472-8919, fax 402-472-2410, E-mail: gosselin@unlinfo.unl.edu; and William M. Last, Department of Geological Sciences, University of Manitoba, 240 Wallace Building, Winnipeg, Manitoba R3T 2N2, Canada, (204) 474-8361, fax 204-261-7581, E-mail: mlast@ccm.umanitoba.ca.
11. **Great Plains Neogene Tectonism.** George W. Shurr, Department of Earth Sciences, St. Cloud State University, St. Cloud, MN 56301-4498, (612) 255-2009 or (612) 253-7810.
12. **Occurrence, Transport, and Transformation of Pesticides and Nutrients in Surface and Ground Waters.** Mary Exner Spalding, Conservation and Survey Division, 113 Nebraska Hall, University of Nebraska, Lincoln, NE 68588-0517, (402) 472-7547, fax 402-472-2410, E-mail: mspalding@unlinfo.unl.edu.
13. **Genesis and Morphology of Paleosols.** Mark Kuzila, Conservation and Survey Division, 113 Nebraska Hall, University of Nebraska, Lincoln, NE 68588-0517, (402) 472-7537, fax

North-Central/South-Central *continued on p. 258*

Southeastern *continued from p. 256*

PROJECTION EQUIPMENT

All slides must be 2" x 2" and fit a standard 35 mm carousel tray. Please bring your own loaded carousel trays, if possible. Two 35-mm slide projectors and screens will be available for each oral technical session. Overhead projectors will be available only by prior arrangement.

EXHIBITS

Exhibit facilities for business, educational, and governmental institutions will be located conveniently across from the technical session rooms in the Knoxville Hilton. Free beverages will be provided in the exhibit area for participants, and 24-hour security will be provided in the exhibit hall. The number of booths is limited, so plan to reserve space early. Exhibits will be open all day Thursday and on Friday morning. For further information and space reservations, contact Larry McKay, Department of Geological Sciences, University of Tennessee, Knoxville, TN 37996-1410, (615) 974-0821, E-mail: mckay@freddy.gg.utk.edu.

WELCOME PARTY AND GUEST ACTIVITIES

Various corporate sponsors will host a welcome party on Wednesday from 6:00 to 9:00 p.m., at a location on the World's Fair site, only a short walk from the Hilton. All party attendees must be registered; on-site registration will be available in the Hilton lobby prior to attending this party.

Knoxville Tours will offer a choice of two activities for guests each day of the meeting:

1. **Gatlinburg and Pigeon Forge.** An extraordinary shopping experience at factory outlet malls and mountain craft shops, at the foot of Great Smoky Mountains National Park.
2. **Museum of Appalachia.** Visit a unique folk museum, including a catered barbeque lunch and mountain music.

STUDENT TRAVEL GRANTS

Limited funds for support of travel expenses for students presenting papers at the meeting are available from the GSA Southeastern Section. For information, contact Michael J. Neilson, Department of Geology, University of Alabama, Birmingham, AL 35294, (205) 934-5102. Travel grant requests must be postmarked no later than March 6, 1995.

ACCOMMODATIONS

A large block of rooms at the Knoxville Hilton, the site of the meeting, has been reserved for attendees, at a special reduced rate of $79 per night for either single or double occupancy. There is an additional $12 room charge for each person in excess of two. Other nearby hotels are likely to have higher rates.

OTHER INFORMATION

More detailed information concerning fees and registration, hotel accommodations, field trips, and other activities will appear in the January 1995 issue of *GSA Today* and as part of the GSA Southeastern Section *Abstracts with Programs* for 1995. Preliminary questions and suggestions should be referred to the local committee chair: Harry McSween, Department of Geological Sciences, University of Tennessee, Knoxville, TN 37996-1410, (615) 974-5498, fax 615-974-2368, E-mail: mcsween@utkvx.utk.edu. ■

402-472-2410, E-mail: mkuzila@unlinfo.unl.edu.

14. **Cretaceous Rocks of the Midcontinent.** David K. Watkins, Department of Geology, University of Nebraska, Lincoln, NE 68588-0340, (402) 472-2648, E-mail: dwatkins@unlinfo.unl.edu; and Richard Hammond, South Dakota Department of Water and Natural Resources, Division of Geological Survey, Vermillion, SD 57069-2390, (605) 677-6162.

15. **Environmental Regulations and the Regulated Community: Impacts and Responses.** Hugh Stirts, U.S. Army Corps of Engineers, Omaha District, Attn. CEMIRO-ED-EE, 215 N. 17th St., Omaha, NE 68102-4978, (402) 221-7164; and David Henni, Dames and Moore, Omaha.

16. **Catastrophic Floods.** John F. Shroder, Jr., and Kevin Cornwell, Department of Geography and Geology, University of Nebraska, Omaha, NE 68182-0199, (402) 554-2662.

17. **Antarctic Paleoclimates and Paleoenvironments.** David Harwood, Department of Geology, University of Nebraska, Lincoln, NE 68588-0517, (402) 472-2648, E-mail: dharwood@unlinfo.unl.edu.

18. **Depositional Environments, Lithostratigraphy, and Biostratigraphy of the White River and Arikaree Groups.** Hannan E. LaGarry, University of Nebraska State Museum, W436 Nebraska Hall, University of Nebraska, Lincoln, NE 68588-0549, (402) 472-2657, fax 402-472-8949, E-mail: dterry@unlinfo.unl.edu; Dennis O. Terry; and Robert M. Hunt, Jr.

19. **Interpreting Animal Behavior from the Fossil Record.** Loren Babcock, Department of Geological Sciences, 155 South Oval Mall, Ohio State University, Columbus, OH 43210, (614) 292-0358, fax 614-292-1496, E-mail: lbabcock@orton.mps.ohio-state.edu.

SHORT COURSE

1. **Field and Laboratory Techniques for Vertebrate Fossils: A Primer for Geologists.** Gregory Brown, University of Nebraska State Museum, Division of Vertebrate Paleontology, W-436 Nebraska Hall, University of Nebraska, Lincoln, NE 68588-0514, (402) 472-2657, fax 402-472-8949, E-mail: gbrown@unlinfo.unl.edu.

FIELD TRIPS

The field trip Coordinator is Roger Pabian, Conservation and Survey Division, University of Nebraska, Lincoln, NE 68588-0517, (402) 472-7564, fax 402-472-2410, E-mail: rpabian@unlinfo.unl.edu.

Premeeting

1. **Late Pennsylvanian and Early Permian Biostratigraphy and Paleoecology in Richardson and Pawnee Counties, Nebraska.** Roger K. Pabian, Conservation and Survey Division, University of Nebraska, Lincoln, NE 68588-0517, (402) 472-7564, fax 402-472-2410, E-mail: rpabian@unlinfo.unl.edu, and Darwin R. Boardman II, 105 Noble Research Center, School of Geology, Oklahoma State University, Stillwater, OK 74078, (405) 744-5315, fax 405-744-7841.

2. **Late Quaternary Fluvial and Eolian Sediments: Loup River Basin and the Sand Hills of Nebraska.** James B. Swinehart, Conservation and Survey Division, University of Nebraska, Lincoln, NE 68588-0517, (402) 472-7529, fax 402-472-2410, E-mail: jbs@unlinfo.unl.edu; David May, Department of Geography, University of Northern Iowa, Cedar Falls, IA 50613, (319) 273-2772, fax 319-273-7103; and David Loope, Department of Geology, University of Nebraska, Lincoln, NE 68588-0340, (402) 472-2647.

3. **Quaternary Geology of Eastern Nebraska.** William J. Wayne, Department of Geology, University of Nebraska, Lincoln, NE 68588-0340, (402) 472-2663 or (402) 472-2601.

4. **Revision of White River Group Stratigraphy, Nebraska and South Dakota.** Hannan LaGarry, W-436 Nebraska Hall, University of Nebraska, Lincoln, NE 68588-0549, (402) 472-2657, fax 402-472-8949; and Dennis Terry and Brant Wells, Department of Geology, University of Nebraska, Lincoln, NE 68588-0340.

Postmeeting

5. **Geology and Paleontology of Ashfall Fossil Beds (Miocene) of Northeastern Nebraska.** Michael R. Voorhies, University of Nebraska State Museum, University of Nebraska, Lincoln, NE 68588-0514, (402) 472-2654, fax 402-472-8949.

6. **Geology of the Ogallala/High Plains Regional Aquifer System in Nebraska.** R. F. Diffendal, Jr., Conservation and Survey Division, University of Nebraska, Lincoln, NE 68588-0517, (402) 472-7546, fax 402-472-2410, E-mail: rfd@unlinfo.unl.edu.

7. **Late Quaternary Landscape Evolution in Eastern Nebraska.** Rolfe Mandel, 1730 SW High St., Topeka, KS 66604-3121, (913) 235-1647; and E. Arthur Bettis III, Iowa Department of Natural Resources, Geological Survey Bureau, University of Iowa, Iowa City, Iowa 52240, (319) 335-1578.

8. **Environmental Geology of Douglas and Sarpy Counties (Omaha), Nebraska.** Robert Goodwin, Woodward-Clyde Consultants, 101 S. 108th Ave., Omaha, NE 68154, (402) 334-8181, fax 402-334-1984.

9. **Upper Pennsylvanian Paleosols, Lower Platte and Weeping Water Valleys, Southeastern Nebraska.** R. M. Joeckel, Department of Geology, University of Nebraska, Lincoln, NE 68588-0340, (402) 472-2663, fax 402-472-4917.

10. **Permian Strata in the Manhattan, Kansas Area: Implications for Climatic and Eustatic Controls.** Allen W. Archer, Page C. Twiss, and R. R. West, Department of Geology, Kansas State University, Manhattan, KS 66506-3201, (913) 532-6724, E-mail: pctwiss@ksuvm.bitnet.

11. **The Crow Creek Member, Pierre Shale (Upper Cretaceous) of Southeastern South Dakota and Northeastern Nebraska: Impact Tsunamite or Basal Transgressive Deposit?** Raymond R. Anderson and Brian J. Witzke, Iowa DNR, Geological Survey Bureau, 109 Towbridge Hall, University of Iowa, Iowa City, IA 52242-1319, (319) 335-1575, fax 319-335-2754, E-mail: Raymond-Anderson@uiowa.edu; and Richard H. Hammond, South Dakota Geological Survey, Science Center—Campus West, University of South Dakota, Vermillion, SD 57069, (605) 624-6162.

POSTER SESSIONS

We encourage students and professional members to take advantage of this highly effective means of communication. Please indicate Poster Session on the GSA abstract form. Each poster booth will provide three 3.5' x 3.5' white boards arranged at table height. Poster sessions will be located in the area near exhibits and will be available for viewing for one-half day.

The Geology Division of the Council on Undergraduate Research will sponsor a poster session on geology research by undergraduate students.

ABSTRACTS

Abstracts must be submitted camera-ready on official GSA abstract forms in accordance with instructions on the forms. Abstract forms are available from: Abstracts Coordinator, Geological Society of America, P.O. Box 9140, Boulder, CO 80301-9140; (303) 447-2020, E-mail: ncarlson@geosociety.org, or from David Loope, GSA North-Central/South-Central Program Coordinator, Department of Geology, University of Nebraska, Lincoln, NE 68588-0340. Forms are also available from GSA Campus Representatives at most colleges and universities.

ABSTRACTS DEADLINE: January 6, 1995

Send one original and five copies to David Loope, GSA Program Coordinator, Department of Geology, University of Nebraska, Lincoln, NE 68588-0340. Abstracts submitted for inclusion in symposia should be sent directly to the symposium organizer listed first above for each symposium.

All abstracts will be reviewed for informative content, proper format, and originality. Authors will be notified of acceptance well in advance of the meeting.

STUDENT PAPERS AND TRAVEL ASSISTANCE

Students will be awarded best student paper awards and travel grants by the section in which they reside. Applications for travel assistance should be made to the appropriate section following the procedures listed below.

The **North-Central Section** of GSA will award $75 for each of the eight papers judged best whose principal author and presenter is a graduate or undergraduate student. Abstracts of papers submitted for consideration for these awards should be so indicated on the abstract form. In addition, awards for travel assistance of up to $200 may be made to students who are student members of the North-Central Section of GSA as of January 1, 1995. To be eligible for a travel grant, the student must present a paper (oral or poster) for which he or she is author or coauthor. Applications for travel assistance awards may be obtained by writing the General Chair, R. F. Diffendal, Jr., Nebraska Geological Survey, 113 Nebraska Hall, University of Nebraska, Lincoln, NE 68588-0517 or calling (402) 472-7546. Applications for travel assistance must be received no later than February 15, 1995.

The **South-Central Section of** GSA will award $200, $100, and $50 for the three best oral student papers and $200 for the best student poster session given at the meetings. Awards for outstanding papers will be based on quality of research and effectiveness of presentation. To be eligible, the abstract must list only student authors who are members of the South-Central Section as of January 1, 1995, and must identify clearly the abstract as a student paper.

In addition, awards for travel will be made to students who are presenting a paper (oral or poster). For further information contact Page C. Twiss, Department of Geology, Kansas State University, Manhattan, KS 66506-3201, (913) 532-6724, fax 913-532-5159, E-mail: pctwiss@ksuvm.bitnet. Applications for travel assistance must be received no later than February 15, 1995.

PROJECTION EQUIPMENT

Two standard 35 mm carousel projectors for 2" x 2" slides and one overhead projector for transparencies will be provided in each meeting room. Please bring your own loaded carousel tray(s) identified with speaker's name, session, and speaker number to your session room before the start of the session. A speaker-ready room equipped with projectors will be available for review and practice.

NORTH-CENTRAL SECTION BUSINESS MEETING

The GSA North-Central Section Management Board will hold its business meeting with breakfast in the Nebraska Center for Continuing Education on April 27, 1995, at 7:00 a.m.

SOUTH-CENTRAL SECTION MANAGEMENT BOARD AND BUSINESS MEETINGS

The GSA South-Central Section Management Board will hold its business meeting on April 26, 1995, at 4:30 p.m. in the Nebraska Center for Continuing Education. The South-Central Section will hold its annual business meeting following the last session on Thursday, April 27, at about 5:00 p.m. in the Nebraska Center for Continuing Education.

EXHIBITS

Exhibits of educational and commercial organizations will be on display in the Nebraska Center in proximity to the symposia, technical, and poster sessions. Exhibit space must be reserved by January 6, 1995. For further information contact George Engelmann, Department of Geography and Geology, University of Nebraska, Omaha, NE 68182-0199, (402) 554-2662, fax 402-554-3518.

SOCIAL EVENTS

A welcoming reception will be held in the Nebraska Center for Continuing Education on Wednesday, April 26, 1995. On Thursday evening, April 27, the annual banquet will be held in the Elephant Hall of the University of Nebraska State Museum, preceded by a social hour beginning at 6:00 p.m. The banquet address will be given by Stanley Schumm of Colorado State University. Van service will be available to take participants to and from the banquet and the Nebraska Center.

Spouse and guest activities will include visits to local museums, the University of Nebraska Athletic Department, and the Animal Science complex. A full list will be included in the final announcement.

The North-Central/South-Central GSA Campus Representatives will hold a breakfast on Friday, April 28, in the Nebraska Center at 7:00 a.m. The Texas Section and Mid-Continent Section of NAGT will hold technical sessions and a business meeting during Thursday and Friday, April 27 and 28. The Great Lakes and Midcontinent sections of SEPM, the North-Central and South-Central sections of the Paleontological Society, and the Pander Society will hold a combined luncheon on Thursday, April 27. The Association for Women Geoscientists will host a breakfast and talk on mentoring relationships on Friday, April 28. An open

North-Central/South-Central
continued on p. 259

GSA SECTION MEETINGS

NORTHEASTERN SECTION

Radisson Hotel and Conference Center in Cromwell, Hartford, Connecticut, March 20–22, 1995. Submit completed abstracts to: Norman H. Gray, Department of Geology and Geophysics, University of Connecticut, 354 Mansfield Rd., Storrs, CT 06269-2045, (203) 486-4434. *Abstract Deadline: November 21, 1994.*

SOUTHEASTERN SECTION

Knoxville Hilton Hotel, Knoxville, Tennessee, April 6–7, 1995. Submit completed abstracts to: Robert D. Hatcher, Jr., Department of Geological Sciences, University of Tennessee, Knoxville, TN 37996-1410, (615) 974-6565. *Abstract Deadline: December 16, 1994.*

NORTH-CENTRAL/SOUTH-CENTRAL SECTIONS

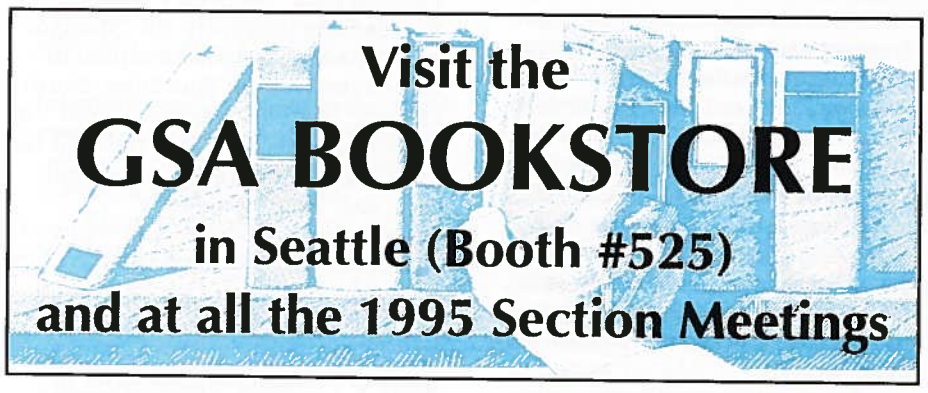
University of Nebraska, Lincoln, Nebraska, April 27–28, 1995. Submit completed abstracts to: David Loope, 332 Bessey Hall, University of Nebraska, Lincoln, NE 68588-0340, (402) 472-2647 *Abstract Deadline: January 6, 1995.*

ROCKY MOUNTAIN SECTION

Montana State University, Bozeman, Montana, May 18–19, 1995. Submit completed abstracts to: David R. Lageson, Department of Earth Sciences, Montana State University, Bozeman, MT 59717-0348, (406) 994-6913. *Abstract Deadline: January 20, 1995.*

CORDILLERAN SECTION

University of Alaska, Fairbanks, Alaska, May 24–26, 1995. Submit completed abstracts to: Catherine Hanks, Geophysical Institute, University of Alaska, Fairbanks, AK 99775-0800, (907) 474-5562. *Abstract Deadline: January 30, 1995.*



North-Central/South-Central
continued from p. 258

house of the invertebrate fossil collections of the University of Nebraska State Museum will be held from 12:00 noon to 1:30 p.m. on April 28.

HOUSING

Rooms will be reserved at the Nebraska Center and at local motels and hotels. A very limited number of budget accommodations will be available only for students in a dormitory on campus on a first-come first-served basis. Restaurants are located in the Nebraska Center, the East Campus Student Union, within walking distance of the Nebraska Center, and across the city. Lists of restaurants will be provided in the registration materials.

PARKING

The Nebraska Center for Continuing Education has free parking for up to 300 vehicles of hotel guests and meeting participants. Additional parking is available on nearby residential streets. Maps showing parking locations will be included in registration materials.

TRAVEL ARRANGEMENTS

The University of Nebraska, Lincoln, is a short distance from I-80, U.S. Routes 6, 34, and 77, and Nebraska Highway 2. Lincoln is served by United Airlines and Airlink through Chicago and Denver, TWA through St. Louis, Northwest Airlink through Minneapolis, and USAir Express through Kansas City. Amtrak stops at Lincoln, as do Greyhound buses. Taxi service from the airport and stations to the Nebraska Center costs about $10 or less. A direct-line free telephone for taxi service is located just to the right of the baggage claim area in the airport. There are Hertz, Dollar, National, Budget, and Avis rental car desks located in the Lincoln Airport Terminal.

If you are certain that you will be coming to the meeting well in advance of the meeting dates and plan to come by plane, train, or bus, book your tickets as early as possible so that you can get the best rates. Have your travel agent then look for any fare reductions that you can take advantage of as they open up. If you register for one of the postmeeting field trips that start and end in Lincoln, you may be able to take advantage of the lower airfares for staying over a Saturday. Persons planning to follow this last suggestion should check immediately with the leader of the trip they are interested in taking to make sure of the dates and probable return arrival time.

DETAILED INFORMATION

Almost all functions of the meeting will be held at the Nebraska Center for Continuing Education, and possibly the East Campus Student Union, a short distance from the Nebraska Center on the University of Nebraska, Lincoln, East Campus. Information concerning registration, hotel and motel accommodations, and activities will appear in the January 1995 issue of *GSA Today* and in the North-Central/South-Central Section *Abstracts with Programs* for 1995. Symposia, short courses, and field trips are in the planning stages, and further suggestions are welcome. Inquiries, additional information, requests, or helpful suggestions should be directed to R. F. Diffendal, Jr., GSA General Chair, 113 Nebraska Hall, University of Nebraska, Lincoln, NE 68588-0517, (402) 472-7546, fax 402-472-2410, E-mail: rfd@unlinfo.unl.edu. ■

GSA ANNUAL MEETINGS

■ 1995

New Orleans, Louisiana
November 6–9
Ernest N. Morial
Convention Center,
Hyatt Regency New Orleans

NEW ORLEANS
BRIDGING THE GULF

General Chairman: ***William R. Craig, University of New Orleans***
Technical Program Chairman: ***Laura Serpa, University of New Orleans***
Field Trip Chairman: ***Whitney Autin, Louisiana Geological Survey***

Call for 1995
CONTINUING EDUCATION COURSE PROPOSALS
PROPOSALS DUE DECEMBER 1, 1994

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 1995 New Orleans Annual Meeting or the 1996 Denver Annual Meeting.

Proposals must be received by December 1, 1994. Selection of courses for 1995 will be made by February 1, 1995. For those planning ahead, we will also consider courses for 1996 at that time.

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

Theme for 1995 Annual Meeting in New Orleans

The theme for the 1995 Annual Meeting in New Orleans is Bridging the Gulf. This theme has several meanings. In particular, we wish to draw attention to the Gulf of Mexico/Caribbean, and the surrounding American continents. The emphasis will be on bridging the knowledge gap that exists across a region divided by political boundaries and language but sharing a common geologic framework. Bridging the Gulf also addresses the need to develop a closer link between technology and the science of geology and to educate the public on issues critical to the development of intelligent policies on the environment and geologic hazards. We also wish to Bridge the Gulf between the past and the future with both a retrospection on the past 30 years of plate tectonics and a look at the future as geology responds to society's needs.

Finally, we view the city of New Orleans, the Mississippi River, its delta, and the Gulf Coast as a laboratory where the long-term effects of humans on the environment can be examined. To this end, the keynote symposium, "The Mississippi River: Control and Consequences," will address the questions raised by man's need to modify his surroundings to ensure a reasonable lifestyle. We invite theme sessions and symposia on the broad range of topics related to our theme. More importantly, however, is our interest in furthering the scientific knowledge of the attendees by developing a strong program of diverse interest to the geoscience community. We call on our colleagues to help us develop a well-rounded program that reflects a broad spectrum of current research and technology in the geosciences. ■

For general information call the GSA Meetings Department, 1-800-472-1988 or (303) 447-2020, ext. 141; E-mail: mball@geosociety.org.
Theme Session Proposals due: January 2, 1995.

■ FUTURE

New Orleans	November 6–9	1995
Denver	October 28–31	1996
Salt Lake City	October 20–23	1997
Toronto	October 26–29	1998
Denver	October 25–28	1999

For general information on technical program participation (1995 or beyond), contact Sue Beggs, Meetings Manager, GSA headquarters.

Student Travel Grants

The GSA Foundation will award matching grants up to a total of $3500 each to the six GSA Sections. The money, when combined with equal funds from the Sections, will be used to assist GSA Student Associates traveling to the 1995 GSA Annual Meeting in New Orleans in November and to the 1995 Section meetings. Contact your Section Secretary for application procedures.

Cordilleran	Bruce A. Blackerby	(209) 278-2955
Rocky Mountain	Kenneth E. Kolm	(303) 273-3932
North-Central	George R. Hallberg	(319) 335-4500
South-Central	Rena M. Bonem	(817) 755-2361
Northeastern	Kenneth N. Weaver	(410) 554-5532
Southeastern	Harold H. Stowell	(205) 348-5098

GSA DIVISION AND SECTION GRANTS 1994

DIVISION RESEARCH GRANTS

Seven of the 12 GSA divisions offer grants for outstanding student research. Divisions that do not currently offer grants are Archaeological Geology, Geoscience Education, History of Geology, International, and Planetary Geology.

Coal Geology Division

The Coal Geology Division presented its seventh annual Antoinette Lierman Medlin Scholarship Award in 1994 to Trent Alan Rehill of Dalhousie University for his proposal, "Petroleum Geology/Basin Modeling in the Central Maritimes Basin, Eastern Canada." The Division presented the Medlin Field Award to Michael R. Caudill for his proposal, "The Origin of Some Late Pennsylvanian Coal Swamps: Climatically Induced Development of Perched Water Tables." The Division considers proposals from any full-time graduate student who is conducting research in coal geology.

Engineering Geology Division

There were no qualified applicants for the Engineering Geology Division Award for 1994.

Geophysics Division

The Geophysics Division presented its seventh annual Allan V. Cox Student Research Award this year for an outstanding student research proposal submitted to the GSA Research Grants Program. Shaosong Huang, a Ph.D. candidate at Virginia Polytechnic Institute and State University, Blacksburg, received the award for his research project, "The Determination of Long-term Lithospheric Deformation and Rheology in NE Honshu, Japan."

Hydrogeology Division

The fifth annual awards for outstanding student research from the Hydrogeology Division were presented in 1994 to four students: Ian C. Jones, University of Texas, Austin, for "Geochemical Evolution of Groundwater in the Pleistocene Limestone Aquifer of Barbados, West Indies"; Marcia K. Schulmeister, University of Kansas, for "Naturally Occurring Groundwater Nitrate: An Evaluation of Nitrate Degradation Mechanisms in Carbonate and Alluvial Aquifers"; Robert John Swartz, California State University, Bakersfield, for "Occurrence of Arsenic in the Kern Water Bank, Southern San Joaquin Valley, California"; and Vikas Tandon, University of Nebraska, Lincoln, for "The Vertical Component of Contaminant Transport in Groundwater Systems."

Quaternary Geology and Geomorphology Division

The Quaternary Geology and Geomorphology Division awarded two students the Mackin/Howard grant in 1994. Amy Beth Church, M.S. degree candidate at the University of Vermont, will study "Geomorphic Response to Colonial Landuse Changes in Vermont." Robert Joseph Viens, Ph.D. candidate at the University of Washington, Seattle, received the grant for his project "The Dynamic Response of Tidewater and Freshwater Calving Glaciers to Millennial-Scale Change."

Sedimentary Geology Division

The Sedimentary Geology Division presented its eighth annual award for an outstanding student research proposal submitted to the GSA Research Grants Program to Oleg V. Pinous, Ph.D. candidate at Ohio State University. The award was for his research project, "Field and Laboratory Investigations of Mesozoic and Paleogene Stratigraphy and Sedimentology of West Siberia and Russian Platform: Application to Improvement of Quantified Eustatic Sea-Level Curves."

Structural Geology and Tectonics Division

The Structural Geology and Tectonics Division presented its ninth annual awards for outstanding student research in 1994. The recipients are Christopher A. Hedlund, Colorado State University, for "Geometry, Kinematics, and Mechanics of Decollement Folding in the Canadian Rockies"; and Jonathan C. Lewis, University of Connecticut, for "The Effect of Changing Plate Motions on the Structure of an Accretionary Prism: The Tertiary Shimanto Belt, Japan." Both recipients are Ph.D.candidates.

SECTION RESEARCH GRANTS

North-Central Section

The North-Central Section of GSA awarded grants to undergraduate students who attend a college or university within the North-Central Section geographic area. Recipients are: Tracey Carpenter, University of Wisconsin—Eau Claire, for "Mineralogical Study of the Cambro-Ordovician Sedimentary Rocks of West-Central Wisconsin"; Dori Farthing, College of Wooster, for "Lead Isotope Systematics of the Troodos Ophiolite, Cyprus: Delineation of Fluid Pathways in Ancient Oceanic Crust"; Dennis C. Gamble, University of Wisconsin—River Falls, for "Gravity Survey of the Hudson-Afton Horst: An Enigmatic Feature of the Midcontinent Rift System;" Jeff Peterson, Gustavus Adolphus College, for "Description, Analysis, and Correlation of Pre–Late Wisconsinan Till in the St. Peter–Mankato Region, Minnesota"; Christine Poschadel, University of Manitoba, for "Paleoenvironmental Interpretation of the Aral Sea"; Brenda Szitta, Lawrence University, for "Distribution of Sand Lenses in the 'Sand and Gravel Aquifer' in the Fox Cities Area"; and Jeremy Tomb, Wright State University, for "Comparison of Pleistocene and Modern Lagoonal Sequences, San Salvador, Bahamas."

South-Central Section

The South-Central Section of GSA presented its seventh annual research awards to qualified graduate students in the section in 1994. Recipients are students who attend a college or university in the South-Central Section geographic area and have submitted applications to the GSA Research Grants Program. The awards presented this year went to Janet Bader, University of Texas, El Paso, for "Bioreduction of Chromium in Contaminated Soils and Potential Application to the Bioremediation of Cr(VI) Contaminated Sites"; David G. Edgerton, University of Texas, Austin, for "Energy Transport Models of Hydrothermal Discharge Zone into Subaqueous Environments: Implications for the Formation of the Red Dog Zinc-Lead Deposit, Western Brooks Range, Alaska"; D. Michelle Williams, Baylor University, for "The Effects of Urbanization on the Hydrologic Response"; and Yu-Zing Zhou, Texas A&M University, for "Provincialism of Palynomorphs from the Late Carboniferous Sediments of the Ancestral Rockies: A Response to Paleoclimatic Change."

The South-Central Section also awarded grants to eight undergraduate students (in fall 1993): Cynthia Burtnett, Wichita State University, for "Depositional Facies of Plio-Pleistocene Carbonates, Ambergris Caye, Northern Belize"; Carmen M. Fraticelli, University of Texas at Arlington, for "Time Range of Fossil Phytoliths in the Terrestrial Sediments of Texas"; Kimberly Rhae Jones, University of Arkansas—Fayetteville, for "Early Morrowan Depositional Patterns in Northwest Arkansas"; Chris Kightlinger, Baylor University, for "Structural Analysis of the Central Arbuckle Anticline"; Scott Michael Krauszer, Baylor University, for "Structural Geology of the Bud Kimball Anticline, Southern Bighorn Basin, Washakie County, Wyoming"; Kelly Latter, Texas Tech University, for "A Geochemical Investigation of Lower Crustal Xenoliths from Potrillo Maar, New Mexico"; Rachel A. Moravec, Tarleton State University, for "Identification of Isolated Pycnodont Teeth from the Lower Cretaceous of North-Central Texas"; and Robert Spang, Baylor University, for "Geology of the Big Spring Anticline and Little Canyon Creek Monocline, Southeastern Bighorn Basin, Washakie County, Wyoming."

Southeastern Section

GSA's Southeastern Section awarded research grants to 11 qualified students within the section. They are Danielle G. Capelle, University of Tennessee, for "Stratigraphy and Development of Catskill Formation (Upper Devonian) Paleosols near Selinsgrove, Pennsylvania"; Michael R. Caudill, University of Tennessee, for "The Origin of Some Late Pennsylvanian Coal Swamps: Climatically-induced Development of Perched Water Tables"; Laura A. Guertin, University of Miami, for "Late Cenozoic Evolution of the Southeastern Florida Peninsula: Lithostratigraphy, Chronostratigraphy, and the Sea Level Record"; Thomas R. Kulp, East Carolina University, for "Late Holocene Paleoclimate Variation in Kane County, Utah, as Evidenced by Paleosol Data"; Stephen L. Palmes, Florida State University, for "Stratigraphy, Structure and Metamorphic History of the Western Blue Ridge, North Georgia"; Carolus Prasetyadi, West Virginia University, for "Structure and Tectonic Significance of the Aileu Complex, East Timor, Indonesia"; Christopher K. Ridgway, University of Alabama, for "Structural Analysis of the Grand Island Pluton Complex, Southeast Alaska"; Donna M. Sharp, University of Tennessee, for "Fold Development of a Limestone Monolayer in an Actively Cleaving Rock"; William Jay Sims, University of Kentucky, for "Geometry and Timing of the Northeast Boundary Faults of the Ancestral Uncompahgre Uplift, Colorado"; Nicholas S. Sirek, University of Kentucky, for "Abundance, Distribution and Predictability of Fractures in Relation to Flow of Groundwater in Leslie County, Kentucky"; and Lee Sheffield Yokel, Auburn University, for "Geology of the Chewacla Marble and Associated Units, Lee County, Alabama."

The remaining three sections—Northeastern, Rocky Mountain, and Cordilleran—did not offer research grants in 1994. The Northeastern Section will initiate a new student research grant program in 1995, which will include both graduate and undergraduate students. Contact the Section Secretary for details on both of these programs. ■

In Memoriam

Robert L. Bates
Columbus, Ohio
June 14, 1994

William J. Bowen III
Beaufort, North Carolina
April 18, 1994

Fred M. Bullard
Austin, Texas

William O. Field, Jr.
Great Barrington, Massachusetts

Robert H. Osborne
Los Angeles, California
July 13, 1994

Robert L. Wilson
Chattanooga, Tennessee
August 8, 1994

GSA Division News

Divisions will recognize the following individuals at the 1994 Annual Meeting in Seattle for their service to the division and/or contributions to the geological sciences.

Coal Geology Division
Russell R. and *Linda A. F. Dutcher,* Distinguished Service Award
C. Blaine Cecil, Distinguished Service Award
Cortland F. Eble, Distinguished Service Award

Engineering Geology Division
C. Michael Scullin, Distinguished Practice Award

Hydrogeology Division
Darryll T. Pederson, Distinguished Service Award
Joseph S. Rosenshein, Distinguished Service Award
Christopher E. Neuzil, 1995 Birdsall Distinguished Lecturer

Quaternary Geology and Geomorphology Division
William C. Bradley, Distinguished Career Award

For a listing of other award recipients to be honored at the Seattle meeting, see page 182 of the July 1994 issue of *GSA Today.*

MEETINGS

■ Indicates new or changed information

GSA Penrose Conferences

October 1995

■ **Mesozoic Evolution of the Cordilleran Continental Margin in Central and Southern California,** October 6–11, 1995, Tehachapi, California. Information: Andrew Barth, Department of Geology, Indiana/Purdue University, Indianapolis, IN 46202-5132, (317) 274-1243, E-mail: ibsz100@indyvax.iupui.edu.

1994 Meetings

October

Association of Engineering Geologists Annual Meeting, October 2–7, 1994, Williamsburg, Virginia. Information: AEG, 323 Boston Post Rd., Suite 2D, Sudbury, MA 01776, (508) 443-4369 or (508) 443-3639.

Federation of Analytical Chemistry and Spectroscopy Societies Annual Conference, October 2–7, 1994, St. Louis, Missouri. Information: FACSS, 198 Thomas Johnson Dr., Suite S-2, Frederick, MD 21702-4317, (301) 846-4797.

International Association for Mathematical Geology Annual Meeting, October 3–5, 1994, Mont Tremblant, Quebec, Canada. Information: C.-J. Chung, Geological Survey of Canada, 601 Booth St., Ottawa, Ontario K1A 0E8, Canada, (613) 996-3413, fax 613-996-3726, E-mail: chung@gsc.emr.ca.

German Geological Society (DGG) Annual Meeting, October 4–7, 1994, Heidelberg, Germany. Information: Th. Bechstädt and R. O. Greiling, Geologische-Paläontologisches Institut, Ruprecht-Karls-Universität, Im Neuenheimer Feld 234, D-6900 Heidelberg, Germany.

Symposium on Porphyry Copper Deposits from Alaska to Chile, October 5–7, 1994, Tucson, Arizona. Information: Jim Laukes, University of Arizona Extended University, 1955 East Sixth Street, Tucson, AZ 85719-5224, 1-800-955-UofA, fax 602-621-3269, E-mail (Internet): jlaukes.ccit.arizona.edu.

Moving Industrial Minerals into the 21st Century, October 5–7, 1994, Nashville, Tennessee. Information: Meetings Dept., SME, P.O. Box 625002, Littleton, CO 80162-5002, (303) 973-9550, fax 303-979-3461.

■ **Association of Earth Science Editors Annual Meeting,** October 15–18, 1994, Oak Ridge, Tennessee. Information: Robert D. Hatcher, Jr., Dept. of Geological Sciences, University of Tennessee, Knoxville, TN 37996-1410, (615) 974-6565, fax 615-974-2368, E-mail: bobmap@utkvx.utcc.utk.edu.

9th National Conference on Hydrogeology and Engineering Geology of Karst Terranes, October 16–18, 1994, Nashville, Tennessee. Information: James F. Quinlan, Box 110539, Nashville, TN 37222, (615) 833-4324; or Geary M. Schindel, (615) 255-2288.

Symposium on the Petroleum Geology and Hydrocarbon Potential of the Black Sea Area, October 16–18, 1994, Varna, Bulgaria. Information: Liz Lador, Petroconsultants S.A., Information Research Division, P.O. Box 152, 24 Chemin de la Mairie, 1258 Perly, Geneva, Switzerland, phone 41-22-721-1717, telex 413-541-PETR CH, fax 41-22-721-1747.

Applications of Sedimentary Geology and Paleontology into the 21st Century, October 16–20, 1994, Snowbird, Utah. Information: Myra Rogers, SEPM, P.O. Box 4756, Tulsa, OK 74159-0756, (800) 865-9865, fax 918-743-2498, E-mail: myralee@ aip.edu.

Ninth Annual Conference on Contaminated Soils, October 17–20, 1994, Amherst, Massachusetts. Information: Paul Kostecki, Environmental Health and Sciences, N344 Morrill, University of Massachusetts, Amherst, MA 01003, (413) 545-2934, fax 413-545-4692.

LIRA Workshop on the Ross Orogen: Crustal Structure and Tectonic Significance, October 21–23, 1994, Dallas, Texas. Information: John W. Goodge, Dept. of Geological Sciences, Southern Methodist University, Dallas, TX 75275, (214) 768-4140, E-mail: jgoodge@sun.cis.smu.edu.

GSA Annual Meeting, October 24–27, 1994, Seattle, Washington. Information: GSA Meetings Department, P.O. Box 9140, Boulder, CO 80301, (303) 447-2020, ext. 113, E-mail: mball@geosociety. org (recently changed from .com).

November

Carolina Geological Society Annual Meeting and Field Trip, November 4–6, 1994, Raleigh, North Carolina. Information: Skip Stoddard, Dept. of MEAS, Box 8208, North Carolina State University, Raleigh, NC 27695-8208, (919) 515-7939, fax 919-515-7802, E-mail: stoddard@meavax.nrrc.ncsu.edu.

■ **Investigations of Lithosphere Architecture and Development,** November 5–9, 1994,Taos, New Mexico. Information: Alan Levander, Rice University, (713) 527-6064, fax 713-285-5214. Send by E-mail a letter of application to Liz McDowell at liz@iris.edu.

Glacial-Interglacial Sealevel Changes in Four Dimensions, November 5–10, 1994, St. Martin, Germany. Information: Josip Hendekovic, European Science Foundation, 1quai Lezay-Marnésia, 67080 Strasbourg Cedex, France, phone 33-88-76-71-35, fax 33-88-36-69-87.

International Symposium on the Cenozoic Tectonics and Volcanism of Mexico, November 7–11, 1994, Puerto Vallarta, Jalisco, Mexico. Information: Hugo Delgado Granados, Inst. de Geofísica, UNAM, Circuito Exterior, C.U., Coyoacán 04510, México D.F., phone (525) 622-4145, 622-4119, 622-4124, fax 525-550-2486, Internet: hugo@tonatiuh.igcofcu.unam.mx; or Gerardo Aguirre Díaz, Estación Regional del Centro, Inst. de Geología, UNAM, Apdo. Postal 376, Guanajuato, Gto, 36000, México, phone and fax 524-732-3038.

Geology and Resources of the Eastern Frontal Belt, Ouachita Mountains, Oklahoma, November 15–17, 1994, Poteau, Oklahoma. Information: Neil H. Suneson, Oklahoma Geological Survey, Sarkeys Energy Center, Room N-131, 100 East Boyd St., Norman, OK 73019-0628, (405) 325-3031.

International Geological Correlation Program Project 351, Early Paleozoic Evolution in Northwest Gondwana, November 29–December 7, 1994, Rabat, Morocco. Information: Naima Hamoumi, Dépt. de Géologie, Faculté des Sciences de Rabat, B.P. 1226 RP Rabat, Morocco, phone 212-7-7719-57, fax 212-7-77-42-61, telex 36607 M.

Northwest Mining Association 100th Annual Convention, November 30–December 2, 1994, Spokane, Washington. Information: Northwest Mining Association, 10 N. Post, Ste. 414, Spokane, WA, 99201-0772, (509) 624-1158, fax 509-623-1241.

December

25th Annual Underwater Mining Institute, December 1–4, 1994, Monterey, California. Information: Karynne Chong Morgan, Underwater Mining Institute, 811 Olomehani St., Honolulu, HI 96813-5513, (808) 522-5611, fax 808-522-5618, Internet: 70673.534@compuserve.com, Compuserve 70673,534.

■ **American Geophysical Union Fall Meeting,** December 5–9, 1994, San Francisco, California. Information: AGU Meetings Dept., 1994 Fall Meeting, 2000 Florida Ave., N.W., Washington, DC 20009, (202) 462-6900, fax 202-328-0566, E-mail: meetinginfo@kosmos.agu.org.

Tectonic Evolution of Southeast Asia, December 7–8, 1994, London, UK. Information: Robert Hall, Geological Sciences, University College, Gower St., London WC1E 6BT, UK, phone 44-784-443592, fax 44-71-387-1612, E-mail (Internet): robert.hall@ucl.ac.uk.

Symposium on Inverse Problems: Geophysical Applications, December 12–14, 1994, Yosemite Fish Camp, California. Information: SIAM Conference Coordinator, 3600 University City Science Center, Philadelphia, PA 19104-2688, (215) 382-9800, fax 215-386-7999, E-mail: meetings@siam.org.

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1995 Meetings

February

Mathematical and Computational Issues in the Geosciences, Third SIAM Conference, February 8–11, San Antonio, Texas. Information: SIAM Conference Coordinator, 3600 University City Science Center, Philadelphia, PA 19104-2688, (215) 382-9800, fax 215-386-7999, E-mail: meetings @siam.org.

U.S. Geological Survey McKelvey Forum on Energy and the Environment: Application of Geosciences to Decision Making, February 13–16, 1995, Washington, D.C. Information: Dudley D. Rice, U.S. Geological Survey, P.O. Box 25046, MS 971, Denver, CO 80225, (303) 236-5711, fax 303-236-8822, E-mail: rice@bpgsvr.cr.usgs.gov.

■ **Paleokarst: Macroscopic Dissolution Features in the Rock Record,** February 17–21, 1995, Bahamian Field Station, San Salvador Island, Bahamas. Information: John Mylroie, Department of Geosciences, P.O. Box 5448, Mississippi State, MS 39762, (601) 325-8774, fax 601-325-2907.

March

American Association of Petroleum Geologists and Society for Sedimentary Geology (SEPM) Annual Convention, March 5–8, 1995, Houston,

Meetings *continued on p. 262*

Texas. Information: Michelle Mayfield, AAPG Annual Meetings Manager, P.O. Box 979, 1444 S. Boulder Ave., Tulsa, OK 74101-0979, (918) 584-2555, fax 918-584-2274.

■ **Prospectors and Developers Association of Canada Convention,** March 5–8, 1995, Toronto, Ontario. Information: Prospectors and Developers Association of Canada, 34 King St. East, 9th Floor, Toronto, Ontario M5C 2X8, Canada, (416) 362-1969, fax 416-362-0101.

GSA Northeastern Section Annual Meeting, March 20–22, 1995, Hartford, Connecticut. Information: Norman H. Gray, Dept. of Geology and Geophysics, University of Connecticut, 354 Mansfield Road, Storrs, CT 06269-2045, (203) 486-4434.

■ **Michigan: Its Geology and Geologic Resources,** March 23–24, 1995, East Lansing, Michigan. Information: S. Paul Sundeen, Michigan DNR Geological Survey Division, P.O. Box 30256, Lansing, MI 48909, (517) 334-6930, fax 517-334-6038.

Oklahoma Geological Survey Workshop on the Ames Structure and Similar Features, March 28–29, 1995, Norman, Oklahoma. Information: Kenneth S. Johnson and Jock A. Campbell, Oklahoma Geological Survey, University of Oklahoma, 100 East Boyd, Rm. N-131, Norman, OK 73019, (405) 325-3031, fax 405-325-7069.

April

Sinkholes and the Engineering and Environmental Impacts of Karst Fifth Multidisciplinary Conference, April 2–5, 1995, Gatlinburg, Tennessee. Information: B. F. Beck, P. E. LaMoreaux & Associates, Inc., Box 4412, Oak Ridge, TN 37831, (615) 483-7483.

Geological Society of South Africa Centennial Geocongress, April 3–7, 1995, Johannesburg, South Africa. Information: Congress Secretariat, Centennial Geocongress, P.O. Box 36815, Menlo Park, 0102, South Africa, phone and fax 27-12-47-3398.

■ **2nd International Symposium on Fractals and Dynamic Systems in Geoscience,** April 4–7, 1995, Frankfurt am Main, Germany. Information: Jörn H. Kruhl, Geol.-Pal.Inst., JW Goethe-Universität, Senckenberganlage 32, D-60054 Frankfurt/M., Germany, 49-69-7982106, fax 49-69-7982958.

10th Himalaya-Karakoram-Tibet Workshop, April 4–8, 1995. Information: David A. Spencer, Geologisches Institut, ETH-Zentrum, CH-8092 Zürich, Switzerland, phone 41-1-632-3698, E-mail: daspencer@erdw.ethz.ch.

GSA Southeastern Section Annual Meeting, April 6–7, 1995, Knoxville, Tennessee. Information: Harry Y. McSween, Dept. of Geological Sciences, University of Tennessee, 306 G&G Building, Knoxville, TN 37996-1410, (615) 974-5498.

■ **National Fossil Exposition XVII,** April 7–9, 1995, Macomb, Illinois. Information: Gilbert Norris, 2623 34th Ave. Ct., Rock Island, IL 61201, (309) 786-6505.

Geological Society of Nevada Symposium III: Geology and Ore Deposits of the American Cordillera, April 10–13, 1995, Reno, Nevada. Information: Bob Hatch, Chairperson, Geological Society of Nevada, P.O. Box 12021, Reno, NV 89510, (702) 323-4569, fax 702-323-3599.

Mechanics of Jointed and Faulted Rock, Second International Conference, April 10–14, 1995, Vienna, Austria. Information: H. P. Rossmanith, Institute of Mechanics, Technical University Vienna, Wiedner Hauptstrasse 8-10/325 A-1040 Vienna, Austria, phone 43-1-58-801-5514, fax 43-1-587-58-63, E-mail: rossmanith@emch80.una.ac.at.

Eighth Annual Symposium on the Application of Geophysics to Engineering and Environmental Problems, April 23–27, 1995, Orlando, Florida. Information: EEGS, Mark Cramer, P.O. Box 4475, Englewood, CO 80155, (303) 771-6101. *(Abstract deadline: October 1, 1994.)*

Third International Symposium on In Situ and On-Site Bioreclamation, April 24–27, 1995, San Diego, California. Information: Betty Weaver, Symposium Coordinator, The Conference Group, 1989 West Fifth Ave., Suite 5, Columbus, OH 43212-1912, toll-free (U.S. and Canada) 800-783-6338, or (614) 424-5461, fax 614-488-5747.

GSA South-Central/North-Central Sections Joint Annual Meeting, April 27–28, 1995, Lincoln, Nebraska. Information: Robert F. Diffendal, Conservation and Survey Division, 133 Nebraska Hall, University of Nebraska, 901 N. 17th Street, Lincoln, NE 68588-0517, (402) 472-7546; Page C. Twiss, Dept. of Geology, Kansas State University, Thompson Hall, Manhattan, KS 66506, (913) 532-6724.

May

Water Pollution Modelling, Measuring and Prediction Third International Conference, May 1–3, 1995, Porto Carras, Greece. Information: Liz Johnstone, Wessex Institute of Technology, Ashurst Lodge, Ashurst, Southampton SO40 7AA, UK, phone 44-703-293-223, fax 44-703-29-2853, E-mail: CMI@uk.ac.rl.ib.

■ **1995 International High-Level Radioactive Waste Management Conference,** May 1–5, 1995, Las Vegas, Nevada. Information: American Nuclear Society, 555 N. Kensington Ave., La Grange Park, IL 60525. *(Summary deadline: November 11, 1994).*

Geotechnica 95, Geosciences and Geotechnology Amid Ecological and Economic Considerations, May 2–5, 1995, Cologne, Germany. Information: Alfred Wegener Stiftung, Wissenschaftszentrum, Ahrstrasse 45, 53175 Bonn, Germany.

■ **American Association of Petroleum Geologists Pacific Section Annual Convention,** May 3–5, 1995, San Francisco, California. Information: Les Magoon, U.S. Geological Survey, 345 Middlefield Road, MS 999, Menlo Park, CA 94025, (415) 354-3006, fax 415-354-3224.

■ **Water Resources at Risk,** May 14–18, 1995, Denver, Colorado. Information: Helen Klose, American Institute of Hydrology, 3416 University Ave., S.E., Minneapolis, MN 55414, (612) 379-1030, fax 612-379-0169.

17th International Geochemical Exploration Symposium, Exploring the Tropics, May 15–19, 1995, Townsville, Queensland, Australia. Information: Russell Myers, 171GES, National Key Centre in Economic Geology, James Cook University, Townsville, Q4814, Australia, phone 61-77-814486, fax 61-77-815522.

continued on p. 263

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Geological Association of Canada–Mineralogical Association of Canada Joint Annual Meeting, May 17–19, 1995, Victoria, British Columbia, Canada. Information: Chris Barnes, General Chair, SEOS, University of Victoria, P.O. Box 1700, Victoria, B.C. V8W 2Y2, Canada, fax 604-721-6200.

GSA Rocky Mountain Section Annual Meeting, May 18–19, 1995, Bozeman, Montana. Information: Stephan G. Custer, Dept. of Earth Sciences, Montana State University, Bozeman, MT 59717-0348, (406) 994-6906.

1995 World Geothermal Congress, May 18–31, Florence, Italy. Information: George Frye, Executive Director, International Geothermal Association, LBL 50C, Rms. 106–108, One Cyclotron Road, Berkeley, CA 94720, (510) 486-4584, fax 510-486-4889.

■ **Basement Tectonics 12th International Conference,** May 21–26, 1995, Norman, Oklahoma. Information: M. C. Gilbert, Conference Chairman, School of Geology and Geophysics, University of Oklahoma, 810 Sarkeys Energy Center, Norman, OK 73019-0628, (405) 325-3253, fax 405-325-3140

Fifth Annual Goldschmidt Conference, May 24–26, 1995, University Park, Pennsylvania. Information: Suzanne St. Pierre, (814) 865-7557, fax 814-865-3749.

GSA Cordilleran Section Annual Meeting, May 24–26, 1995, Fairbanks, Alaska. Information: David B. Stone, Dept. of Geology and Geophysics, University of Alaska, Fairbanks, AK 99775-0760, (907) 474-7565.

■ **National Association of Geology Teachers Eastern Section Annual Meeting,** May 25–28, 1995, Toronto, Ontario. Information: Robert C. Lord, Conference Coordinator, Suite 1507, 1300 Marlborough Court, Oakville, Ontario L6H 2S2, Canada.

Walter A. Bell Symposium on Paleobotany and Coal Science, May 28–June 1, 1995, Sydney, Nova Scotia. Information: Erwin L. Zodrow, University College of Cape Breton, P.O. Box 5300, Sydney, Nova Scotia, B1P 6L2, Canada, fax 902-562-0119, or Paul C. Lyons, U.S. Geological Survey, MS 956, Reston, VA 22092, fax 703-648-4227.

June

SEG International Field Conference on Carbonate-hosted Lead-Zinc Deposits, June 3–6, 1995, St. Louis, Missouri. Information: Martin Goldhaber, U.S. Geological Survey, P.O. Box 25046, MS 973, Federal Center, Denver, CO 80225-0046, fax 303-236-3200, E-mail: mgold@helios.cr.usgs.gov.

35th U.S. Symposium on Rock Mechanics, June 4–7, 1995, Lake Tahoe, California–Nevada. Information: Jaak Daemen, Mining Engineering, MS 173, University of Nevada, Reno, NV 89557-0139, (702) 784-4309, fax 702-784-1766; or Richard Schultz, Geological Engineering, MS 173, University of Nevada, Reno, NV 89557-0139, (702) 784-4318, fax 702-784-1766.

Clay Minerals Society 32nd Annual Meeting, June 4–8, 1995, Baltimore, Maryland. Information: Patricia Jo Eberl, Clay Minerals Society, P.O. Box 4416, Boulder, CO 80306, (303) 444-6405, fax 303-444-2260. *(Abstract deadline: August 26, 1994.)*

Seventh International Symposium on the Ordovician System, June 12–16, 1995, Las Vegas, Nevada. Information: Margaret N. Rees, 7th ISOS, Dept. of Geoscience, University of Nevada, Las Vegas, NV 89154-4010, (702) 895-3890, fax 702-895-4064, E-mail: rees@nevada.edu.

European Coal Conference, June 26–July 1, 1995, Prague, Czech Republic. Information: European Coal Conference '95, Faculty of Science, Charles University, Albertov 6, 128 43 Prague 2, Czech Republic, phone 42-2-24915472, fax 42-2-296084. *(Abstract deadline: February 28, 1995.)*

July

■ **International Union of Geodesy and Geophysics XXI General Assembly,** July 2–14, 1995, Boulder, Colorado. Information: IUGG XXI General Assembly, c/o AGU 2000 Florida Ave., NW, Washington, DC, (202) 462-6900, fax 202-328-0566, E-mail: iugg_xxiga@kosmos.agu.org.

Eleventh Symposium on Coastal Sedimentology, July 3–9, 1995, Niteroi, Brazil. Information: Cleverson Guizan Silva, Dept. de Geologia/LAGEMAR, Universidade Federal Fluminense, Av. Bento de Maria da Costa 115-a, Charitas, Niteroi, R.J. 24.370-190, Brazil, fax 55-21-711-9917.

■ **First Australian Conodont Symposium and Boucot Symposium (in honor of Art Boucot),** July 18–21, 1995, North Ryde, New South Wales, Australia, Information: Ruth Mawson, Centre for Ecostratigraphy and Palaeobiology, School of Earth Sciences, Macquarie University, North Ryde, NSW, 2109 Australia, 61-2-850 8336, fax 61-2-850 8428, E-mail: rmawson@laurel.ocs.mq.edu.au.

Seventh International Williston Basin Symposium, July 23–25, 1995, Billings, Montana. Information: W. Kipp Carroll, General Chairman, (406) 245-2367.

August

3rd International Field Conference and Symposium on Intraplate Magmatism (IGCP 336): Petrology and Metallogeny of Volcanic and Intrusive Rocks of the Midcontinent Rift System, August 22–September 1, 1995, Duluth, Minnesota. Information: Penny Morton, Dept. of Geology, University of Minnesota, Duluth, MN 55812, (218) 726-7962, fax 218-726-8275; E-mail: pmorton@ua.d.umn.edu.

Orogenic Lherzolites and Mantle Processes 2nd International Workshop, August 24–September 5, 1995, Granada, Spain. Information: H. G. Barsczus, Géofluides GBE/ISTEEM-C.P. 057, Université de Montpellier 2, 34095 Montpellier Cedex 5, France, phone 33-6714-3933, fax 33-6714-4774, E-mail: barsczus@dstu.univ-montp2.fr.

Mineral Deposits: From their Genesis to Their Environmental Impacts, 3rd Biennial SGA Meeting, August 28–31, 1995, Prague, Czech Republic. Information: Jan Pasava, Czech Geological Survey, Klarov 131/3, 118 20 Praha 1, Czech Republic, phone 42-2-537011, fax 42-2-7980965.

Tectonics and Metallogeny of Early/Mid Precambrian Orogenic Belts, August 28–September 1, 1995, Montreal, Canada. Information: J. A. Percival, Geological Survey of Canada, 601 Booth St., Ottawa, Ontario K1A 0E8, Canada, (613) 995-4723, fax 613-995-9273, E-mail: jpercival@601C.gsc.emr.ca, or J. N. Ludden, Dept. de Géologie, Université de Montréal, CP 6128, Succ. A, Montréal, Québec H3C 3J7, Canada, (514) 343-7389, fax 514-343-5782, E-mail: luddenj@ere.umontreal.ca.

Third Hutton Symposium: The Origin of Granites, August 28–September 2, 1995, College Park, Maryland. Information: Michael Brown, Dept. of Geology, University of Maryland, College Park, MD 20742, (301) 405-4082, fax 301-314-9661.

September

Karst Waters and Environmental Impacts Fifth International Symposium and Field Seminar, September 10–20, 1995, Antalya, Turkey. Information: Gültekin Günay, P.O. Box 357, Kızılay, 06420 Ankara, Turkey, (312) 235-2543, fax 312-235-2862.

■ **Third Thematic Conference on Remote Sensing for Marine and Coastal Environments,** September 18–20, 1995, Seattle, Washington. Information: ERIM, P.O. Box 134001, Ann Arbor, MI 48113-4001, (313) 994-1200, ext. 3234, fax 313-994-5123.

October

American Institute of Professional Geologists 1995 Annual Meeting, Prosperity and Professional Geology, October 1–5, 1995, Denver, Colorado. Information: Ron W. Pritchett, 8244 S. Leyden Ct., Englewood, CO 80112, phone and fax (303) 741-0670.

Fifth International Conference on Seismic Zonation, October 17–19, 1995, Nice, France. Information: Earthquake Engineering Research Institute, 499 14th St., Suite 320, Oakland, CA 94612-1902, (510) 451-0905, fax 510-451-5411; or Association for Earthquake Engineering, Domaine de Saint-Paul, BP 1, 78470 Saint-Rémy-lès-Chevreuse, France, 30-85-22-03, fax 30-52-75-75.

SEPM Research Conference on Alluvial Fans: Processes, Forms, Controls, Facies Models, and Use in Basin Analysis, October 17–21, 1995, Death Valley, California. Information: Myra Rogers, SEPM, P.O. Box 4756, Tulsa, OK 74159, (918) 743-9765, fax 918-743-2498.

Society for Industrial and Applied Mathematics Annual Meeting, October 23–26, 1995, Charlotte, North Carolina. Information: SIAM Conference Coordinator, 3600 University City Science Center, Philadelphia, PA 19104-2688, (215) 382-9800, fax 215-386-7999, E-mail: meetings @siam.org. *(Abstract Deadline: April 24, 1995)*

1996 Meetings

August

■ **Geological Association of Canada–Mineralogical Association of Canada Joint Annual Meeting,** May 27–29, 1996, Winnipeg, Manitoba. Information: G. S. Clark, Dept. of Geological Sciences, University of Manitoba, Winnipeg, Manitoba, R3T 2N2. (204) 474-8857, fax 204-261-7581.

■ **North American Paleontological Convention-VI,** June 9–12, 1996, Washington, D.C. Information: NAPC-VI, c/o Department of Paleobiology, Mail Stop 121, National Museum of Natural History, Washington, DC 20560.

■ **30th International Geological Congress,** August 4–14, 1996, Beijing, China. Information: Secretariat Bureau, 30th International Geological Congress, P.O. Box 823, Beijing 100037, P.R. China.

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

The Geological Society of America

Congressional Science Fellowship 1995–1996

The Geological Society of America is accepting applications for the 1995–1996 Congressional Science Fellowship. The Fellow selected will spend a year (September 1995–August 1996) in the office of an individual member of Congress or a congressional committee for the purpose of contributing scientific and technical expertise to public policy issues and gaining firsthand experience with the legislative process. The American Association for the Advancement of Science conducts an orientation program to assist the Fellow seeking a congressional staff position in which he or she can work on major legislative issues.

Criteria

The program is open to highly qualified postdoctoral to mid-career earth scientists. Candidates should have exceptional competence in some area of the earth sciences, cognizance of a broad range of matters outside the Fellow's particular area, and a strong interest in working on a range of public policy problems.

Award

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

To Apply

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

DEADLINE FOR RECEIPT OF ALL APPLICATION MATERIALS IS FEBRUARY 15, 1995

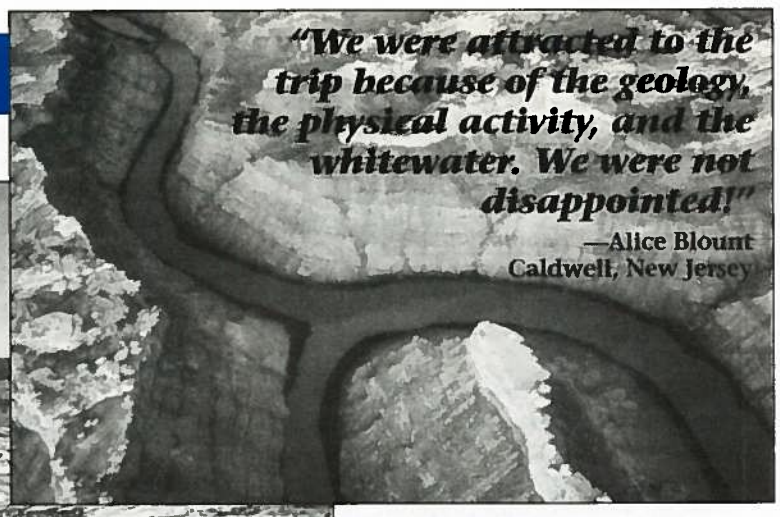
Participants Praise 1994 GeoVentures

GeoTrip

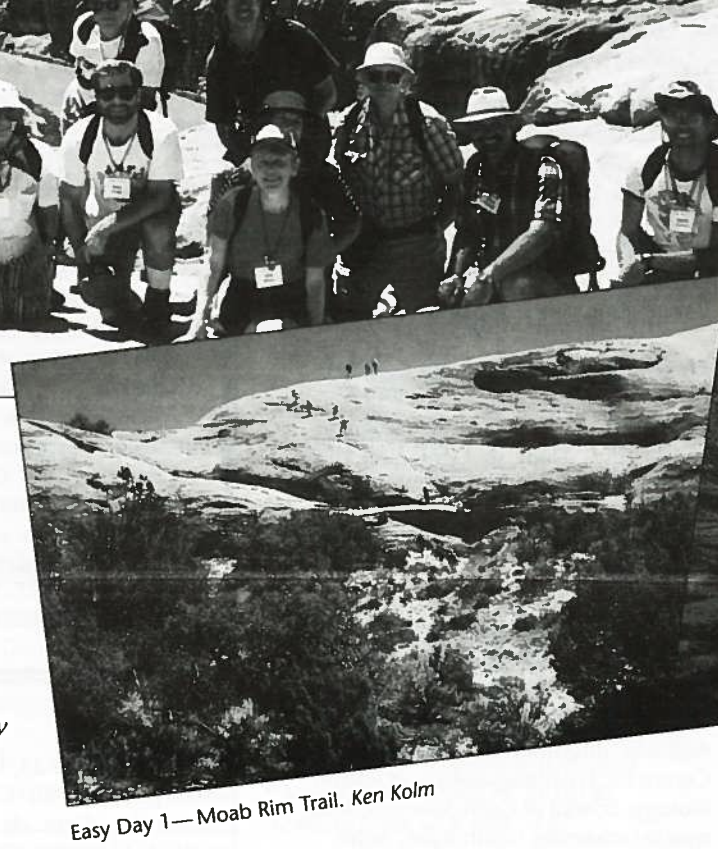
Rim to River: Moab, Canyonlands, and Cataract Canyon.

13 participants. May 28–June 4, 1994. *Leaders: Kenneth Kolm and John Emerick, Colorado School of Mines; John A. Campbell, Fort Lewis College.*

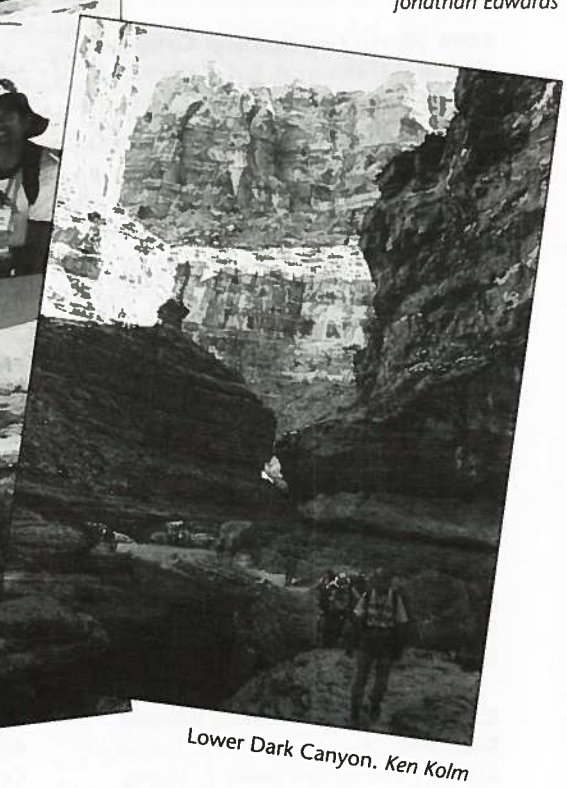
Moab gang. *Ken Kolm*



Confluence of Green and Colorado Rivers. *Jonathan Edwards*



Easy Day 1—Moab Rim Trail. *Ken Kolm*



Lower Dark Canyon. *Ken Kolm*

"All of us, both the professional geologists and the non-geologists were included in the group's camaraderie. We were like one big family by the time the trip concluded," according to Jonathan Edwards of Towson, Maryland.

"I enjoyed the Moab, Utah, trip and would certainly not want to have missed it. This is a very interesting and scenic part of the world and you should certainly run trips there again," wrote Nels Vollo of Kamloops, British Columbia.

The 1994 GSA GeoVentures offered two field-based programs unrelated to the annual or section meetings. The total of 44 participants, ranging in age from 25 to 73, represented a diversity of interests and backgrounds.

This educational program serves professionals who enjoy 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 long, and the itinerary includes an assortment of destinations.

GeoHostel

Scenic Geology of the Central Colorado Rocky Mountains.

31 participants. June 25–30, 1994. *Leaders: Gregory Holden and Kenneth Kolm, Colorado School of Mines.*

Gunnison gang, Blue Mesa Reservoir. *Edna Collis*

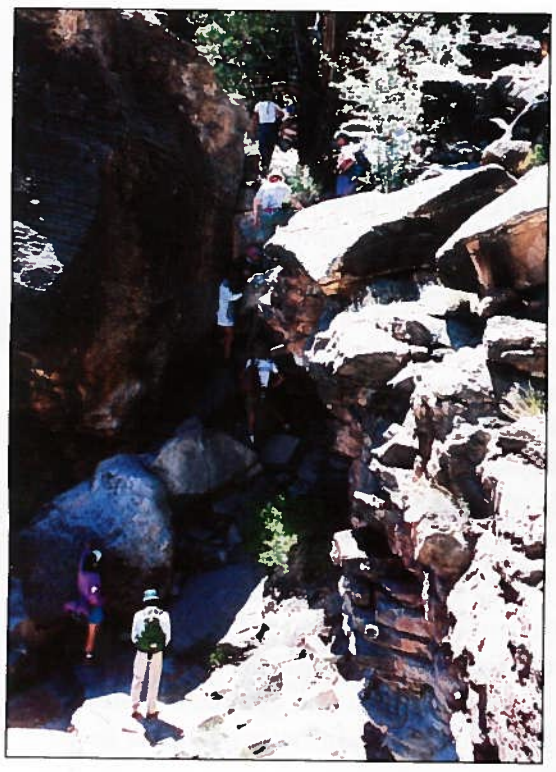
GeoHosteler Dick Schofield at Schofield Pass (no relation). *Sue Tanges*

GeoHostelers Bob Beringer, Lilya Noskov, and Amy Ross. *Edna Collis*

GeoHostelers Karen and Daryl Streiff, Kate Crawford, and Sue Tanges. *Edna Collis*

"The 1994 GeoHostel was outstanding in every way. Everyone involved in the presenting and planning of this program, including the selection of field trip locations, couldn't have done a better job. Thanks for this outstanding experience," wrote Robert Beringer of Ventura, California.

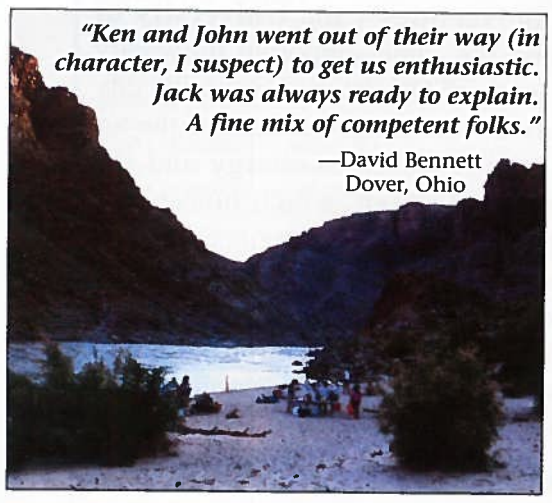
"The trip was great and I'll never forget it! The leaders, fellow GeoHostelers, and the geology were all wonderful. I'll definitely consider participating in future trips," Lilya Noskov of Highlands, New Jersey, said.



Powell Canyon. *Ken Kolm*

"Ken and John went out of their way (in character, I suspect) to get us enthusiastic. Jack was always ready to explain. A fine mix of competent folks."

—David Bennett
Dover, Ohio



On the beach, Cataract Canyon.

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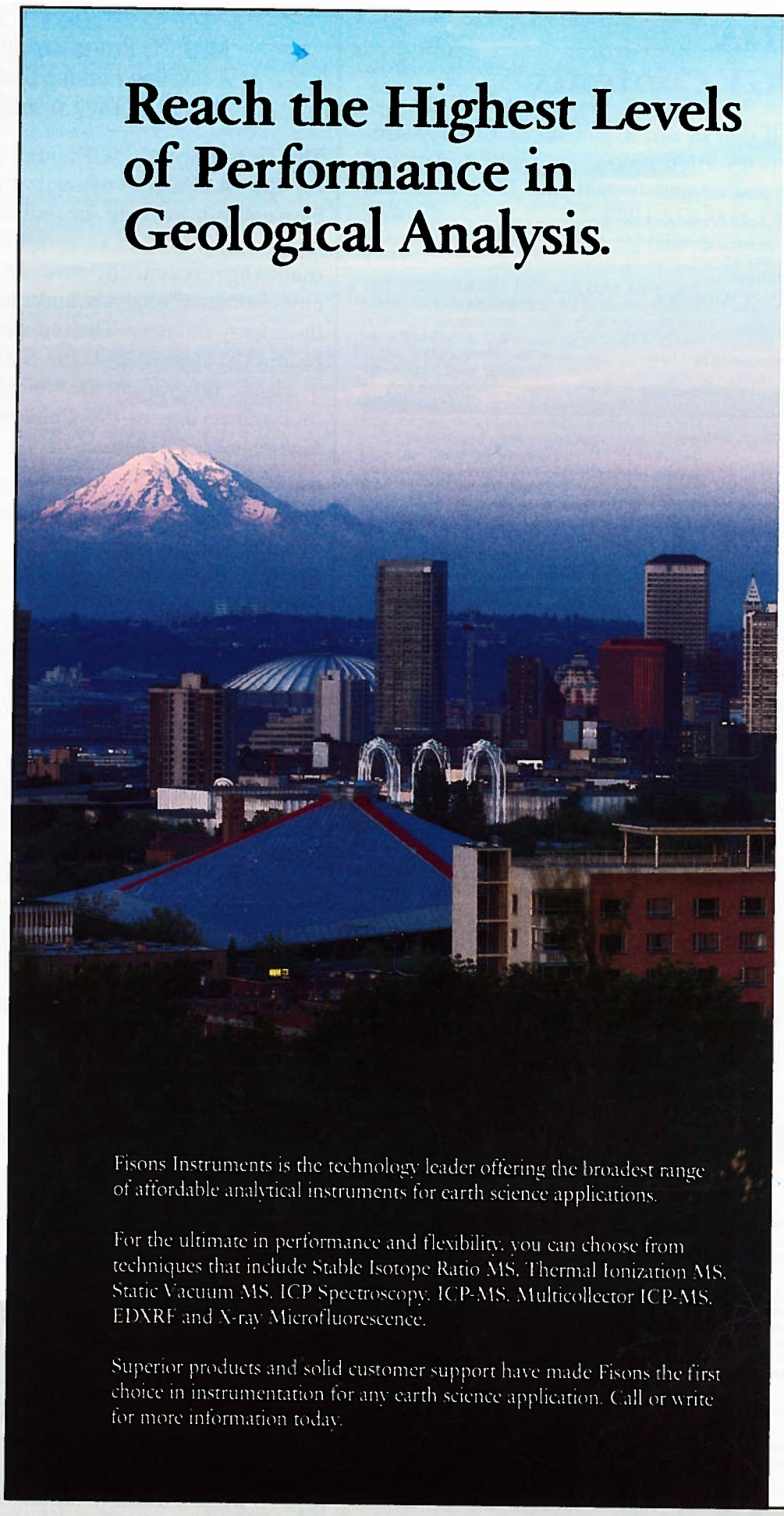

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Near Engineer Pass. *Sue Tanges*

"I am still on cloud nine about this trip! I had a lot of fun and learned a great deal."

—Patricia Deen
Carlsbad, California

Black Canyon of the Gunnison. *Edna Collis*

October *BULLETIN* and *GEOLOGY* Contents

Are you missing out? If you're not a *Bulletin* or *Geology* subscriber, you may miss the articles listed below. Subscribe today and receive all 1994 issues, even if you've already paid your 1994 dues. Call Membership Services today at 1-800-472-1988.

The Geological Society of America
BULLETIN
Volume 106, Number 10, October 1994

CONTENTS

GEOLOGY
VOLUME 22
NO. 10
P. 865–960
OCTOBER 1994

MAPCO Professorship of Environmental Quality
**** A Position Linking Energy And The Environment ****
The University of Oklahoma

The University of Oklahoma invites applications and nominations for the MAPCO Professorship of Environmental Quality. The University is seeking an individual with vision, commitment, and leadership abilities to establish a program of interdisciplinary teaching, research, and service in a field that involves environmental analysis and quality, particularly in relationship to the energy industry. The individual selected to fill this position will be jointly appointed to the Sarkeys Energy Center and to a home academic program in the College of Arts and Sciences, the College of Engineering, or the College of Geosciences, as appropriate to his/her area of expertise.

The individual filling this position will be awarded tenure and an academic rank commensurate with his/her qualifications. Salary and benefits will be commensurate with experience and are negotiable. Starting date is also negotiable, however, the position is available as early as 1 January 1995.

One of the nation's "flagship universities", the **University of Oklahoma** is a major, comprehensive, state-supported university located approximately 20 miles south of Oklahoma City in the city of Norman. The campus contains a wide range of state-of-the-art facilities supporting teaching and research in energy and the environment. The **Sarkeys Energy Center**, which houses the College of Geosciences and part of the College of Engineering, is a premier 350,000 square foot academic facility with 200 teaching and research laboratories located on the Norman Campus. It is the focus of much of the University's energy and environmental research and the program center for key energy research growth areas of strategic importance to the University.

Qualifications

- A reputation for excellence in teaching in a field involving environmental assessment and quality, particularly in relationship to the energy industry;
- Demonstrated ability and desire to work effectively beyond the academic realm with regional, national and international business and professional leaders in the energy and related industries;
- A national reputation for research excellence in a field involving environmental assessment and quality, especially in regard to the impact of the production and use of energy on the environment, in general, and on air and water, in particular;
- Demonstrated capability to build and work effectively with multidisciplinary academic research teams and programs; and
- Meet the qualifications for appropriate academic rank and tenure in the home academic program.

An earned doctorate is preferred. Candidates without the doctorate will be considered if they meet the stated qualifications and additionally have distinguished academic backgrounds or outstanding achievements in business or government.

Applications

Initial screening of complete applications will begin on 1 November 1994, but the search will remain open until the position is filled. Complete applications will consist of a letter of interest from the applicant, current vita/resume, and a list of references (with addresses and telephone and FAX numbers) that the search committee may contact. **Address all correspondence to:**

Dean John T. Snow
Chair, MAPCO Professorship Search Committee
Sarkeys Energy Center, Room 710
100 E. Boyd Street
Norman, Oklahoma 73019-0628.

The University of Oklahoma is an Affirmative Action, Equal Opportunity Employer.
Women and Minorities are Encouraged to Apply.
OU is Responsive to the Needs of Dual Career Couples.

CLASSIFIED ADVERTISING

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To answer coded ads, use this address: Code # ----, GSA Advertising Dept., P.O. Box 9140, Boulder, CO 80301-9140. All coded mail will be forwarded within 24 hours of arrival at *GSA Today* office.

Positions Open

POSTDOCTORAL POSITION WITH THE STANFORD ROCK FRACTURE PROJECT

Applications are invited for a postdoctoral position available on or after Dec. 1, 1994 at a base salary of $20,500 to $28,000. The position is for one year with a possibility of extension for another year. Candidates are required to be structural geology Ph.Ds. who have proven records of detailed field studies of faults and fractures. Applicants with experience in petrographic imaging techniques and numerical modeling applicable to fractures in sedimentary rocks for the purpose of understanding their formation processes, internal fabrics, hydraulic characteristics, and geometric patterns will be given priority. The ultimate purpose of the project is to improve upon the existing subsurface fracture prediction and characterization technology. Vitae, a letter of current research interest, and a list of references (including phone-fax numbers) should be sent by Oct. 21, 1994 to: Rock Fracture Project, Department of Geological and Environmental Sciences, Stanford University, Stanford, CA 94305. The Stanford Rock Fracture Project, co-directed by A.Aydin & D. D. Pollard, has three postdoctoral and twelve graduate students, and state-of-the-art facilities providing an excellent opportunity for basic and applied research. AA/EOE.

U.S. GEOLOGICAL SURVEY
CHIEF, GEOLOGICAL DIVISION
SENIOR EXECUTIVE SERVICE

The U.S. Geological Survey (USGS) anticipates seeking candidates for the full-time position of Chief, Geologic Division. Applicants should have achieved national recognition for outstanding scholarship and professional research in the geosciences as well as possess significant managerial experience. This is a career civil service position, in the Senior Executive Service, with a salary range that begins at $96,830 per annum.

The Chief Geologist provides science management leadership for the conduct of the Geologic Division's domestic and foreign programs developing basic patterns of organization, operating policies, program planning, allocation of resources, delegating authority for the conduct of program operations, and monitoring progress toward mission objectives. Science investigations and research activities generally fall into several major categories which include: earthquake, volcano, and engineering studies; regional geology; mineral resources; and energy marine geology.

Applicants should submit an Application for Federal Employment (SF-171, available from any federal personnel office), a Reference and Qualifications Analysis form, and a Narrative Qualifications Statement addressing the knowledges, skills, abilities, and other characteristics required by the position, which are as follows:

1. Ability to manage a scientific organization.
2. Skill in acquiring and effectively managing resources in a scientific research environment.
3. Skill in organizational representation and interpersonal liaison.
4. Interdisciplinary knowledge of the geosciences which underlie the program functions of the division.
5. Knowledge of numerous functional areas of geologic investigations.

Telephone inquiries or requests for forms including complete vacancy announcement (with KASOC's described in more detail), may be directed to Sandy Sherman on (703) 648-7421 or Lisa Snooks on (703) 648-7420.

Applications must be received at the following address by November 15, 1994, and should reference announcement #SES-94-1. U.S. Geological Survey, Office of Personnel, 215 National Center, Reston, VA 22092.

All applicants tentatively selected must submit to urinalysis to screen for illegal drug use prior to appointment.

The U.S. Geological Survey is an equal opportunity employer. U.S. citizenship is required.

UNIVERSITY OF NEBRASKA-LINCOLN
DEPARTMENT OF GEOLOGY
ENVIRONMENTAL GEOLOGIST

A tenure-track Assistant Professor appointment in Environmental Geology at a salary level of about $36,000 is available beginning January 1995 or August 1995. A Ph.D. in Geology or related field and a commitment to research and teaching are required. We seek a candidate with interests in Tertiary and Quaternary paleoenvironmental reconstructions. The successful candidate should enhance current departmental strengths in climate history of continental interiors and high latitudes, and/or environmental aspects of hydrogeology. The successful candidate will be expected to establish an externally funded research program and teach undergraduate and graduate students in Geology and Environmental Studies.

An ability to teach courses in geomorphology, and experience in modern depositional systems, glacial geology, environmental geochemistry, or other aspects of global change will be an advantage.

Please submit a letter of application, statement of teaching and research interests and experience, curriculum vitae, publications list, and letters from three referees to: Dr. Nancy Lindsley-Griffin, Department of Geology, 214 Bessey Hall, University of Nebraska, Lincoln, NE 68588-0340. Application deadline is November 1, 1994.

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 Dr. Lindsley-Griffin.

EARTH HISTORY

The Earth Sciences Department at the University of California, Santa Cruz, invites applications for a tenure-track position at the assistant professor level (Step I-III). We seek an individual who applies innovative research approaches to studying the evolution of life, Earth history, and global change. Candidates should have expertise and primary research interests in paleontology and secondary interests in biogeochemisty, chemostratigraphy, paleoceanography, or paleoclimatology that complement existing research programs in Earth and Marine Sciences, which include paleoceanography/paleoclimatology and low temperature geochemistry. The successful candidate will teach at both the undergraduate and graduate levels including introductory courses in paleontology and Earth history as well as advanced courses in their area of expertise. The candidate will be expected to develop a vigorous research program including the supervision of graduate students.

USCS's research programs in Earth and Marine Sciences are supported by a broad range of analytical facilities, including gas, solid source, and ICP mass spectrometers, located in a new 132,000-sq.-ft. building.

Salary: $35,900-$38,800 (9-month basis), depending on qualifications and experience. Position available fall 1995, contingent upon availability of funds. Minimum qualifications: Ph.D. or equivalent in Earth Sciences or related field completed or expected by effective date, a demonstrated record of research excellence and potential to obtain external funding, and a commitment to and talent for teaching at both the undergraduate and graduate level.

To apply send curriculum vitae, a brief summary of research and teaching interests, reprints, and the names of five persons from whom the department may request letters of recommendation to Professor James Zachos, Search Committee Chair, UC Santa Cruz, Earth Sciences Department, Santa Cruz, CA 95064. In your reply, refer to provision #428. Closing date: October 31, 1994. UCSC is an AA/EEO/IRCA employer.

THE DEPARTMENT OF GEOLOGY AND GEOLOGICAL ENGINEERING at the University of Idaho is seeking an academic leader to fill the position of department head. The University of Idaho is located in the state's north panhandle eight miles from Washington State University in Pullman, WA, and is Idaho's primary institution for graduate education and research. The 15-member Geology and Geological Engineering faculty has a strong commitment to undergraduate and graduate education with emphasis on both teaching and research. During 1995, several of the department faculty will relocate to state-of-the-art facilities in the new Earth Resources Building which is currently under construction.

The Geology and Geological Engineering Department invites applications from individuals with a Ph.D. in geology or a related field, university level teaching experience, and a record of scholarship, including both grants and refereed publications, commensurate with the rank of full professor. Specialization in structural or economic geology is preferred, but other specialities are encouraged to apply. To apply, submit a cover letter, CV, and a list of names, addresses and phone numbers of four references to: Arthur W. Rourke, Biological Sciences, University of Idaho, Moscow, ID 83844-3051. Search and selection procedures will be closed when a sufficient number of qualified candidates have been identified, but not earlier than November 15, 1994.

To enrich education through diversity, the University of Idaho is an equal opportunity/affirmative action employer.

UNIVERSITY OF CALIFORNIA, SANTA BARBARA

The Department of Geography and the Environmental Studies Program invite applications for a joint tenure track faculty position at the Assistant Professor level in the area of soils. The successful applicant must hold a Ph.D. in the earth sciences or related fields (for example, physical geography, geology, soil science, environmental sciences, environmental engineering) with an emphasis in soils: their formation, physical, chemical and biological properties, soil classification and mapping. Applicants with a strong background in soil/water/vegetation relationships/interactions and their study at regional scales by means of mathematical and computer methods including geographic information systems and remote sensing), or with expertise in geomrophology, are strongly encouraged to apply. The appointee to this position is expected to develop a strong research program, work with undergraduate and graduate students, and teach courses at the undergraduate and graduate levels. The Department of Geography and the Environmental Studies Program are multidisciplinary academic units with active research and teaching programs in earth systems and environmental sciences, and on the human dimensions of global environmental processes. The application deadline is January 13, 1995. The starting date is July 1, 1995. Qualified applicants should mail a complete curriculum vitae, a statement of research and teaching interests, and arrange to send three (3) letters of reference to: Dr. Hugo A. Loaicigia, Chair of Soils Search Committee, Department of Geography, University of California, Santa Barbara, CA 93106-4060. The University of California is an Equal Opportunity/Affirmative Action Employer.

DEAN
COLLEGE OF SCIENCE

California State Polytechnic University, Pomona, Calif., is seeking applications & nominations for Dean of the College of Science. Req. qualifications: earned doctorate; record of research, teaching & scholarship to support a sr. faculty appt; 3 or more yrs of admin. experience requiring academic leadership & stewardship. Application/Job Description call (909) 869-3409; fax 909-869-4395; or E-mail to: SJCARDONA@CSUPomona.edu. AA/EOE

Massachusetts Institute of Technology

Faculty Positions

Department of Earth, Atmospheric, and Planetary Sciences

(1) The Department seeks to expand research, faculty interaction, and teaching in the area of fluid-rock systems. The position is in the general area of fluid transport within all geological systems in the earth's crust, ranging from petroleum and ground water reservoirs to magma systems and active faults. Particular emphasis will be placed on candidates involved in the dynamic modeling of fluid-rock systems.

(2) The Department also seeks to expand research in the area of surface processes on both the earth and the terrestrial planets. Areas of interest include dynamic geomorphology, the surface geology of active tectonic areas, and the study of climatic processes.

We hope to attract candidates who will interact with other areas of strength within the Department, particularly in geology, geophysics, geochemistry, paleoclimatology and meteorology. Preference will be given to junior applicants; minority and female applicants are particularly encouraged to apply.

Interested individuals should send curriculum vitae, a statement of research and teaching interests, and references to: **Professor Thomas H. Jordan, Head, Department of Earth, Atmospheric and Planetary Sciences, Room 54-918, MIT, Cambridge, MA 02139; email: thj@mit.edu.**

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Herndon Distinguished Professor in Geology

Trinity University
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Trinity University is seeking an outstanding scientist to fill the Imogene and Harold D. Herndon Distinguished Professorship in Geology. This endowed Professorship augments a nationally recognized undergraduate program in geology. The Herndon Distinguished Professor will be appointed at Professor rank and will be selected from experienced candidates with outstanding credentials in **hydrogeology**, **geomorphology**, or related disciplines. Candidates must have an established record of excellence in undergraduate teaching, be willing to develop the undergraduate curriculum, and be nationally recognized for their achievements in teaching, research, and professional activities including the ability to obtain external funding for research and education. Candidates must be prepared to teach the introductory course in geology and advanced undergraduate courses related to their field of expertise, and must be willing to include undergraduates in their research activities.

Letter of application, curriculum vitae, statement of teaching and research interests, three letters of reference, and other materials of the candidate's choice should be sent to Professor Walter W. Coppinger, Chair, Department of Geology, Trinity University, 715 Stadium Drive, San Antonio, Texas 78212-7200 by December 15, 1994. Letters of nomination are encouraged, as well as nominations by telephone (210) 736-7606, FAX (210) 736-8264, or e-mail to wcopping@geology.trinity.edu. Applications from minority and women candidates are especially encouraged. Trinity University is an Equal Opportunity, Affirmative Action Employer.

Services & Supplies

FOR SALE: *GSA Bulletins*, July 1970 to present; *GSA Today*, Vol. 1 to present. Make offer to include shipping. All in mint condition. Contact: M. L. Bregman, 8340 S. Sandusky Ave., Tulsa, OK 74137-1835.

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Opportunities for Students

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

JOI/USSAC Ocean Drilling Fellowships. JOI/U.S. Science Advisory Committee is seeking doctoral candidates of unusual promise and ability who are enrolled at U.S. institutions to conduct research compatible with that of the Ocean Drilling Program. Both one-year and two-year fellowships are available. The award is $20,000 per year to be used for stipend, tuition, benefits, research costs and incidental travel, if any. Applicants are encouraged to propose innovative and imaginative projects. Research may be directed toward the objectives of a specific leg or to broader themes. Proposals and appliciations should be submitted to the JOI office according to the following schedule: Shorebased Research (regardless of DSDP or ODP leg): 12/1/94.

For more information and to receive an application packet, contact: JOI/USSAC Ocean Drilling Fellowship Program, Joint Oceanographic Institutions, Inc., 1755 Massachusetts Ave. NW, Suite 800, Washington, DC 20036-2102 (Andrea Leader: 202-232-3900; Internet: aleader@brook.edu).

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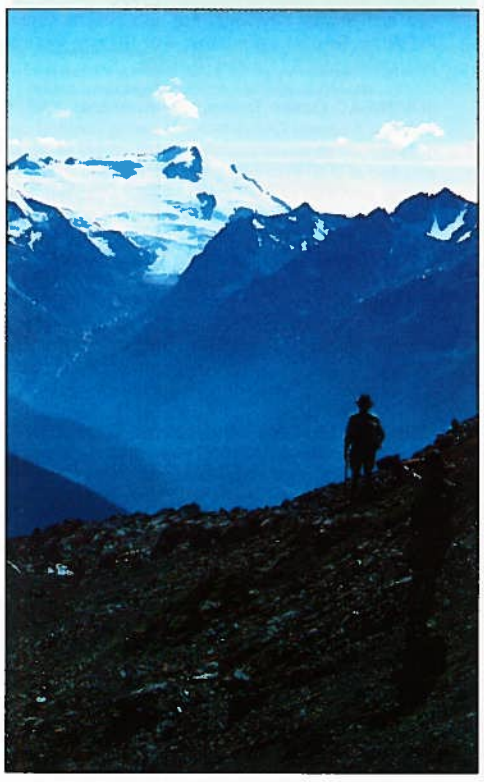

Richard J. Stewart

For more information:
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