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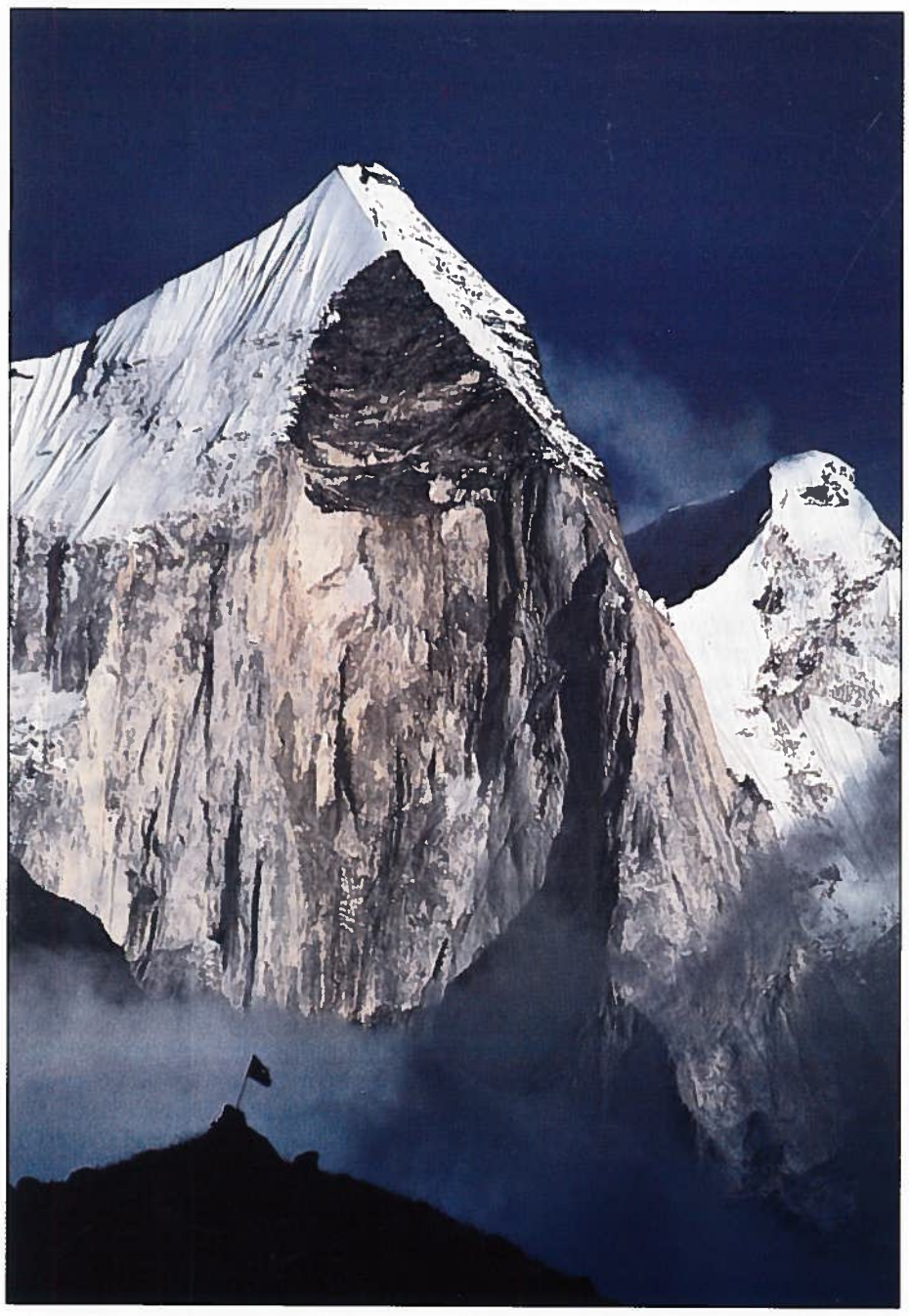

Bhagirathi leucogranite of the Higher Himalaya (Garhwal region, India) intruding the Tethyan sedimentary series. This is one of several postcollisional Tertiary leucogranites of the Himalaya (see Table 1 for the age data). Photos by Mugs Stump.

Rise of the Himalaya: A Geochronologic Approach

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ABSTRACT

Recent geochronologic and geologic data shed new light on the pattern of tectonic evolution of the Himalaya. Following the continent-continent collision between the Indian and Asian plates in early Tertiary time, the Proterozoic-Cambrian rocks of the leading edge of the Indian plate were reactivated during the Himalayan orogeny. Postcollisional events include a complex history of deformation, metamorphism, plutonism, large-scale thrusting, north-south compression and extension, and the uplift and unroofing of the Himalaya. Hornblende K-Ar and $^{40}Ar/^{39}Ar$ ages from amphibolite-facies Higher Himalayan crystalline (HHC) rocks indicate two regional metamorphic events: one in the Eocene after the collision, and the other in the early Miocene during intense activity of the Main Central thrust. U-Pb (zircon) and Rb-Sr isochron ages demonstrate that postcollisional intrusions of leucogranites occurred in four phases: in the Eocene (50–35 Ma) in the northwest Higher Himalaya; early-middle Miocene (24–15 Ma) in the Higher Himalaya; middle–late Miocene (15–7 Ma), in the northern Himalaya (within the Tethys Himalaya in south Tibet); and 7–2.5 Ma in the Nanga Parbat massif. Different mechanisms probably were responsible for the generation of these leucogranites from the partial melting of the HHC rocks. Most of the leucogranitic intrusions seem to have occurred in the Miocene. Within the Higher Himalaya, compression along the Main Central thrust and extension along the detachment fault between the metamorphic sequence and overlying Tethyan sedimentary sequence (South Tibetan detachment system) occurred simultaneously at least at some point in the early Miocene. Geochronologic and sedimentologic data indicate three prominent phases of uplift-denudation in the Himalaya: early Miocene (21–17 Ma); late Miocene (11–7 Ma) and Quaternary. The early Miocene phase reflects the intense activity of the Main Central trust, the South Tibetan detachment system, a rapid pulse of uplift and denudation of HHC rocks, development of the Siwalik basin, and increase in clastic flux from the Higher Himalaya. The late Miocene phase seems to have encompassed the beginning of the Main Boundary thrust, another major pulse of clastic sediments to the Siwalik Range, and the Indus and Bengal fans, and was coeval with onset of monsoon seasonality. Present seismicity, fission-track analysis, geodetic studies, antecedent river profiles with deep gorges, and enormous sedimentation in the Indo-Gangetic plains, Arabian Sea, and Bay of Bengal provide evidence for the ongoing dynamism, uplift, and unroofing of the Himalaya, expressing its "morphogenic phase."

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INTRODUCTION

The growing interest in the evolution of the Himalaya stems in part from the majestic dimensions of this mountain belt and in part from the unparalleled opportunity it provides for studying continent-continent collisional orogenesis as part of a complex set of processes acting both beneath and on the surface of Earth. The upheaval of the Himalaya represents a significant event in the Cenozoic history of our planet, not only for its geological implications, but also for the impact it has had on the ecology of Asia. Throughout its 2500 km arcuate length, the Himalaya epitomizes the Huttonian tenet of modern geology—dynamism of the solid Earth. Three significant aspects of orogenesis—magmatism, metamorphism, and tectonism—are well illustrated in the Himalaya, where tectonic and erosional forces currently compete, and crystalline rocks that were once deep-seated are now exhumed and occupy lofty levels (Fig. 1—see p. 88).

Following recognition in the context of plate tectonics that the Himalaya is a classic example of continent-continent collisional orogeny (Dewey and Bird, 1970), several models have been proposed for its geologic evolution (e.g., Powell and Conaghan, 1973; Le Fort, 1975, 1989; Molnar and Tapponnier, 1975; Fuchs, 1981; Gansser, 1981; Valdiya, 1984; Molnar, 1984; Searle et al., 1987). Fundamentally, all these plate-tectonic models agree on the northward drift of India in the Mesozoic, the consumption of the Tethyan ocean along the Indus-Tsangpo suture zone in the Cretaceous–early Tertiary, and the India-Asia collision and its attendant compression and deformation in the Cenozoic, giving rise to the Himalaya. However, on a

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SAGE REMARKS

"I will forever enjoy learning, but I weary of being taught" —*W. Churchill*

A Summary of the First GSA Presidential Conference on Earth Science Education

Ed Geary, GSA Coordinator for Educational Programs
E-an Zen, 1991–1992 GSA President

Breaking Down the Barriers to Science Literacy

Learning and teaching are central to our science education system, but what children should learn and how teachers should teach are at the center of the current debate on science education. Today's science students and teachers are being inundated by an ever-growing volume of scientific facts and terms, yet facts are meaningless and terms are tiresome without relevance and context. Scientific studies of Earth and the environment provide both relevance and context, but barriers to science literacy exist at many levels.

Breaking down the K–12 and college barriers to science literacy and improving earth science education were the major topics of discussion at the first GSA Presidential Conference. The conference was co-sponsored by the Johnson Foundation, the Coalition for Earth Science Education (CESE), and the National Science Foundation.

During January 14–17, 1993, 53 participants from across North America met at the Johnson Foundation's Wingspread conference center in Racine, Wisconsin, and discussed how to improve earth science education at the elementary, secondary, and college levels, and break down the barriers between them. The group included a college president; state and county science supervisors; deans and professors of earth science, science education, and education in general; elementary and secondary teachers; and educators from several earth science societies and science centers.

Participants were selected for their professional diversity, divergent viewpoints, and concern for science and science education. Several states, including California, Colorado, New York, Texas, Louisiana, Virginia, and Maryland, were represented by multiple participants in an effort to form action nuclei and encourage the development of regional education reform strategies.

Conference participants were asked to address four key issues currently limiting the effectiveness of earth science education as a mechanism for promoting science literacy: (1) inequities in the K–12 and college reward systems, (2) the perception among students, teachers, administrators, and the general public that earth science is not particularly important or relevant, (3) inadequacies in the training of earth science teachers, and (4) the need for more professional development opportunities. The following excerpts from the conference highlight the range of discussion on these issues.

The Magnitude of the Problem

- An elementary teacher from New Orleans stated that she had very little time to prepare from one class to the next; no budget for equipment or supplies ("I'm lucky if the kids have pencils and paper") and only one professional day per year. Upon earning an M.Sc. she was rewarded with a raise of $17.00 per month.
- A national-award-winning high school teacher from Colorado said that her school is at the bottom of the financial heap. She and her colleagues work a great deal of overtime and often pay for supplies out of their own pockets. Her students include sexually abused kids, and one of her students committed murder over the last holiday season. Yet she and her colleagues are constantly criticized for not doing a better job.
- A high school teacher in California indicated that most of his students and their parents have no interest in learning. He teaches for the benefit of the handful of students who are interested in science and who want to break out of their environment.
- Almost all teachers present were frustrated by having rules, dictums, and curriculum changes handed down from on high with no chance for input.
- About 14% of students in grades 7–9 are enrolled in earth science courses, but only 3% of schools offer earth science courses in grades 10–12.
- Despite the growing number of environmental, resource, and natural hazards problems facing our nation, many educators, students, and K–16 administrators continue to believe that earth science is somehow less important to a student's schooling than biology, chemistry, and physics. Only in New York State does earth science hold equal status to the other sciences.
- Most universities do not accept earth science as a laboratory science credit, despite the fact that where qualified earth science teachers are available, earth science is often a more rigorous laboratory course than chemistry or physics.
- There is a distinct shortage of well-trained earth science teachers. This leads to a heavy reliance on textbooks and perpetuates the belief that science is boring.
- Many models of teaching and learning are not consistent with the way we want K–12 teachers to teach. University faculty who teach future earth science teachers need a better understanding of how earth science should be taught at the elementary and secondary levels.
- Most college faculty agree that teaching is important, but in reality, research and publications are still the keys to promotion and tenure.

In education, as in science, complex, multidimensional problems are not easy to solve. However, by bringing diverse people and resources together and examining problems holistically rather than in fragments, we believed that new strategies and partnerships could be developed to address these problems. This was the task set before the conference participants, and following three and a half days of discussion and debate, the following recommendations emerged.

Conference Recommendations

The Reward System

1. Earth science teachers at all levels need to be recognized by their peers and society for their professional teaching contributions. This recognition could take the form of appropriate financial rewards; tangible professional respect by peers, parents, and students; public recognition of teaching accomplishments; opportunities for professional growth and advancement; and freedom to function professionally.
2. Universities need to develop appropriate techniques for establishing and evaluating good classroom teaching.
3. Discussions and changes are needed in elementary and secondary schools, university departments, and college administrations, so that promotion, salary, and tenure decisions do in fact reward and encourage good teaching, community service, and research, with equal value for each.

The Perception Issue

1. Encourage teachers at all levels to integrate earth science concepts and earth awareness into both science and nonscience courses.
2. Reduce textbook use. Encourage active learning and discovery.
3. Redesign introductory science courses (college) across the board.
4. Whenever possible, highlight the connections between relevant environmental issues and earth science.
5. Encourage dialogues between secondary and college teachers and administrators on what must be done to have earth science accepted as a laboratory science for college admissions purposes.

Professional Development Issues

1. Provide opportunities for and encourage professors to become better teachers. Begin this process in graduate school.
2. Provide earlier and more continuous classroom experiences for future K–12 teachers.

"The time is always right to do what is right"

—Martin Luther King

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3. Encourage partnerships between K–12 teachers and college faculty.
4. Provide more opportunities for cross-level (elementary-secondary-college) dialogue and interaction.
5. Provide more scientific research opportunities for K–12 teachers.
6. Develop and disseminate regionally relevant earth science curricula.

Most education conferences end with a series of recommendations. Hands are shaken, good-byes are said, and people leave feeling good about what they have done. Ten years later, since no one was designated to act on the conference recommendations, a different group of participants meet to discuss the same old problems.

Participants at the first GSA Presidential Conference agreed that if we didn't want to do this conference all over again in ten years, it was time to break this cycle. Consequently, before the conference ended, all participants identified specific tasks that they would personally undertake during the next 12 months to improve earth science education and break down the barriers to science literacy in their regions. Among the commitments agreed to by the participants were: creating a Gulf Coast Earth and Environment Center; developing a video "portrait" of good earth science teaching; establishing regional earth science resource and information clearinghouses; initiating educational partnerships with teachers and scientists in their communities; and offering workshops for K–12 teachers and college faculty to improve their earth science teaching.

At three-month intervals each of the participants will be contacted to find out how they are progressing on their tasks, and in 1994, GSA, in conjunction with CESE, hopes to convene a follow-up conference to examine progress on these issues and strengthen regional and state science education reform efforts.

We invite all interested GSA members to learn more about these efforts. Together we can "do what is right" and break down the barriers to science literacy for all students.

For additional information on the First GSA Presidential Conference, please contact Ed Geary. ■

Nominations Sought for 1993 Biggs Earth Science Teaching Award

Whitman Cross II
Vice-Chairman, Geoscience Education Division

The GSA **Geoscience Education Division** welcomes nominations for the 1993 Biggs Earth Science Teaching Award.

PURPOSE: To reward and encourage outstanding teaching of earth science at the college level.

AWARD: $500 (made possible through support from the Donald and Carolyn Biggs Fund).

ELIGIBILITY: All earth science instructors and faculty at 2- and 4-year colleges who have taught for 10 years or less.

Flyers will be sent to all earth science departments for posting. Nomination forms, including criteria and requirements may be photocopied from the back of the flyers. Nomination forms are also available from GSA:

Biggs Nomination Form
c/o Edward E. Geary
Coordinator for Educational Programs
Geological Society of America
P.O. Box 9140
Boulder, CO 80301

DEADLINE: **All nomination materials must be postmarked by *July 30, 1993.***

Allow sufficient time for bringing all support materials together; we suggest that nominators begin the process well before the academic year comes to a close. We look forward to a broad participation across the earth science spectrum. ■

GSAF UPDATE

Robert L. Fuchs

Much Ado about Taxes

President Clinton has announced a program to raise taxes on a great many tax-paying individuals and entities. Deficit reduction and increased taxes are topics of intense discussion in the media and elsewhere. Just about everyone feels she or he is going to suffer a "tax hit" this year.

Cheer up—this is not yet the end of the world. Tax payments can still be abated, tax problems mitigated through careful tax planning and long-term estate planning. Charitable giving, both direct and through planned gifts, continues to be a principal ingredient in developing a sensible path to income tax minimization.

Over the past months and years GSAF Update has provided information on numerous ways and means of increasing the amount of money a geologist is able to keep in her or his bank account short term, her or his estate long term. A good example is the gift of appreciated securities, a contribution of shares of stock in which the donor has a cost basis less than the current market value. A gift of such stock avoids the capital gains tax on the increase of market value over cost. In essence, the government has become a partner in the gift by allowing the GSA Foundation to keep the amount of the capital gains tax.

In future articles in *GSA Today* we shall point out interesting and profitable ways in which GSA members can take advantage of provisions in the tax laws and regulations that allow greater retained income and increased charitable giving.

Facts about Taxes

Property received by inheritance acquires a stepped-up basis in the beneficiary's hands equal to date-of-death value. Your mother's house cost $25,000; today it is worth $150,000. After her death you become the owner. Your cost basis: $150,000.

A contribution is deemed to be made upon "delivery" to the charity. For checks, this is at the time of mailing; for stock, upon physical delivery of a properly endorsed certificate or broker wire transfer; for credit card, when the charge is made, not paid.

Gifts of property worth more than $5000 (house, car, etc.) require an appraisal by a qualified appraiser not earlier than 60 days before the transfer. IRS Form 8283 must be filed with the donor's tax return to establish the tax deduction.

Gift of a remainder interest in a personal residence or farm qualifies for a tax deduction at the time of the gift even though the donor continues to live in the residence for life. Some calculations with respect to actuarial considerations and depreciation are required in order to arrive at the fair market value of the remainder interest for deduction purposes.

The face value of a life insurance policy is included in one's estate for estate tax purposes, although the beneficiary receives the proceeds tax free. To reduce estate taxes, transfer ownership of the policy to the beneficiary, or consider a life insurance trust if several policies are involved.

Finally, don't neglect to consult your personal tax advisor when dealing with tax matters that relate to your specific situation. ■

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detailed scale, disputes on the tectonics are numerous. In this short article, we do not intend to probe the particulars of differing thoughts on the Himalayan orogeny. What we emphasize here is *time,* the essential element not only in understanding the geohistory of the Himalaya, but also in testing the tectonic models. To understand *how,* we must also know *when.* Although the review papers cited above have used some geochronologic data in their discussion, we have attempted to synthesize the age data comprehensively and to analyze them in the light of current discussions on Himalayan geology. These data, together with geologic evidence, suggest an *episodic* uplift-denudation history of the Himalaya throughout Neogene and Quaternary time.

TIMING OF MAGMATISM AND METAMORPHISM IN THE HIMALAYA

The time of continental collision between India and Asia has been estimated to be 65–45 Ma, on the basis of paleomagnetic data from the Indian Ocean, peninsular India, and the Trans-Himalayan magmatic belt. This was not necessarily a synchronous event but perhaps occurred with an oblique geometry, the northwestern part of the Indian plate colliding first around the Cretaceous-Tertiary (K-T) boundary and the collision terminating in the eastern Himalaya toward the end of the Eocene (Patriat and Achache, 1984; Besse et al., 1984; Klootwijk, 1984; Jaeger et al., 1989; Klootwijk et al., 1992; Treloar and Coward, 1991).

The Higher Himalayan crystalline (HHC) rocks constitute the backbone of the Himalaya. Toward the north, the HHC rocks form the basement (infrastructure), which is overlain by Tethyan sedimentary rock. The contact between these has been been recognized in places to be an extensional normal fault (the South Tibetan detachment system; Burchfiel et al., 1992). Toward the south, the HHC rocks were emplaced over the Lesser Himalayan sediments in the form of nappes and klippen (i.e., Outer crystalline rocks) along the Main Central thrust (Fig. 1). Available Rb-Sr whole-rock isochrons and U-Pb zircon ages from the HHC and Outer crystalline rocks date back to Proterozoic-Cambrian (Fig. 2), indicating that these rocks belonged originally to the Indian shield, but were reactivated during the Cenozoic Himalayan orogeny.

Postcollisional events within the Himalaya encompass a complex history of deformation, crustal thickening and shortening, metamorphism, leucogranitic intrusion, thrusting of regional dimension, extensional tectonism between the HHC and overlying Tethyan sedimentary rocks, and uplift-denudation of the Himalaya.

The polyphase deformation and metamorphism of the Himalayan package have been reviewed by Thakur (1980), Windley (1983), Le Fort (1986), and Hodges et al. (1989). An important problem has been the timing of regional metamorphism(s) related to the Himalayan orogeny. Amphibolite-facies metamorphism has affected the HHC rocks. Except for their lower parts, which are slightly metamorphosed, most of the Tethyan sedimentary strata have escaped the Himalayan regional metamorphism (Gansser, 1981; Le Fort, 1989). Hornblende K-Ar and $^{40}Ar/^{39}Ar$ ages (with closure temperatures of 500–550 °C) provide time constraints on the metamorphic history of the high-grade HHC rocks (Fig. 3). The ages from Nepal cluster around 20–24 Ma, but those from the northwest Himalaya date back to the Eocene. Treloar and Rex (1990) and Sorkhabi et al. (1992) have suggested that the thermal peak of the Barrovian-type (intermediate pressure and temperature) regional metamorphism in the northwestern HHC rocks predated 40 Ma, and thus took place not long after the continental collision if the metamorphism was related to the India-Asia collision and crustal thickening. On the basis of concordant hornblende $^{40}Ar/^{39}Ar$ and sphene U-Pb ages from an amphibolite, Hodges et al. (1991) inferred that the regional metamorphism in the Nepalese part of the HHC rocks occurred at 22–21 Ma.

These age differences reflect the polymetamorphic nature of the HHC rocks as discussed by Hodges et al. (1989), who distinguished between an early Barrovian-type metamorphism that took place after the collision, and a later regional (essentially Buchan-type [high temperature, low pressure]) metamorphism that occurred during the Main Central thrusting. According to Le Fort (1986), however, the second event was an inverted Barrovian-type metamorphism related to the Main Central thrusting and was followed by a secondary retrograde metamorphism. Obviously more isotopic age data with higher closure temperatures obtained from various parts of the HHC rocks are necessary to detect the signatures of polymetamorphism throughout the Himalaya, and attempts to model the Himalayan metamorphic history based on "age guessing" or "extrapolating age data" from one area to another may be misleading.

Copeland et al. (1991) determined very young (<5 Ma) hornblende, mica, and K-feldspar $^{40}Ar/^{39}Ar$ ages from near the Main Central thrust in central Nepal and have interpreted them to be the result of resetting by hot fluids channeling along the thrust after migrating upward through the Lesser Himalaya, and having originated from the movement in early Pliocene time of the Main Boundary thrust.

Radiometric data have revealed postcollisional timing of plutons in the Higher Himalaya. These two-mica (commonly tourmaline-bearing) leucogranites have high initial Sr and Pb ratios, low Nd isotopic ratios, and a high range of $\delta^{18}O$ (Table 1; Le Fort et al., 1987, and references therein). Nd model ages yield crustal residence times of 1.1 to 2.3 b.y. (Allegre and Othman, 1980). Available age data from central and eastern parts of the Himalaya suggest that the leucogranites, although chemically similar, can be classified into two groups: the Higher Himalaya belt leucogranites (especially those between the Higher Himalayan metamorphic rocks and the overlying Tethyan sedimentary rocks in Nepal), which were emplaced earlier (24–15 Ma); and the northern Himalayan belt leucogranites (within the Tethys Himalaya in southern Tibet, also called the Lhagoi Kangari Belt by Chinese geologists), which yield younger emplacement ages (15–4 Ma).

The origin of the postcollisional leucogranites, although they are volumetrically a minor component of the Himalaya, is controversial. Le Fort (1975, 1986) and Le Fort et al. (1987), concentrating on the central parts of the Himalaya, suggested that the Himalayan leucogranites were generated by partial melting of the Tibetan slab gneisses induced by fluids (H_2O and CO_2) rising from devolatizing footwall rocks during the overthrusting of the hot Tibetan slab over the cold Lesser Himalaya along the Main Central thrust. This widely accepted model, however, seems to be only part of a complicated story. In Pakistan, Zeitler

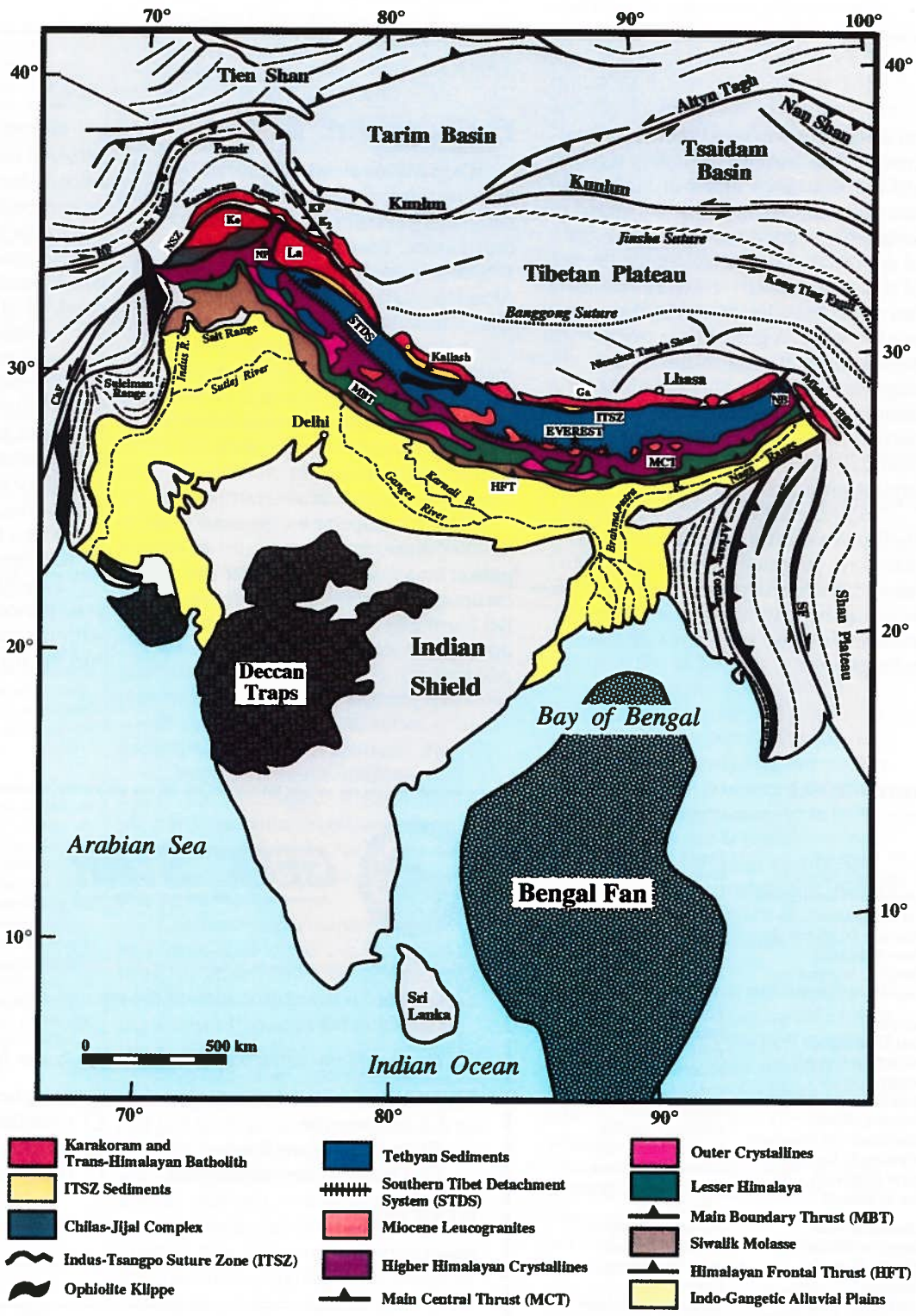

Figure 1. Geologic map and regional tectonic framework of the Himalaya (after Molnar and Tapponnier, 1975; Gansser, 1981; Windley, 1983, and other sources). The Himalaya seems to be the last of a series of collisions of the Gondwana fragments with Eurasia. Older accretions have occurred along the Jinsha and Bangong-Nujiang sutures (e.g., Şengör, 1981). The Indus-Tsangpo suture zone (ITSZ) represents the initial boundary between the Indian and Asian plates, along which the Neo-Tethyan ocean was consumed to give rise to the Trans-Himalayan magmatic arc. The thrust contact between the Himalaya and the ITSZ has been variously called the Main Mantle thrust in Pakistan, the Zanskar thrust in India, and the Gandese thrust system in Tibet. Geologically, the Himalaya is divisible into four longitudinal belts: (1) the Tethys (Tibetan) Himalaya encompassing the shelf and shelf-edge sediments of Neo-Tethys deposited from late Proterozoic–Cambrian to Late Cretaceous–early Eocene time on the passive continental margin of the Indian plate; (2) Higher Himalayan crystalline (HHC) rocks, also called Central crystalline rocks, Great Himalaya, and Tibetan slab, which includes various metamorphic and granitic rocks; the boundary between the HHC rocks and the Tethys Himalaya has recently been found to be a normal fault of extensional mode and shear sense (Pecher, 1991, and references therein), called the South Tibetan detachment system (Burchfiel et al., 1992); (3) the Lesser Himalaya, which comprises sedimentary and low-grade metasedimentary rocks of early Paleozoic and Precambrian age and is separated from the HHC rocks by the Main Central thrust (MCT) system; and (4) the Sub-Himalaya, or Siwalik molasse of middle Miocene to Pleistocene age, separated from the Lesser Himalaya by the Main Boundary thrust (MBT) system to the north, and from the Indo-Gangetic alluvial plains by the Himalayan frontal thrust (HFT) to the south. These morphotectonic units decrease in altitude from north to south, and their thrust boundaries are north dipping. ChF—Chapman fault; Ga—Gandese; HF—Herat fault; KF—Karakoram fault; Ko—Kohistan; La—Ladakh; NB—Namche Barwa (7755 m); NP—Nanga Parbat (8125 m); NSZ—Northern (Shyok) suture zone; SF—Sagaing fault. All the rivers shown have their sources in places close to Mt. Kailash.

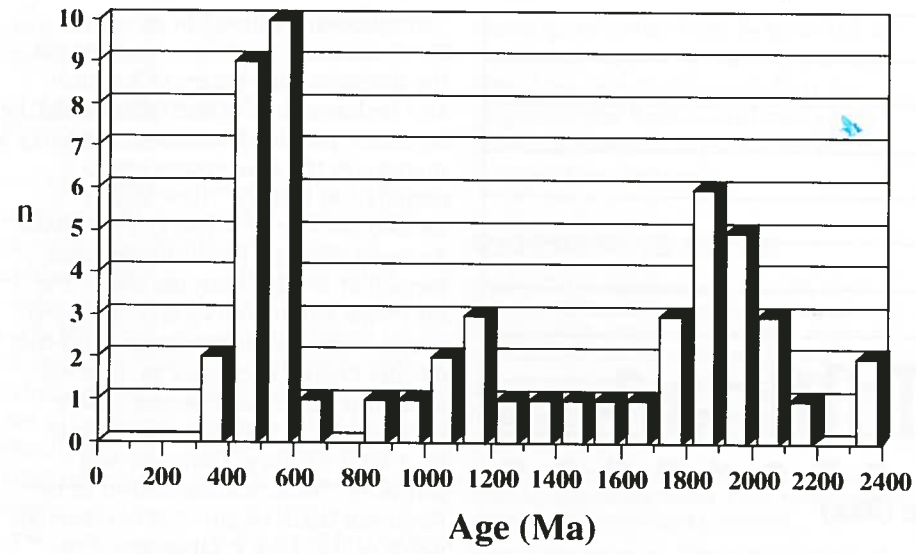

Figure. 2. Histogram of Rb-Sr isochron and U-Pb zircon ages reported in the past two decades from the gneisses and granites of the HHC and their klippen and nappes in the Lesser Himalaya (i.e., Outer crystallines). Rb-Sr ages reported before 1977 have been recalculated using the currently agreed constants. Where more than one age was available for a sample, the latest one was used. Most of these data have been reported from the Indian parts of the Himalaya, and the references are in Bhanot et al. (1980) and Sorkhabi (1991). The ages range from 400 to 2300 Ma, with two distinct peaks—one at 400–600 Ma and the other at 1800–2000 Ma—straddling a slight peak at 1000–1100 Ma. Very high initial Sr ratios point to their derivation from still older continental crust. These ages are similar to those found for the crystalline rocks of the Indian shield (Sarkar, 1980), indicating that the crystalline rocks in the Higher Himalaya and Lesser Himalaya were originally the northerly extension of the Indian shield but were involved in the Cenozoic Himalayan orogeny. The peaks at 1800–2000 Ma and the slight peak at 1000–1100 Ma indicate Precambrian magmatic events. Le Fort et al. (1986) argued that the 500 Ma peak represents a thermal episode that has affected not only the Himalayan edge of India, but also in part most of the other fragments of Gondwana through zones of crustal extension and thinning along which substantial amounts of lower crustal material melted. This episode is part of the Pannotios Cycle of Stump (1987).

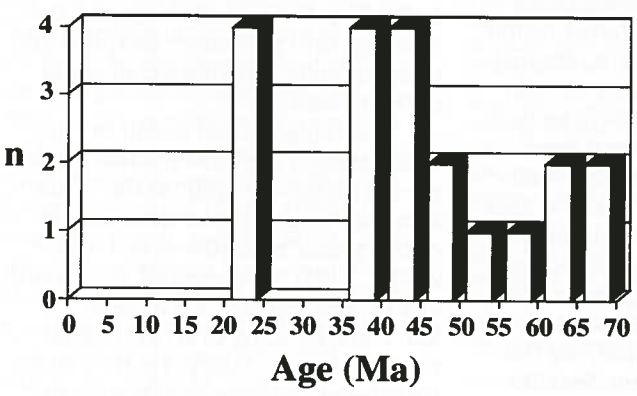

Figure 3. Histogram of hornblende K-Ar and $^{40}Ar/^{39}Ar$ ages from the Higher Himalayan metamorphic rocks (Pakistan, India, Nepal), recording paleotemperatures of 500–550 °C. (Data from Saxena and Miller, 1972; Krummenacher et al., 1978; Maluski and Matte, 1984; Hubbard and Harrison, 1989; Treloar and Rex, 1990; Chamberlain et al., 1991; Sorkhabi, et al., 1992.)

TABLE 1. RADIOMETRIC AGES FROM POSTCOLLISIONAL LEUCOGRANITES IN THE HIMALAYA

Pluton	Method, material*	Age (Ma)	Source†
Pakistan			
Swat	U-Pb (zr)	~35	Zeitler and Chamberlain (1991)
Naran	"	~50	"
Nanga Parbat	"	2.3, 5, 7	"
India			
Zanskar	Rb-Sr (ms)	17 ±0.2	Searle and Frye (1986)
Bhagirathi	Rb-Sr (5 points)	64 ±11	Stern et al. (1989)
	Rb-Sr (minerals)	21.1 ±0.9	
	K-Ar (ms)	18.9 ±1.3	
Nepal–S. Tibet			
Mustang	K-Ar (bt)	15, 24	Krummenacher (1971)
Manaslu	Rb-Sr (7 points)	29 ±1	Hamet and Allegre (1978)
	Rb-Sr (wr-ms; 6 points)	15.3–20.5	Vidal et al. (1982)
	Rb-Sr (11 points)	18.1 ±0.5	Deniel et al. (1987)
	U-Pb (mo)	25	"
	Rb-Sr (ms)	14.9–21.4	"
	K-Ar (ms)	13–16.1	"
	Ar/Ar (ms, bt)	13.3–18.4	Copeland et al. (1990)
	Ar/Ar (ks)	3.4–10.7	"
Makalu-	K-Ar (bt, ms)	14.4–16	Wager (1965)
Lhotse-	K-Ar (bt)	18.7, 19	Krummenacher et al. (1978)
Nuptse-	Rb-Sr (6 points)	92.7 ±9.4	Kai (1981)
Rongbuck	Rb-Sr (bt)	14.1 ±0.2	"
	Rb-Sr (4 points)	52 ±1	Ferrara et al. (1983)
	Rb-Sr (wr-mineral)	13.7–17.3	"
	U-Pb (mo)	21.9, 24	Scharer (1984)
	U-Pb (mo)	22–25	Copeland et al. (1987)
	Ar/Ar (ms, bt, ks)	16.2, 17.1, 16.2	"
	Ar/Ar (ms)	16.5 ±0.4	Hubbard and Harrison (1989)
	Ar/Ar (ks)	15.5 ±1.8	"
	U-Pb (mo)	20.6 ±0.2	Parrish (1990)
	Ar/Ar (ms,bt)	15.3–15.8	Villa (1990)
Bhutan			
Chekha	Rb-Sr (bt)	11, 10	Gansser (1983)
Gophu La	Rb-Sr (bt-ms)	15, 14.4	Ferrara et al. (1985)
	Ar-Ar (orthoclase)	~18	Villa and Lombardo (1986)
SE Tibet–Bhutan			
Lhozhag	Rb-Sr (wr-ms)	15.1, 15.8	Debon et al. (1983)
	K-Ar (ms)	13.3 ±1	Debon et al. (1985)
Kula Kangari	Ar-Ar (bt, ms)	10.7–11.4	Maluski et al. (1988)
South Tibet			
Nyalam	K-Ar (ms)	12, 12.5	Zhang et al. (1981)
	U-Pb (mo)	16.8 ±0.6	Scharer et al. (1986)
	Ar-Ar (ms, bt)	14.8, 16.6	Maluski et al. (1988)
Gabug	Rb-Sr (7 points)	43 ±3	Wang et al. (1981)
	K-Ar (ms)	14.7	"
	K-Ar (ms)	18.4, 20.1	Zhang et al. (1981)
Gyirong	K-Ar (ms, bt)	21.1–20.4	"
North Himalayan Belt (Tibet)			
Gyaco La	K-Ar (2bt-2ms)	13.3 ±0.4	Debon et al. (1985)
	Rb-Sr (wr-bt-ms)	7.1, 8.4	Debon et al. (1986)
Kari La	K-Ar (3wr-3bt)	10.8 ±0.8	Debon et al. (1985)
Maitia (Maja)	U-Pb (mo)	9.8, 9.2	Scharer et al. (1986)
	Ar-Ar (ms, bt)	6.4, 5.8	Maluski et al. (1988)
Lhagoi Kangari	U-Pb (mo)	15.1 ±0.5	Scharer et al. (1986)
	Ar-Ar (ms, bt)	12.3, 10.7	Maluski et al. (1988)
Kung Co	Ar-Ar (ms, bt)	15	"

*bt: biotite; ks: K-feldspar; mo: monazite; ms: muscovite; wr: whole rock; zr: zircon.
†Referenced in Krummenacher et al. (1978); Zhang et al. (1981); Ferrara et al. (1983); Scharer et al. (1986); Debon et al. (1986); Le Fort et al. (1987); Castelli and Lombardo (1988); Maluski et al. (1988); Hubbard and Harrison (1989); Stern et al. (1989); Zeitler and Chamberlain (1991). The scattering of data on emplacement ages is due to the fact that these leucogranites were generated from older crustal material, and thus Pb inheritance in zircon and heterogeneous Sr isotopic ratios make them difficult to date precisely.

and Chamberlain (1991) found two leucogranites of 35 and 50 Ma (U-Pb zircon ages) in the Swat-Nayan region, lying to the west of Nanga Parbat massif, rocks that may have resulted from melting in the lower parts of the crust induced by tectonic thickening of the Indian continental plate as suggested by England and Thompson (1984). Such an origin is consistent with hornblende $^{40}Ar/^{39}Ar$ cooling ages of 45–38 Ma from metamorphic rocks surrounding the leucogranites. Given the similarity in the metamorphic history of the Swat region (Pakistan) (Treloar and Rex, 1990) and the Zanskar region (northwest India, farther east of Nanga Parbat) (Sorkhabi et al., 1992), we suspect that such Eocene leucogranites may also exist in northwest India.

Zeitler and Chamberlain (1991) also found very young leucogranites of 2.3, 5, and 7 Ma (U-Pb zircon) within the Nanga Parbat massif. They have interpreted these to have formed by decompressional melting during rapid exhumation that has affected the Nanga Parbat massif in the past 10 m.y. In fact, as Zeitler and Chamberlain (1991) mentioned (see also Castelli and Lombardo, 1988), it is possible that such a mechanism was partially responsible for the generation of the early–middle Miocene anatectic leucogranites in Nepal—e.g., Makalu and Manaslu—which also cooled and have been exhumed very rapidly, as thermochronologic data show (Table 1). Given the early Miocene age of the South Tibetan detachment system (discussed below) and its prominent role in the exhumation of the HHC, formation of the early to middle Miocene leucogranites appears to be synchronous with the beginning of extension within the Higher Himalaya. Note that these leucogranites are located close to the South Tibetan detachment system (Fig. 1).

EPISODIC TECTONIC-EXHUMATION HISTORY OF THE HIMALAYA

Various geochronologic and geologic evidence indicates that the uplift-denudation of the Himalaya since the continental collision has *not* been a *uniform* event throughout time, but rather has occurred in an *episodic* manner. A synthesis of available information points to the following scenario.

Early Miocene (21–17 Ma) Phase of Uplift-Denudation

This major phase of uplift-denudation has been suggested by several geologists (e.g., Gansser, 1981; Valdiya, 1984) and has been elaborated with geochronologic data emphasizing the formation of the Tibetan plateau by Harrison et al. (1992).

Throughout the Himalaya, during the late Eocene and almost the entire Oligocene, there seems to be a hiatus in sedimentation and the development of laterite and karst surfaces (Wadia, 1975; Powell and Conaghan, 1973; Johnson et al., 1985; Le Fort, 1989). However, starting in early Miocene time, the Murree and Siwalik fluvial sediments were deposited in a basin that formed in front of the rising Himalaya (Gansser, 1981; Johnson et al., 1985). Further evidence for this marked uplift-denudation episode is provided by the stratigraphy of the Bengal Fan—the world's largest—which has been formed increasingly since the early Miocene from sediments derived from the Himalaya (Curray, 1991), the HHC rocks being the main source (France-Lanord et al., 1992). Whiting and Karner (1991) also reported a sharp increase in subsidence rates on the western margin of India beginning at ~25 Ma, which they ascribed to Indus Fan loading.

Fission-track analysis of detrital zircons from the Siwalik Group in Pakistan (Cerveny et al., 1988) and in India (Sorkhabi, unpublished data), $^{40}Ar/^{39}Ar$ analysis of detrital muscovite and K-feldspar from the Bengal Fan (Ocean Drilling Program Leg 116) by Copeland and Harrison (1990), and fission-track analysis of apatite from the same core samples (Corrigan and Crowley, 1993) indicate that the Hima-

Himalaya *continued on p. 90*

Himalaya *continued from p. 89*

laya has been unroofing at fast rates for the past 18 m.y. (inferred from the fact that radiometric mineral ages are zero to only a few million years older than depositional ages, and from distribution of fission-track lengths).

Other evidence comes from the record of seawater $^{87}Sr/^{86}Sr$. The flux of dissolved Sr transported by rivers originating in Himalaya-Tibet accounts for about 25% of the global Sr budget. By calculating the Sr isotopic evolution curve for the past 100 m.y., Richter et al. (1992) showed that riverine Sr flux increased after the India-Asia continental collision in the early Tertiary, with a rapid increase at ~20 Ma. Krishnaswami et al. (1992) also showed such an increase of the Sr flux in the Ganga-Brahmaputra river system during the past ~20 m.y.

The thermal history of the HHC rocks in the northwest Himalaya as determined from K-Ar and $^{40}Ar/^{39}Ar$ dating of mica and from fission-track ages (Zeitler, 1985; Treloar and Rex, 1990; Sorkhabi, 1991) also indicates that cooling of the rocks during the early–middle Miocene was very fast (~30 °C/m.y.). Given that the cooling of the rocks occurred because of their uplift to surface (unroofing), rapid cooling of the HHC rocks in the early Miocene is indicative of rapid unroofing in the Himalaya, consistent with the sedimentation history discussed above.

In a histogram of mica cooling ages determined in the past three decades for various parts of the Himalayan metamorphic and granitic rocks, the majority of cooling ages are early–middle Miocene, with a peak at 18–16 Ma (Fig. 4). These cooling ages correspond to paleotemperatures of 300–350 °C (closure temperatures of mica), and indicate at least 10 km of unroofing of the Himalayan rocks since 17 Ma.

The unroofing of the HHC rocks has been due to erosion as well as to motion along faults bounding it: the Main Central thrust shear zone to the south was intensely active in early–middle Miocene time (Gansser, 1981; Valdiya, 1984; Le Fort, 1989), as was the South Tibetan detachement system to the north. Available data indicate that the detachment system was very active in the early Miocene. Hodges et al. (1992) suggested that normal faulting in the Everest region occurred between 22 and 19 Ma, on the basis of U-Pb ages of accessory minerals from an amphibolite in the footwall and an undeformed granite cutting across the fault, and that it was simultaneous with the compression along the Main Central thrust zone. In the Zanskar region (India), discordant mica K-Ar ages from the footwall and hanging wall of the normal fault also indicate early Miocene activity (Sorkhabi, 1991). Treloar et al. (1991) argued that the Main Mantle thrust separating the Kohistan block from the Higher Himalaya in Pakistan (Fig. 1) was originally a south-verging thrust, but later became a north-side-down extensional structure. On the basis of fission-track ages reported by Zeitler (1985) which yield similar apatite ages (~15 Ma), but discordant zircon ages across the fault, Treloar et al. (1991) inferred that the extension took place before 15 Ma, and was active during the period 23–20 Ma.

The Trans-Himalayan Xuxu pluton, near Lhasa, which was intruded at 42 Ma, was rapidly cooled and unroofed at 21–18 Ma, as demonstrated by $^{40}Ar/^{39}Ar$ dating of biotite from rocks collected from a vertical profile (3600–4600 m) (Copeland et al., 1987), the $^{40}Ar/^{39}Ar$ age spectrum analysis of

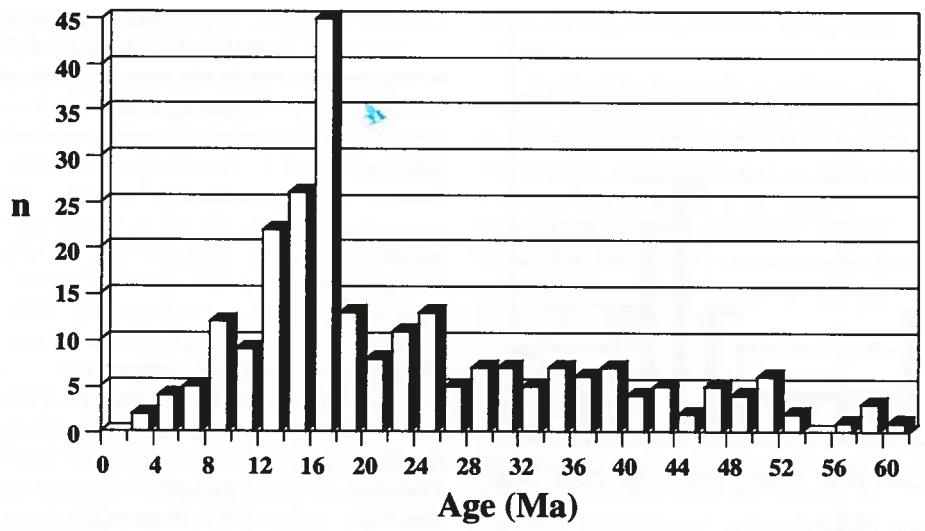

Figure 4. Histogram of 247 Cenozoic cooling ages of the HHC and Outer crystalline rocks determined by Rb-Sr (biotite), and K-Ar and $^{40}Ar/^{39}Ar$ (biotite or muscovite) methods, corresponding to paleotemperatures of 300–350 °C. Pre-Cenozoic ages, especially on biotite, carrying excess argon or incomplete resetting, were excluded from the histogram. Most of the younger ages (<8 Ma) are from the Main Central thrust zone. A period of rapid cooling and a major pulse of exhumation in the Himalayan occurred at 18–16 Ma. Many sources have been used for this histogram. The references up to 1979 are given in Mehta (1980). Other major sources include Honegger et al. (1982), Ferrara et al. (1983), Maluski and Matte (1984), Zeitler (1985), Debon et al. (1986), Maluski et al. (1988), Hubbard and Harrison (1989), Copeland et al. (1991), Treloar and Rex (1991), Sorkhabi (1991, and unpublished data), and references therein.

a single-grain K-feldspar sample (Richter et al., 1991), and the fission-track analysis of apatites (Pan et al., 1992). Furthermore, Copeland and Harrison (1990) obtained a cluster of $^{40}Ar/^{39}Ar$ ages at 15–20 Ma from detrital K-feldspars from the Tsangpo River near Lhasa. In Kailash, results of $^{40}Ar/^{39}Ar$ age spectrum on a K-feldspar from a cobble show very rapid cooling between 19 and 18 Ma (Harrison et al., 1991). Miocene Kargil molasse in Ladakh (lying to the west of Kailash) (Thakur, 1980) is also probably the sedimentary product of rapid denudation. However, whether rapid uplift-exhumation during the early–middle Miocene affected plutonic rocks along the whole of the Trans-Himalayan batholith is yet to be resolved.

Late Miocene (11–7 Ma) Phase of Uplift-Denudation

From the mass accumulation rates of terrigenous clastics from eleven Ocean Drilling Project (ODP) sites in the Indus and the Bengal fans, Rea (1991) found that during 9–6.5 Ma the clastic flux increased by a factor of 2.5 to 13. Independently, Amano and Taira (1992) studied sedimentary strata drilled from the Bengal Fan (ODP Leg 116) and found that the sedimentation rate increased abruptly between 10.9 and 7.5 Ma. In another study farther west, in the northwest Indian Ocean, ODP Leg 117 scientists discovered that until ~10 Ma the sedimentary deposits were siliclastic, but since 10 Ma and especially since ~7 Ma, biogenic deposits have dominated, and they commonly contain opal and microfossils (various radiolaria and foraminifera), which are associated with the monsoon through the process of upwelling. These data indicate that development of the Himalayan barrier to the monsoon is correlated to the 11–7 Ma phase of uplift (Ocean Drilling Program Leg 117 Scientific Drilling Party, 1988a, 1988b).

On the basis of a comparison of more than 20 sections of the foreland basins in the Himalaya dated by magnetostratigraphy, Burbank (1991) also detected a pronounced increase in regional subsidence at ~11 Ma. By studying a 2800 m section of the Siwalik strata in Pakistan, Johnson et al. (1985) found that at about 11 Ma (the time boundary between the lower and middle Siwalik Group) the sedimentation rate increased from 0.12 to 0.30 mm/yr and simultaneously blue-green hornblende appeared, which is attributed to rapid uplift of the Nanga Parbat region and the associated erosion of ultramafic rocks in northern Pakistan. Several horizons of the 2550 m Baikya section of the Siwalik Group in Nepal have been investigated by Copeland et al. (1992), who determined $^{40}Ar/^{39}Ar$ ages on 91 detrital K-feldspars to be only 3 m.y. older than their age of deposition (8.4 to 6.7 Ma), indicating rapid unroofing throughout this period.

Carter et al. (1992), studying the sedimentation record of the Siwaliks in Nepal, found that a disruption occurred at ~7.5 Ma due to the initiation of the Main Boundary thrust; uplift within the foreland at this time is recorded by local intraformational breccia and erosional unconformities, and it coincided with the monsoon seasonality in the Indian subcontinent. In Langtang National Park, central Nepal, on the basis of $^{40}Ar/^{39}Ar$ cooling ages of muscovite, Macfarlane et al. (1992) detected two major periods of movement of the Main Central thrust as a duplex structure: an early, ductile phase at 20–15 Ma, and a late, brittle phase after 9–7 Ma, coeval with the development of the Main Boundary thrust to the south.

Fission-track apatite ages of 10–5 Ma obtained from the HHC rocks in the Kaghan-Babusar region of Pakistan (Zeitler, 1985), the Zanskar region of northwest India (Sorkhabi, 1991), and various parts of the Higher Himalayan belt in India (Ball, 1981) indicate an unroofing of at least ~4000 m since late Miocene time. Unfortunately, absence of fission-track length measurements on these samples (due to their low track density) does not give information on the pattern and rapidity of cooling and exhumation. (Sorkhabi is working on this problem.)

In southern Tibet, along the Nyainqentanglha Range, Pan and Kidd (1992) found a low-angle ductile detachment structure along which movement occurred at 8–6 Ma, shown by $^{40}Ar/^{39}Ar$ ages on mica.

Quaternary Phase of Uplift-Denudation

Gansser (1983) emphasized this phase of uplift, which he called the "morphogenic phase." Studies by D. W. Burbank and his co-workers on the intermontane basins of Kashmir and Peshawar in the northwest Himalaya have provided valuable information on the Quaternary uplift-denudation history. These basins formed because of activity of the Main Boundary thrust. The Kashmir basin formed at 5–4 Ma with the rise of the Pir Panjal Range to its south. Sedimentation continued in the basin until the middle Pleistocene; since then, these lacustrine and deltaic deposits have been uplifted 1400–3000 m at a rate of at least 4 mm/yr (Burbank and Johnson, 1983). Sedimentation in the Peshawar basin began ~2.8 Ma through uplift of the Attock Range along the southern margin of the basin. Widespread sedimentation was terminated after 0.6 Ma by the rapid rise of the Attock Range, at an average uplift rate of 0.5 mm/yr for the past 0.6 m.y. (Burbank and Tahirkheli, 1985).

Similar intermontane basins exist not only in Nepal (Takkhola, Pokhra, and Kathmandu basins), but also in the Trans-Himalaya (e.g., Skardu basin in Pakistan and Kargil basin in India), where detailed investigation is needed to infer their neotectonics. Farther south, active faulting has been occurring along the Himalayan frontal thrust, which separates the Pleistocene Siwalik sedimentary rocks from the Indo-Gangetic alluvial plains (Nakata, 1989) (Fig. 1). These data support the idea that the Quaternary morphogenic phase of uplift has affected all zones of the Himalaya.

The Nanga Parbat massif in Pakistan presents the most notable example of Quaternary uplift in the Himalaya. Pioneering fission-track studies of this massif by Zeitler et al. (1982; Zeitler, 1985) have revealed very young apatite ages, ranging from 0.4 to 2.8 Ma, corresponding to an average unroofing rate of 5 mm/yr for the Nanga Parbat massif during the Quaternary.

The antecedent drainage pattern in the Himalaya is a classic example of its kind (Holmes, 1965) and has been studied by, e.g., Seeber and Gornitz (1983). Most of the rivers flowing through the Himalaya originate to the north and cut deep gorges through the loftier Himalaya; the present topography of the Himalaya postdates the river courses. The Indus gorge at Nanga Parbat is the most remarkable one. The elevation difference between the river (1100 m) and the Nanga Parbat peak (8125 m) is >7000 m over a distance of only 21 km (Gansser, 1983). Along the Indus Valley, at Jalipur, Misch and Raechl (1935) found that very young (Pleistocene?), little-consolidated sandstones were steeply folded and transgressed by the Indus River terraces.

Rapid uplift-denudation of the Himalaya during the Quaternary is also recorded in the stratigraphy of the Indus and Bengal fans, where Rea (1991) detected a pulse of clastic input that began between 3.7 and 2.5 Ma and lasted for 2 m.y. Amano and Taira (1992) found a prominent increase in the contribution of sediments to the Bengal Fan around 0.9 Ma.

Geodetic surveys in the Himalaya not only demonstrate uplift of the Himalaya but also provide some idea about the current rates of the uplift. Measurements made across the Siwalik Range in India reveal an uplift rate of 0.8 mm/yr (Narain, 1975). North–south leveling in Nepal during the past 15 years indicates active uplift of the Lesser Himalaya and Higher Himalaya at 2 and 4 mm/yr, respectively (Jackson et al., 1991). Finally, seismicity along the Himalayan thrusts and its syntaxial bends on the west and the east gives

evidence for its ongoing dynamism and upheaval.

SUMMARY AND CONCLUSIONS

The episodic history of the Himalaya outlined above commenced with an early–middle Miocene phase of uplift-denudation. Here the question arises, What exactly happened in the early Miocene that produced such intense tectonic activity, upheaval, and exhumation? To answer this question, one must consider the fact that the Himalaya is the product of the India-Asia convergence and that the convergence may have been accommodated in several ways. Lateral extrusion of the Indochina block along the Red River fault (a left-lateral, ductile strike-slip shear zone) during the Oligocene–early Miocene is a case in point, and several lines of evidence supporting this have been elaborated by Tapponnier et al. (1986) and Harrison et al. (1992). However, this should not prevent us from looking to tectonic accommodation within the Himalaya itself prior to the Miocene. For example, we do not know exactly when the Main Central thrust began (though it had an active phase in the early Miocene). Did it form in the Eocene (Dewey et al., 1988) or the late Oligocene (Hodges et al., 1989)?

The idea that the early Miocene extension and detachment between the HHC rocks and the overlying Tethyan-Tibetan sedimentary sequence occurred as a result of the gravitational collapse of a topographical high (Burchfiel et al., 1992) implies crustal stacking within the Himalaya to produce such a relief before Miocene time. Given that the Himalayan frontal thrust, the Main Boundary thrust, and the Main Central thrust become older from south to north, one can envision the existence of an even older thrust between the Indus-Tsangpo suture zone and the Main Central thrust. Perhaps the South Tibetan detachment system was originally a thrust fault that later became an extensional normal fault. Studies establishing the extensional tectonics of this normal fault do not preclude such a possibility. Treloar et al. (1991) considered this to be the case with the Main Mantle thrust, and Jain et al. (1992) argued that extensional deformation in Zanskar was superposed on an earlier phase of ductile shearing with a top-to-southwest sense of thrust movement. Valdiya (1989) considered the detachment normal fault as a reactivated structure, which has accommodated part of the India-Asia convergence.

In summary, the Himalaya has undergone a complex and episodic tectonic history. The available geochronologic data and geologic evidence demonstrate that 21–17, 11–7, and 2–0 Ma mark pulses of major uplift-exhumation and events associated with the tectonism of the Himalaya. There is the possibility of other local or regional pulses, however, and further studies will refine the episodic history on a detailed scale. It is appropriate to recall the words of Eduard Suess, who almost 100 years ago wrote in his first article on Tethys: "Our scholars will some day know more than their masters do now; so let us patiently continue our work and remain friends."

Acknowledgments

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Himalaya *continued on p. 92*

NACSN Asks for Recommendations

The North American Commission on Stratigraphic Nomenclature passed a resolution at its October 28, 1992, meeting in Cincinnati, Ohio, to "solicit opinion from the profession as to whether or not to amend the 1983 North American Stratigraphic Code so as to provide for formalization of sequence-stratigraphic units." A committee that will make recommendations on this matter was established at the same meeting.

All workers concerned with sequence stratigraphy are invited to communicate their opinions and specific recommendations to Donald E. Owen, Chairman, NACSN, Department of Geology, Lamar University, P.O. Box 10031, Beaumont, TX 77710, (409) 880-8234, fax 409-880-8007.

Opinions are solicited as to whether sequence-stratigraphic units should be considered a special type of Allostratigraphic Unit, as defined in the existing North American Stratigraphic Code (*AAPG Bulletin*, 1983) and how sequence-stratigraphic units relate to the Unconformity-Bounded Units (Synthems) of the ISSC (*GSA Bulletin*, 1987). Recommendations on exactly what kind of sequence-stratigraphic units and surfaces (sequences, parasequences, marine-flooding surfaces, condensed zones, etc.) that should be formalized or remain informal are solicited also. Comments will be considered until July 31, 1993, but earlier submittal of opinions and recommendations is encouraged. ■

Call for Papers—Engineering Geology

Contributions are being solicited for a volume on clay and shale slope instability which will be submitted to the Geological Society of America for publication in the Reviews in Engineering Geology series. It is anticipated that the volume will cover a wide range of topics pertaining to clay and shale slopes, including characterization of shear strength and other engineering properties; aspects of hillslope hydrology related to slope stability; mechanical analyses of slope stability; the influence of structural and stratigraphic details on slope stability; regional and local hazard assessment; and case histories of both failures and remedial efforts. Papers that integrate both geological and engineering aspects of clay and shale slope instability are especially welcome. Manuscripts will be subjected to peer review and revision, if necessary, before acceptance. A guide for authors is currently in preparation. Target date for submission of manuscripts, along with the names and addresses of at least two qualified reviewers, is June 1, 1993.

For additional information, please contact either of the two co-editors: William C. Haneberg, New Mexico Bureau of Mines and Mineral Resources, Campus Station, Socorro, NM 87801, (505) 835-5808; Scott A. Anderson, Department of Civil Engineering, University of Hawaii, Holmes Hall 383, 2540 Dole Street, Honolulu, HI 96822, (808) 956-9859.

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FORUM

Bruce F. Molnia

Forum is a regular feature of *GSA Today* in which many sides of an issue or question of interest to the geological community are explored. Each Forum presentation consists of an informative, neutral introduction to the month's topic followed by two or more opposing views concerning the Forum topic. Selection of future Forum topics and participants is the responsibility of the Forum Editor. Suggestions for future Forum topics are welcome and should be sent to: Bruce F. Molnia, Forum Editor, U.S. Geological Survey, 917 National Center, Reston, VA 22092, (703) 648-4120, fax 703-648-4227.

ISSUE: Geoscience Literature Pricing (Part 2)

This is the second half of a two-part Forum examining the geoscience literature pricing issue. The March *GSA Today* Forum began the in-depth look at this controversial topic by presenting the perspective of the academic library community.

PERSPECTIVE III: Pricing—A Commercial Publisher's Perspective

Peter Shepherd, Pergamon Press, Oxford, UK

Pergamon Press is one of the leading international publishers of journals in the geosciences. As such, we try to reconcile the demand to publish more and more papers, and the need of researchers to access those papers, with the inadequacy of library funds to match that growth. Figure 7 graphically illustrates the problem we all face. Since the mid-1970s, in real terms, library funding has failed to keep up with the expanding investment in research and development, and the growth in the scientific literature which has resulted.

This problem has affected the geosciences as much as any other discipline, and the dilemma of how to accommodate the growth in the literature and to disseminate articles efficiently in a way that is also sensitive to prevailing conditions in the market provides journal publishers with their major challenge today. How has Pergamon reacted to that challenge? First, Pergamon Press does not encourage the creation of new journals in the geosciences, so much a feature of the 1980s. Since 1989, we have launched only one new geoscience journal, *Exploration and Mining Geology.* Although further new titles are under investigation, only where it can be shown that currently available journals are providing an inadequate service to authors and readers will a new title be launched.

With more than 20 existing geoscience journals, the main focus at Pergamon Press is the ongoing development of these titles, to ensure that they continue to serve the fields they cover. We do this in a number of ways. The most important is careful quality control of the individual papers published; a task performed by the journal editors, supported by their editorial boards and referees. Only when the editor and the publisher are satisfied that quality will be enhanced rather than degraded will the volume of papers published in a particular journal be expanded.

Volume growth does have an impact on prices, but the effect is not the same for every journal. Like most commercial publishers, Pergamon Press publishes a number of highly specialized geoscience journals, which are purchased almost exclusively by libraries and have circulations of about 1000. These journals are necessarily relatively expensive per page published, as the editorial, production, distribution, and marketing costs are spread over relatively few subscribers. Contrast this with Pergamon's largest journal in the field, *Geochimica et Cosmochimica Acta,* which, in addition to a larger circulation to libraries, has several thousand individual subscribers among members of the Geochemical Society and the Meteoritical Society. Table 3 demonstrates that a commercial publisher can provide a broad-spectrum journal with a large circulation, at a relatively low price, not only to individuals, but also to libraries. More specialized journals, with lower circulations, must, necessarily, be more expensive per page to the subscriber. For both types of journal, however, there is a relation between growth in volume and growth in subscription price, while the growth in price per page is either zero or relatively modest.

As an international publisher, Pergamon Press is well aware of the sensitivity of libraries throughout the world to continuing subscription price increases. In those countries where the availability of hard currency is a problem, access to the international scientific literature is now severely restricted. Our mission at Pergamon Press is to ensure the efficient dissemination of the results of scientific research, and we have recently started an initiative to make our journals more widely available to libraries with severe funding problems. Pergamon PLUS (Pergamon Library Users Support) is a new service that enables authors of articles in Pergamon journals to make a direct financial contribution to libraries at no cost to themselves. Each time a paper is accepted for publication in a Pergamon journal, the corresponding (senior) author will receive a credit for £25 to be awarded to any library of his or her choosing. Initially, Pergamon PLUS is being tested on selected Pergamon geoscience journals in 1993, and will thus be of special interest to readers of *GSA Today.* Further details of Pergamon PLUS can be obtained from: Peter Shepherd, Publishing Director, Pergamon Press Ltd., Headington Hill Hall, Oxford, OZ3 QRW, UK; phone 865-743500, fax 865-743954.

Pergamon Press acknowledges that for the practicing geoscientist access to the latest literature is just as important as access to the latest equipment and instrumentation. As traditional methods of disseminating the results of scientific research are under structural and financial pressures, more creative approaches by the publishing community are needed to maintain and improve that access. Pergamon Press is committed to developing these approaches.

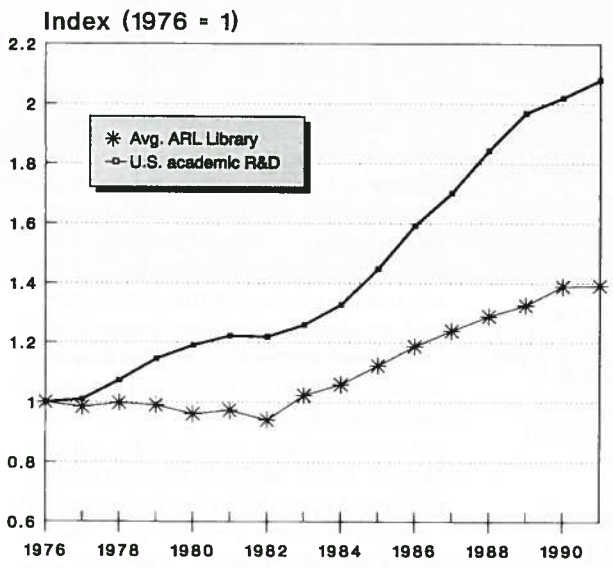


Figure 7. U.S. academic R & D and library expenditures, in constant 1982 dollars. R&D data are from "Science and Engineering Indicators—1991" (National Science Board), Appendix Table 5.1; library data are from Association of Research Libraries (ARL).

TABLE 3. SUBSCRIPTION PRICES FOR SOME PERGAMON PRESS GEOSCIENCE JOURNALS

Journal	1991		1992*	
	Subscription price (US $)	Price per page (US $)	Subscription price (US $)	Price per page (US $)
Chemosphere	875	0.22	944 (8%)	0.24 (9%)
Geochimica et Cosmochimica Acta	580	0.15	670 (15%)	0.15 (0%)
Journal of Structural Geology	375	0.31	432 (15%)	0.33 (6%)
Journal of South American Earth Sciences	140	0.33	224 (60%)	0.37 (9%)
Quaternary Science Reviews	270	0.49	416 (54%)	0.49 (0%)

Note: These journals are definitively priced in £ sterling, and converted to US $ at a rate of £ = US $1.60.

*Numbers in parentheses are increase of 1992 prices over 1991 prices.

PERSPECTIVE IV: Pricing—A Scientific Society's Perspective

Judy C. Holoviak, Director of Publications, American Geophysical Union, Washington, D.C.

When a scientific society undertakes the publication of journals, it makes a long-term commitment to the scientific community—to the authors and readers. Papers entrusted to the society must be available for today's and tomorrow's students and researchers. For the American Geophysical Union (AGU), this commitment means that AGU will control the editorial decisions, will set the prices, and will retain the rights to future dissemination.

The market for society-published journals is the membership. The members purchase for their own use and influence the purchasing decision for their institutions. Scientific societies are directed by the scientific community at every level of decision making from selection of an editor to setting the price. In this way, the interests of the science are integrated into the entire publication process.

The pricing decisions of a society respond to the pressures of the membership and the overall mission to advance the science. The members of the board of directors of a scientific society do not and by law cannot benefit individually from their actions. Their decisions are not made on the basis of tax incentives, shareholder returns, or personal pocketbooks. Every commercial business has a responsibility to maximize profit for its owners.

The right library price for a society publisher is a simple equation; total expenses less offsetting revenue from page charges, reprints, and member subscriptions, divided by the anticipated institutional subscribers. Total expenses include all direct costs of running editorial offices, of turning accepted papers into finished journals, and of delivery; also included are indirect costs and any other financial contributions the journal is expected to make to the society. Most of the direct costs can be projected from the number of pages planned. For AGU, page charges account for about 23% of journal revenue. Member subscriptions are set at a small multiple of the incremental cost, and thus each member subscription contributes above its direct cost. The price to members must be kept at the highest reasonable levels in order to keep the price to institutions down.

Concern over the decreasing numbers of institutional subscribers is probably the largest single factor driving 1993 subscription rates up. Expenses do not decrease much when a subscription is canceled. Thus a 10% decrease in subscribers translates into a roughly 10% increase in price for those who remain. If the pages in the journal also grow, the resulting subscription price increase will far outstrip what libraries might expect on the basis of the inflation rate.

The future looks bleak. Without new money for library acquisitions, we need to seek other ways to stop the downward spiral. Many publications should go out of business. The individual cancellation efforts of libraries alone cannot achieve that end. A concerted effort by the scientific community to weed out those journals with a high ratio of cost to benefit is required.

PERSPECTIVE V: Cost, Quality, and Value of Journals: A Geoscientist's Perspective

Paul Ribbe, Virginia Polytechnic Institute, Blacksburg

Genuinely concerned geoscientists who even occasionally publish the results of their research can play decisive roles in both the economics and the mechanics of scholarly communication. For it is researchers who represent all of the writers and most of the readers,

Forum *continued on p. 94*

Forum *continued from p. 93*

i.e., we are both the "producers" and the "consumers" of most scientific periodicals (and there are many: ~40,000!).

In these years of continuing crisis in library acquisition of journals, we are at the root of the problem and we can help resolve it. Others in this Forum have defined the crisis and suggested means to deal with it. I hope to convince you that it is possible to make meaningful value judgments of journals and that for more than trivial reasons, serials published by our professional societies are greatly to be desired over similar journals published by commercial presses.

What is the value of a scientific periodical? First of all, value involves cost, and that is the crux of the matter for money-starved libraries. Unfortunately, however, it is a matter of almost no concern to publishing geoscientists; almost none subscribe to the commercial journals they read and publish in.

Value also involves quality, which is harder to define than cost, because now we're considering degree of excellence or status in a scale of preferences. There is a widely applied bibliometric rating for journals determined by the Institute for Scientific Information (ISI) and published in ISI's annual "Science Citation Reports." It's called the impact factor, which is basically a ratio between the number of citations of a particular journal and the number of citable papers published therein. It is reasonably objective, especially if averaged over 3 or 4 years. These factors should be relied on to rate journals comparatively only within constricted disciplines, such as "mineralogy" or "paleontology" or "exploration geophysics," but not among such groupings. I have found impact factors to be directly correlated to ISI's immediacy index (a measure of how quickly the average article in a particular journal is cited), to the percentage of papers in a journal which have received financial support in the form of a federal grant, and even to the number of grants acknowledged in those papers. With the caveats mentioned, impact factors are reasonable measures of quality.

Value involves both cost and quality and no doubt a large dose of subjective perception. A journal that one person disdains, another may esteem, or at least choose for reasons as trivial as personal vanity: "I am an associate editor of that {obscure and/or outrageously priced} European journal." "They accepted my paper with almost no hassle from reviewers and no suggestion to shorten it." "They published my work quickly—it's very important for the world to see it within 5 to 6 months." Or more concretely, "They give free reprints, and there are no page charges!" Etcetera.

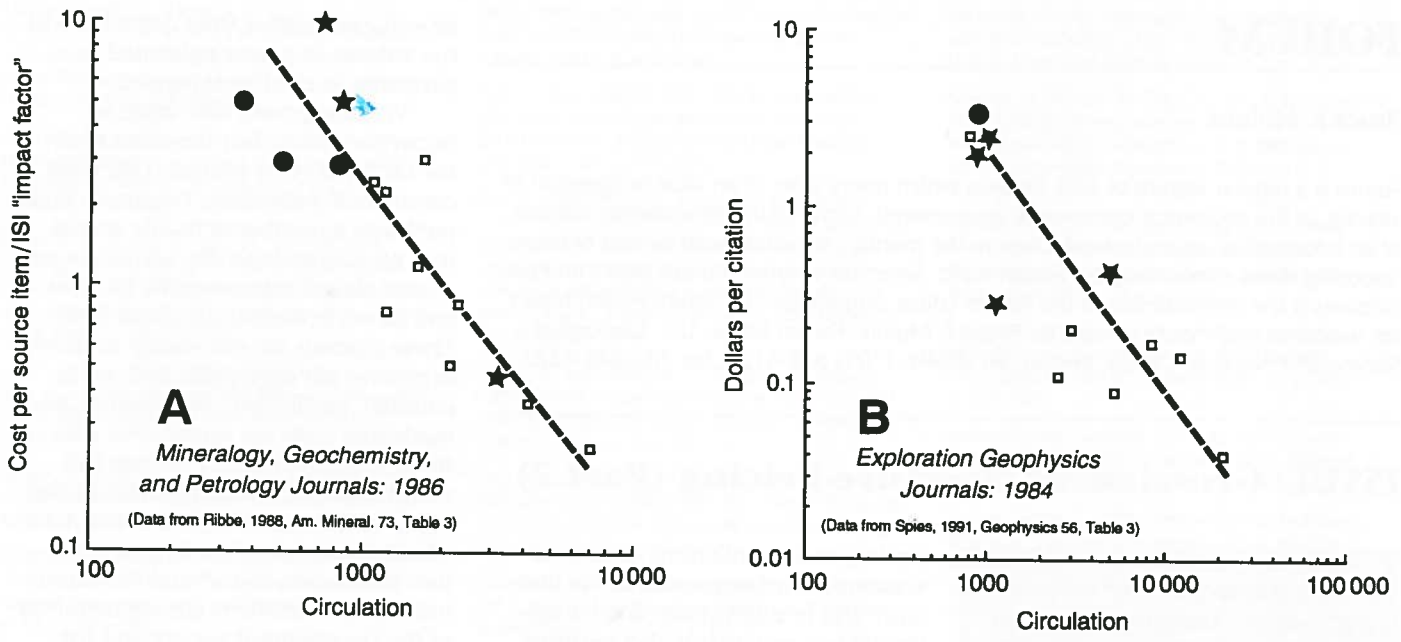


Figure 8. Circulation data for (A) 15 journals in mineralogy, geochemistry, and petrology, and (B) 12 journals in exploration geophysics, both on multilog scales. The former are plotted against cost per source item divided by the ISI impact factor, the latter against dollars per citation, the inverse of Spies' (1991) index. Circles are commercial serials; stars are serials that are under the auspices of professional societies but are published by commercial European presses; squares are journals of professional societies.

Several value parameters have been suggested. I used a "cost/quality index" in which "cost" to libraries was simplistically defined as dollars per citable source item, and "quality" as ISI's impact factor. "Cost" + "quality" = an index of "value." Another approach is to divide the journal's cost per thousand characters of text by its impact factor, or, as a measure of demonstrated usefulness to the profession, cost divided by the number of citations the journal received. Using any of these parameters, the results are similar. (1) On the average, bibliometric ratings (impact factors) for geoscience journals in general are the same whether they are published by professional societies or by the commercial press. (2) Libraries must pay, on the average, four times as much for the latter (the range: about two to more than 20 times for similar publications). (3) But of greatest interest is the fact that society journals have four times more favorable cost/quality indexes than commercial journals.

Should it matter to a scientist who chooses a journal in which to publish whether or not it has wide circulation? The logical answer is "Yes, of course." But this information is rarely available (one major commercial press refused to give it to me). Using what was available a few years back, before widespread cancellations set in, I compiled the data for Figure 8. These graphs are my final comment about the "value" of a journal in terms of its impact on a discipline. The fact that multilog scales are required to show the relation of quality per unit cost to circulation, and cost per unit impact to circulation, and that most journals fall at the high end of both graphs ought to be communicated to all those who both write and (presumably) read and use the scientific literature.

Individual authors must decide where to publish on the basis of what they value. Self-interest always has been highly weighted, in part because of intense pressures to publish from colleagues, academic administrators, and granting agencies. So to act with integrity in regard to the all-too-common phenomena of "shingling" and "the salami effect" is difficult for some. Progress in solving the crisis at hand may be slow, but it inevitably will come from informed scientists acting responsibly, from administrators or faculty senates requiring that only a limited number of papers be selected for presentation to promotion and tenure committees, from granting agencies (who have already taken some steps), and from library committees making hard decisions and canceling subscriptions to what once may have been "sacred cow" journals, perhaps on the basis of some of the criteria discussed above.

PERSPECTIVE VI: The Crisis in Publication Prices, Continued

E. M. Moores, University of California, Davis

In January 1992, to introduce a special book review section of *GSA Today,* I wrote an editorial expressing my continuing shock at the rapid rise in book prices. As an example, I discussed a book priced at $135, which could have been published by a nonprofit organization such as GSA for $20–$30, depending upon the expected sales. I also wondered what the pricing of books out of reach of students is doing to our collective educational effort. I asked what can we do as scientists to alleviate this situation and asked for replies from readers.

Most of those who responded argued that the problem was principally with certain northern European for-profit publishing houses. Comments included the following.

"The presidents of IUGS and IUGG and the presidents of the major earth science societies (GSA, AGU, AAPG, Geological Society of London, Geologische Vereinigung, Société Géologique de France, Australian Geological Society, Japan Geological Society, etc.) should write joint or separate letters to major publishers pointing out the problems, threatening cutbacks in library subscriptions, and making recommendations to its members not to publish in these journals."

"Economy-conscious scientists should not avail themselves as editors to journals with astronomical prices."

"One should encourage prospective authors not to publish books with these publishers."

"Senior scientists should advise their library-administration not to subscribe to journals and not to purchase books published by profit-making-only publishing houses; exceptions should be considered if well-reasoned special recommendations are made."

"Books or articles in journals published by profit-making-only publishing houses should be considered gray literature. Candidates for promotion or tenure should be asked why they chose to publish with such publishing houses. When such practice is generally adopted, young scientists would be much more concerned before they sign a contract or send a manuscript to an offending journal."

"Why have the costs of books nearly tripled in the past 15 years when the cost of electronics is going down? Why, when most authors have their books on disks, do many large publishers demand printouts and send them to Southeast Asia for typesetting? Price of paper skyrocketing? The American Paper Institute can't say by how much. So if you call it a factor of five, the cost of paper would have raised production costs by only 13%. Does Asian typesetting reduce costs? Nobody in the industry seems to know. Book publishing is a technological industry that does not know how to use its technology. We should encourage and implement the revolution of development of books and articles from on-line sources."

In the past year, the situation has shown no signs of abating. This continuation of the crisis has led to the suggestions made by *GSA Bulletin* Editors John E. Costa and Arthur G. Sylvester in the January 1993 *GSA Today,* and the comments in this Forum. As scientists we all would benefit by following this collective advice.

PERSPECTIVE VII: An Editor-Geoscientist's View

Jere H. Lipps, University of California, Berkeley

In the January 1992 issue of *GSA Today,* Eldridge Moores complained about the high price of books and journals issued by commercial publishers, and he suggested that they might "kill the goose that laid the golden egg." This complaint is not new; most of us have made it before. All of us believe that these publishers price their products too high.

Products? Of course. That is exactly what they are. The commercial publishers make a product for a select market, based on demand, whereas the societies perform a service. There is an enormous difference between a product

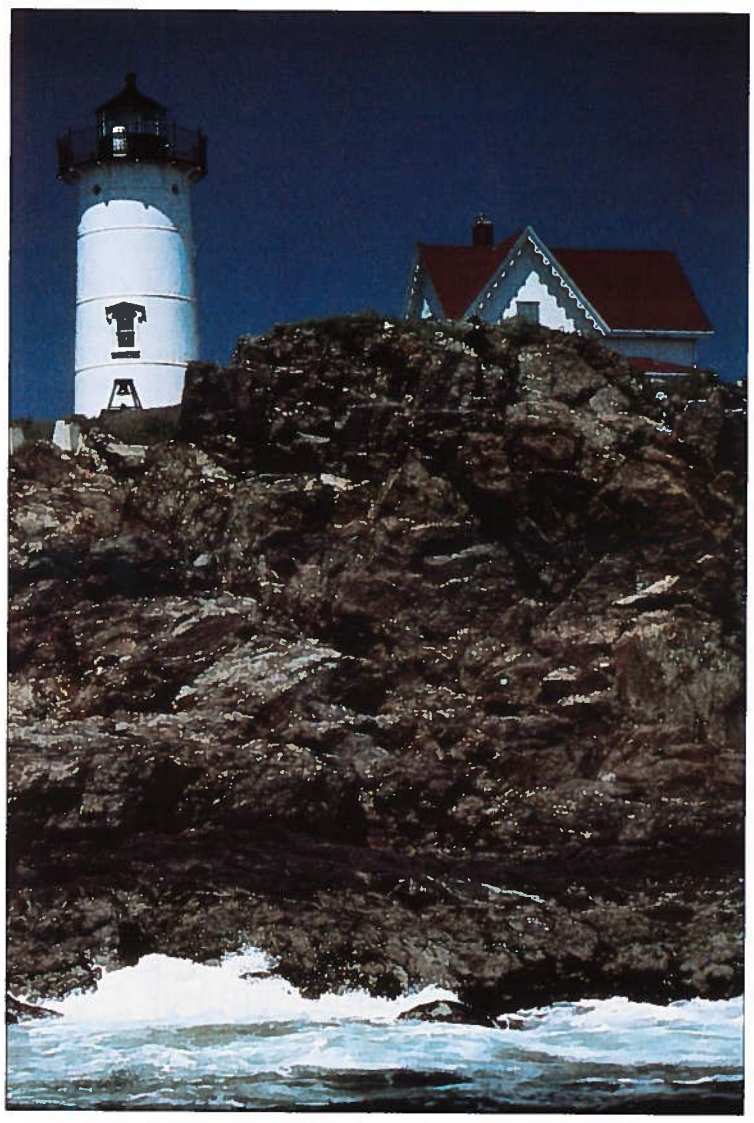
Forum *continued on p. 107*

BOSTON

CHARGING INTO THE FUTURE

1993 ANNUAL MEETING

Boston, Massachusetts ▪ October 25–28



Nubble Light on Cape Neddick, southern Maine. Rock is Cretaceous gabbro, among the youngest rock units in Maine. Photo by Thomas K. Weddle.

New England geologists are preparing a broad-based, enthusiastic welcome for GSA's Annual Meeting next October in Boston. The New England Intercollegiate Geological Conference (NEIGC), which commissioned me to issue the invitation, exists solely to organize annual field trips (and guidebooks) for professionals and students. Building on the bedrock of that tradition, the Annual Meeting Committee, from eight universities, several consulting firms, and secondary schools, has planned a meeting that is something like a Millennial Celebration. Its central focus, Geology and Health (or, as some say, "Rocks and Docs"), underscores the centrality of geological knowledge and education to discussions of human interactions with global and local environments.

Symposia, and notably the half-day Keynote Symposium, include several focused on the central theme. The rest of the program is GSA's largest ever: theme sessions, field trips of great geological variety and significance (with at least two volumes of field guides), and short courses (with text) on the cutting edge of many fields. The former Science Theater has evolved into a Computer Technology Program with its own space in the Exhibit area. A new feature, the *Science Classroom of the Future* will feature a recurring program of lectures and workshops on computer hardware and software in the service of geology, as well as a similar hands-on program. Education programs for K–12 teachers have a full range of offerings including field trips, short courses, and free one-day admission. Special events and guest activities of great variety and interest will have the special flavor of Boston. An evening performance by the 100+-voice Bravo Boston GSA Chorale is likely to elevate the musical stature of Boston to new heights.

Boston at any season is a highly stimulating scientific, academic, cultural, historic, business, gastronomic, and tourist paradise. The end of October, moreover, is the height of the foliage season, a magnificent time in New England for any outdoor interest, but especially for field trips and guest tours. The Hynes Convention Center is at the hub of the "Hub of the Universe" (as Bostonians say) near Quincy Market, the waterfront, and many of the above attractions, within walking distance or a short ride on the MBTA (the public transport). On behalf of the Annual Meeting Committee and the geologists of New England's IGC, I am pleased to invite you to Boston and look forward to welcoming you to what we hope and expect will be one of the most significant and most enjoyable meetings of GSA in this millennium.

Jim Skehan, S.J.
General Chairman, 1993 Annual Meeting Committee

REGISTRATION AND DETAILS: *JUNE GSA Today*

ABSTRACTS DUE JULY 7; PREREGISTRATION DUE SEPTEMBER 24
For abstracts forms (303) 447-8850

REGISTRATION, HOUSING, AND PROGRAM INFORMATION AVAILABLE JUNE 1
(303) 447-2020 or 1-800-472-1988

ASSOCIATED SOCIETIES
Association for Women Geoscientists ▪ Association of Geoscientists for International Development ▪ Cushman Foundation ▪ Geochemical Society ▪ Geoscience Information Society ▪ Mineralogical Society of America ▪ National Association of Geology Teachers ▪ National Earth Science Teachers Association ▪ Paleontological Society ▪ Sigma Gamma Epsilon ▪ Society of Economic Geologists ▪ Society of Vertebrate Paleontologists

Call for Papers and Announcement of Symposia and Theme Sessions

ABSTRACTS DEADLINE FOR INVITED AND VOLUNTEERED PAPERS—WEDNESDAY, JULY 7

Technical sessions consist of both invited and volunteered papers organized in one of three presentation formats: symposia, theme sessions, and discipline sessions. *All abstracts are due for review by July 7.*

The Joint Technical Program Committee (JTPC) will select abstracts and determine the final session schedule. The JTPC consists of approximately 30 geoscientists representing each of the associated societies and GSA divisions participating in the technical program. The JTPC chairs, nominated by the Boston Annual Meeting Committee and approved by the GSA Council, also serve a four-year term on GSA's ongoing Program Committee, which oversees all technical program activities.

The JTPC meets August 6–7 in Boulder, Colorado. Speakers will be notified within 14 days following that meeting.

The final session schedule will appear in the September issue of *GSA Today.*

1993 TECHNICAL PROGRAM CHAIRS

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Harvard University
Dept. of Earth and Planetary Sciences
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Gradient Corporation
44 Brattle Street
Cambridge, MA 02138
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Fax: 617-864-8469

PRESENTATION MODES

Papers may be presented in one of two modes:

Oral—This is a verbal presentation before a seated audience. The normal length of an oral presentation is 15 minutes, including time for discussion. Projection equipment consists of two 35 mm projectors, one overhead projector, and two screens.

Poster—Approximately 40% of volunteered papers are presented in poster mode. Each poster-session speaker is provided with three horizontal, free-standing display boards approximately 8' wide and 4' high. The speaker must be present for at least two of the four presentation hours.

Papers for discipline sessions may be submitted in either oral or poster mode.

Papers for theme sessions are to be submitted in oral mode only, except for T21 and T35. If the abstract is submitted in the incorrect mode, the abstract will NOT be considered for the theme session, but will automatically be considered for a discipline session instead.

ABSTRACT FORMS

All abstracts must be submitted on the **1993 Abstract Form,** available from the Abstracts Coordinator at GSA headquarters, from the conveners of symposia, from the geoscience departments of most colleges and universities, and from the main federal and state survey offices. The abstract form will be used as camera-ready copy for publication of *Abstracts with Programs.*

SPEAKER—AUTHOR LIMITATIONS

Because of scheduling limitations, **submit only one volunteered abstract** as speaker or poster presenter for discipline and/or theme sessions. Multiple submissions as speaker-presenter for volunteered abstracts may result in rejection of all abstracts. Note that this limitation does not apply to, nor does it include, invited contributions to symposia.

Geology and Health: 1993 Annual Meeting Theme

The health of humanity requires adequate natural resources and a benign environment. Achieving these requirements will depend heavily on advances in the geological sciences. The human family will need new insights, new techniques, and solutions to a wide range of local, regional, and global problems. The symposia and theme sessions devoted to Geology and Health at GSA 1993 will address these needs.

Keynote Symposium: Geology and Health

Leading off the theme on Monday morning will be a special Keynote Symposium sponsored by the Boston Annual Meeting Committee and organized by Heinrich D. Holland, Harvard University and Teresa S. Bowers, Gradient Corporation.

The science and practice of geology have contributed a great deal to the health of mankind. They are also responsible for a number of environmental hazards. The symposium addresses some of the current environmental threats to human health and assesses the likely changes in their intensity during the coming decades.

GSA's Institute for Environmental Education (IEE) Sponsors 1993 Programs

The IEE provides an educational interface between the geological community and the private and public sectors on matters of the environment. IEE programs are directed at strengthening the role of geoscientists in areas of geologic hazards mitigation, land use management, mineral and energy resources management, waste management, and water resources management.

The IEE, in cooperation with the GSA Geology and Public Policy Committee, will sponsor its second Annual Environmental Forum on Sunday afternoon, October 24. The forum, A Crisis in Waste Management, Economic Vitality, and a Coastal Marine Environment: Boston Harbor and Massachusetts Bay, concerns an example of the problem of balancing active port functions and waste disposal with restoration and protection of the marine environment in and around a large coastal metropolitan area. The Boston Harbor–Massachusetts Bay area is used for transportation, fishing , recreation, and tourism, as well as waste disposal, and the forum will examine from many points of view the sometimes conflicting science, policy, economic, and legal issues surrounding the cleanup of Boston Harbor.

In addition to the forum, IEE will also sponsor or cosponsor with GSA divisions several theme sessions in the technical program. These are identified with the global symbol IEE.

Invited Papers (Symposia)

This format includes only abstracts that have been invited by the convener of a symposium. *Abstracts are to be sent directly to the convener by July 7.* The convener is responsible for obtaining two independent reviews of each abstract, and for sending the reviews and the abstracts to GSA headquarters prior to the JTPC meeting.

The 1993 symposia are listed below. A preliminary schedule will be available by May 15. Please call the GSA Meetings Department for information.

S1. **Keynote Symposium—Geology and Health.**
1993 Annual Meeting Committee. Heinrich D. Holland, Harvard University; Teresa S. Bowers, Gradient Corporation, Cambridge, Massachusetts.

S2. **Fractal Geometry and Chaos Theory and Their Use in the Earth Sciences.**
Engineering Geology Division. Christopher C. Barton, U.S. Geological Survey, Denver.

S3. **Geological Insight and Ground-water Modeling.**
Hydrogeology Division. Kenneth Belitz, Dartmouth College; Leonard F. Konikow, U.S. Geological Survey, Reston.

S4. **The Permian-Triassic Mass Extinction: Causes and Consequences.**
Paleontological Society. David J. Bottjer, University of Southern California.

S5. **Fluids and Fluid Flow in the Crust.**
Geochemical Society. Susan L. Brantley, Pennsylvania State University; Barbara L. Dutrow, Louisiana State University.

S6. **Inferring Paleoearthquakes from Fault-Rock Fabrics: Experimental and Field Evidence.**
Structural Geology and Tectonics Division. Frederick M. Chester, St. Louis University; Ronald L. Bruhn, University of Utah.

S7. **Coalification: Metamorphic Parameters and Interpretation of Maturation Histories.**
Coal Geology Division. Alan Davis, Pennsylvania State University; Paul C. Lyons, U.S. Geological Survey, Reston.

S8. **Sedimentological and Stratigraphic Framework of Ground-water Resources.**
Sedimentary Geology Division, SEPM (Society for Sedimentary Geology). Gordon S. Fraser, Indiana Geological Survey; Mary P. Anderson, University of Wisconsin—Madison.

S9. **Neogene and Quaternary Sea-level Change and Coastal Plain Evolution: U.S. East Coast.**
Quaternary Geology and Geomorphology Division. Thomas W. Gardner, Pennsylvania State University; Peter C. Patton, Wesleyan University.

S10. **Organics and Ore Deposits.**
Society of Economic Geologists, International Geological Congress. Thomas H. Giordano, New Mexico State University.

S11. **Geochemical Aspects of Minerals in Physiological Fluids.**
Mineralogical Society of America. George Guthrie, Los Alamos National Laboratory.

S12. **Sedimentary Diagenesis of Nitrogen and Sulfur in Organic Matter.**
Organic Geochemistry Division of the *Geochemical Society.* Robert I. Haddad, Unocal Corporation, Brea, California; Marty B. Goldhaber, U.S. Geological Survey, Denver.

S13. **Evolution and Global Consequences of the Himalayan Orogenic System.**
International Division. Kip V. Hodges, Massachusetts Institute of Technology.

S14. **Deep Seismic Imaging across Continental Margins: From the Ocean-Continent Boundary to the Beach and Beyond.**
Geophysics Division. Simon L. Klemperer, Stanford University; W. Steven Holbrook, Woods Hole Oceanographic Institution, Massachusetts.

S15. **Human Problems, Foraminiferal Solutions.**
Cushman Foundation. Jere H. Lipps, University of California, Berkeley; David B. Scott, Dalhousie University, Halifax, Nova Scotia.

S16. **The First Half-Billion Years in the Inner Solar System.**
Planetary Geology Division. George E. McGill, University of Massachusetts.

S17. **Chlorine and Fluorine as Monitors of Fluid-Rock Interaction: New Developments.**
Geochemical Society, Mineralogical Society of America. Jean Morrison, University of Southern California; James L. Munoz, University of Colorado.

S18. **Historical Research as a Function of Exploration Methodology.**
History of Geology Division. Samuel T. Pees, Samuel T. Pees and Associates, Meadville, Pennsylvania.

S19. **Analytical Methods in Archaeological Geology.**
Archaeological Geology Division. Henry P. Schwarcz, McMaster University, Hamilton, Ontario.

S20. **Beyond Student Literacy: How To Create an Earth-Literate Public.**
Geoscience Education Division. Dorothy L. Stout, Cypress College, California.

S21. **Successfully Funded Laboratory and Field Technique Programs in the Geosciences.**
National Association of Geology Teachers, National Science Foundation. Brian B. Tormey, Pennsylvania State University; Susan Hixson, National Science Foundation.

S22. **Finding and Communicating Geoscience Information.**
Geoscience Information Society. Constance S. Wick, Harvard University.

S23. **Metamorphic and Metamorphosed Ore Deposits.**
Society of Economic Geologists. Half Zantop, Dartmouth College.

Volunteered Papers

This format includes all abstracts that are not specifically invited for a symposium. Each paper will have a minimum of three reviews. Two types of sessions are available:

1. DISCIPLINE SESSIONS

Papers are submitted to one scientific category (discipline). The JTPC representatives select and schedule the papers in sessions focused on this one discipline, e.g., hydrogeology, geochemistry.

2. THEME SESSIONS

Papers are submitted to a specific pre-announced title and to ONE scientific category. Theme sessions are interdisciplinary; each theme may have as many as three categories from which authors may choose ONE. After each theme description below, the categories are identified by name and number as they appear on the **1993 Abstract Form.**

Theme submissions must include:

- the theme number (e.g., T11),
- five key words of the theme title (e.g., Environmental Geology: The Voice/Warning), and
- one category (e.g., Environmental Geology—#6 on abstract form).

Papers for theme sessions are to be submitted in oral mode only, except for T21 and T35. If the abstract is submitted in the incorrect mode, the abstract will NOT be considered for the theme session, but will automatically be considered for a discipline session instead.

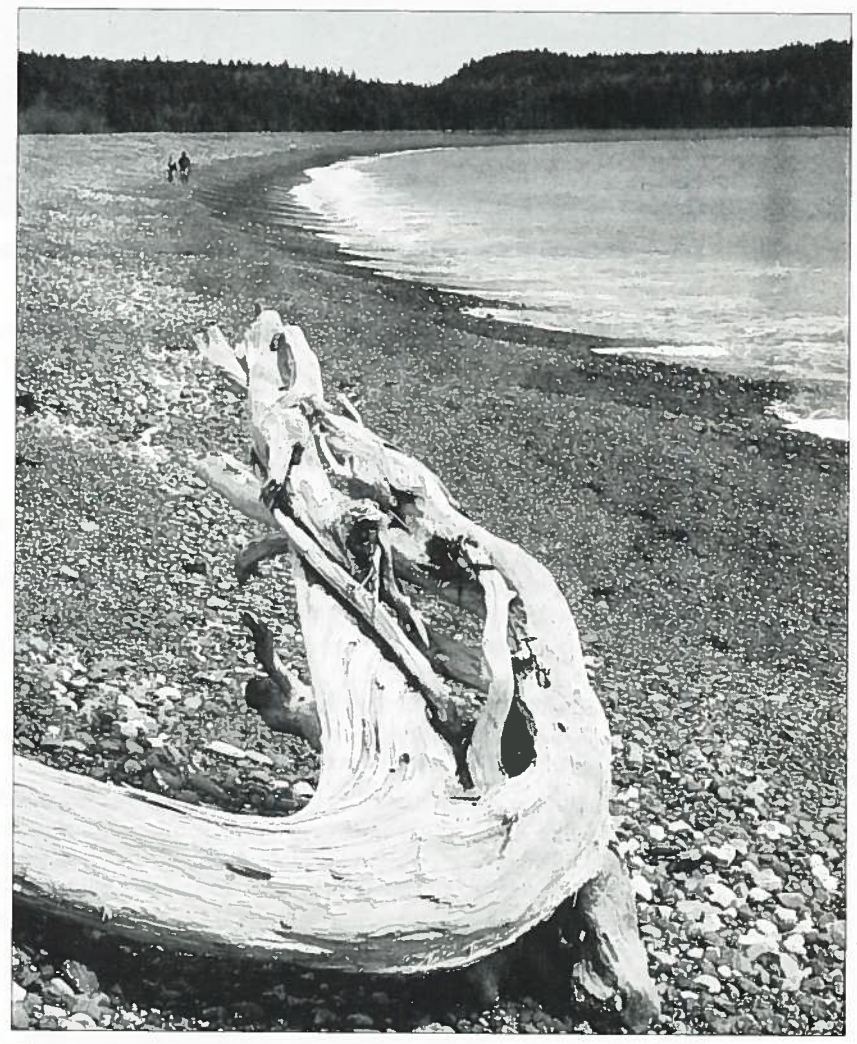
Each theme session has been proposed by an advocate. *Advocates may not invite speakers; however, advocates may encourage colleagues to submit abstracts, with the understanding that there is no guarantee of acceptance.* Each theme advocate evaluates abstracts initially only on the basis of topical relevance.

All abstracts will then be evaluated by three appropriate JTPC reviewers in the discipline for which they are submitted; a fourth review will be provided by the theme advocate.

If an abstract is submitted to but not accepted for a theme session, it will continue through the evaluation process to be considered for the appropriate discipline session.

During the August 6–7 JTPC meeting, the designated JTPC representative (in consultation with the theme advocate) will organize theme sessions from the abstracts approved for presentation.

Schedules for theme sessions will be available immediately after the JTPC meeting and will appear in the September issue of *GSA Today.*



Jasper Beach, Machiasport, Maine. The beach derives its red cobbles from erosion of Devonian rhyolite. Beach cusps are particularly well developed. Photo by Thomas K. Weddle.

Theme Topics

T1. **Fractal Geometry, Self-Organized Criticality, Chaos Theory, and Their Application in the Earth Sciences.**
Engineering Geology Division. Christopher C. Barton, U.S. Geological Survey, Denver.

Fractal geometry provides a means of mathematically describing and modeling the complex patterns that earth scientists and engineers map, measure, and describe in ever-increasing detail. The physical processes and their spatial and temporal evolution that result in fractal patterns are described by two theories, self-organized criticality (few degrees of freedom) and chaos theory (many degrees of freedom). All three are being extensively applied to earth science data sets and processes. These sessions are coordinated with the GSA short course Fractals and Their Use in Earth Sciences, which is part of the meeting on October 29–30.

Engineering Geology (5).

T2. **Tectono-metamorphic Evolution of North and Central America.**
Rob Berman, Geological Survey of Canada, Ottawa, Ontario.

This session focuses on an ongoing project to compile a metamorphic map of North and Central America. The emphasis will be on display of preliminary regional-scale maps, although more detailed studies that affect representation and/or digital manipulation of metamorphic, geochronologic, and petrologic data are also welcome.

Petrology, Metamorphic (22), Structural Geology (30), Tectonics (31).

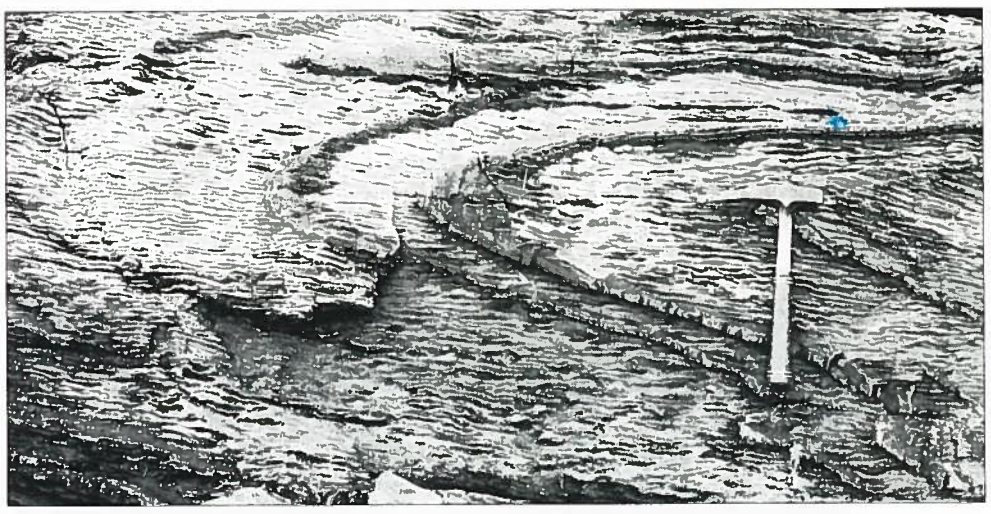
T3. **Teaching Mineralogy. Mineralogical Society of America.**
John B. Brady, Smith College, Northampton, Massachusetts; Jo Laird, University of New Hampshire.

The goal of this session is to encourage dialogue about the teaching of mineralogy to undergraduates in the 1990s. Speakers are encouraged who will share their thoughts about the content of a mineralogy course and their ideas about how to make modern mineralogy exciting and accessible to undergraduate students.

Geology Education (9), Mineralogy/Crystallography (16).

T4. **Coalification: Metamorphic Parameters and Interpretation of Maturation Histories.**
Coal Geology Division. Alan Davis, Pennsylvania State University; Paul C. Lyons, U.S. Geological Survey, Reston.

This theme session will follow the symposium on the same subject in order to consider organic geochemical information and the mineralogy of coal-measure



Fold with axial plane cleavage in bedded Proterozoic limestone. Rockport Harbor, Maine. Photo by Henry N. Berry IV.

rocks in addition to regional patterns of coal rank and organic maturation.

Coal Geology (2), Geochemistry, Aqueous/Organic (7), Mineralogy/Crystallography (16).

T5. **Geochemistry of Large Rivers.**
John M. Edmond, Massachusetts Institute of Technology.

Large rivers are being affected by human activities at an increasing rate. Drainage areas contribute measurably to the overall geochemical cycles of the elements, and detailed sampling reveals this on a continental as well as local scale. Recent results from large, pristine systems will be presented.

Environmental Geology (6), Geochemistry, Other (8), Hydrogeology (13).

T6. **Geologic Impacts of the Gulf War.**
Farouk El-Baz, Boston University; Ali Al-Shamlan, Kuwait Foundation for the Advancement of Science, Kuwait.

The invasion of Kuwait on August 2, 1990, and the war that followed resulted in much damage to the environment of Kuwait, southern Iraq, and northeastern Saudi Arabia. The geologic impacts include pollution of the coastal zone from major oil spills and disruption of the desert surface from military activities.

Environmental Geology (6), Marine Geology (14), Quaternary Geology/Geomorphology (25).

T7. **Hydrogeochemistry Related to Health and Disease.**
Hydrogeology Division, Institute for Environmental Education.
Gerald L. Feder and Edward R. Landa, U.S. Geological Survey, Reston.

The geochemical environment has a major influence on drinking-water quality, and the resulting water quality may have an important effect on health and disease. Some health effects may be a result of naturally occurring chemical constituents. Additionally, the geochemical environment may influence the fate and transport of anthropogenic contaminants. This theme session will explore studies relating hydrogeochemical processes to patterns of human and animal health and disease. Studies involving direct collaboration of earth science and health professionals are especially welcomed.

Environmental Geology (6), Geochemistry, Aqueous/Organic (7), Hydrogeology (13).

T8. **The Urban Ocean Environment: Geological Perspectives.**
Sedimentary Geology Division, SEPM (Society for Sedimentary Geology).
Michael E. Field, U.S. Geological Survey, Menlo Park; Bradford Butman, U.S. Geological Survey, Woods Hole.

Estuaries and continental shelves adjacent to metropolitan centers are a focus of increasing public concern because of contamination from pesticides, sewage, hydrocarbons, heavy metals, and other toxic and hazardous wastes. Contaminants are often associated with sediment particles, especially fine-grained sediments, and geological studies can provide key information on the distribution, transport, and long-term fate of contaminants, and perspective for identifying solutions. This theme session will demonstrate how national environmental issues in estuaries and urban ocean settings are being addressed using state-of-the-art concepts employed by sedimentary geologists and oceanographers.

Environmental Geology (6), Marine Geology (14), Sediments, Clastic (28).

T9. **Processes of Supradetachment Basins.**
Julio Friedmann, University of Southern California; Robert P. Fillmore, University of Kansas, Lawrence.

Understanding of supradetachment basins currently lags behind that of most other basin types. This session will examine the processes affecting the fill, structure, and geometry of basins formed above detachment faults. Stratigraphy, structural geology, and geochronology with respect to the style, pace, and tectonic significance of basin development will be emphasized.

Stratigraphy (29), Structural Geology (30), Tectonics (31).

T10. **Environmental Geology: The Voice of Warning.**
Geology and Public Policy Committee, Institute for Environmental Education. Monica Gowan, GeoLogic, Bellingham, Washington.

Community decision making that leads to wiser use of Earth requires a citizenry informed on the risks of natural hazards, resource availability and consumption, and the impacts of human activities. The session goal is to encourage geologists to participate in developing citizenry that is well informed on critical environmental issues.

Engineering Geology (5), Environmental Geology (6), Hydrogeology (13).

T11. **Environmental Geology: The Voice of Reason.**
Geology and Public Policy Committee, Institute for Environmental Education.
Monica Gowan, GeoLogic, Bellingham, Washington.

Decision makers are commonly influenced by public opinion and the perceived risks of environmental hazards. The session goal is to encourage geologists to advocate the application of appropriate geoscience information in proposed environmental solutions, and to assist the public in developing a rational perspective that incorporates the relevant geoscience.

Environmental Geology (5), Engineering Geology (6), Hydrogeology (13).

T12. **Interpreting Stromatolites: Biological vs. Sedimentological Information.**
John P. Grotzinger, Massachusetts Institute of Technology; Andrew H. Knoll, Harvard University.

Stromatolites are the quintessential features of Precambrian carbonate sedimentary rocks. They are widely considered to be a principal source of information on the early evolution of life on Earth. However, as organo-sedimentary structures, their morphologies and microfabrics are not determined solely by biological activities. Developments over the past few decades have illustrated how important the environment is in controlling morphology and how carbonate deposition and diagenesis influence microfabric. This theme session will explore the interrelations between biologic and sedimentologic controls on stromatolite development with a view toward establishing their relative roles.

Paleontology/Paleobotany (18), Precambrian Geology (24), Sediments, Carbonates (27).

T13. **Mineral Resources in Developing Nations: Economic Impact and Environmental Concerns.**
Institute for Environmental Education. Carroll Ann Hodges, U.S. Geological Survey, Menlo Park; Half Zantop, Dartmouth College.

Mineral resource issues were conspicuously absent at the 1992 Earth Summit, but that forum demonstrated that environmental consciousness is not confined to the industrialized world. Mitigation of environmental problems will likely be increasingly required in developing nations economically dependent on exploiting their mineral endowment. The session will focus on the costs and benefits to all parties.

Economic Geology (4), Engineering Geology (5), Environmental Geology (6).

T14. **Evolution and Global Consequences of the Himalayan Orogenic System.**
International Division. Kip V. Hodges, Massachusetts Institute of Technology.

This theme session will follow the symposium on the same subject and is designed to facilitate an exchange of ideas among geologists working in the Himalayas and paleoclimatologists concerned with possible worldwide consequences of Himalayan orogenesis. The session will be devoted to the rapidly expanding geologic and geochronologic database for the orogen, general reviews of the tectonic evolution of different segments of the orogen, and geochemical and paleontological evidence for the nature and timing of Miocene-Pliocene climatic changes.

Geochemistry, Other (8), Paleontology/Paleobotany (18), Tectonics (31).

T15. **Evolution and Biogeography of Marine Microplankton During the Paleocene Epoch.**
Brian T. Huber, Smithsonian Institution; Richard K. Olsson, Rutgers University.

This session will outline recent advances in biochronology, taxonomy, phylogeny, and biogeography of the various groups of marine microplankton that evolved following the terminal Cretaceous extinctions and during the rest of the Paleocene epoch. These will be related to the major paleoceanographic changes that occurred at this time.

Micropaleontology (15), Paleoceanography/Paleoclimatology (17), Stratigraphy (29).

T16. **Health Implications of Metals in Soils.**
Engineering Geology Division, Institute for Environmental Education.
Holly L.O. Huyck, Denver, Colorado; Charles W. Welby, North Carolina State University.

This theme session will explore hazardous characteristics of trace metals in soils. Effects of mineralogy and geochemistry on metal behavior in soils and on resulting bioavailability to plants or people are emphasized. Presentations on amelioration of such effects are also encouraged. This session combines engineering and environmental geology, geochemistry, soil science, and related medical research.

Engineering Geology (5), Environmental Geology (6), Geochemistry, Other (8)

T17. **Constraints on the Evolution of the Early Earth.**
Stein B. Jacobsen and Charles L. Harper, Harvard University.

This symposium will focus primarily on new field observations, isotopic, trace element, experimental and modeling constraints on the Hadean as well as the very earliest Archean rocks such as Acasta and Isua. The major questions to be addressed are the timing of the differentiation of Earth into crusts, mantle, core oceans, and atmosphere, as well as the state of Earth at the end of the Hadean era.

Geochemistry, Other (8), Petrology, Igneous (21), Petrology, Metamorphic (22)

T18. **Paleogeography of Silurian Taconica.**
Markes E. Johnson, Williams College, Williamstown, Massachusetts; David Roy, Boston College.

The session will be devoted to the passive flank of Silurian Taconica, as understood through temporal and spatial changes in the geology of the Appalachian Trough facing the stable platform interior of Laurentia. Aspects of climate, sea-level change, sedimentary provenance, and marine communities will be characterized for the highly variable shoreline from Quebec to Alabama.

Paleontology/Paleobotany (18), Sediments, Clastic (28), Stratigraphy (29).

T19. **The Cretaceous-Tertiary Boundary Event: Biotic and Environmental Changes.**
Gerta Keller and Norman MacLeod, Princeton University.

This theme session will focus on the biotic and environmental effects across the Cretaceous-Tertiary (K-T) transition in a wide spectrum of fossil organisms, stable isotopes, and mineralogic and sedimentologic features in order to assess the timing, duration, nature, and geographic structure of the mass extinction, the associated environmental changes, and the relation to proposed impact horizons. Special emphasis will be placed on new data which indicate that the K-T boundary mass extinction may have been primarily a low-latitude event. Environmental changes in climate, sea level, precipitation, runoff, wind stress, and circulation will be explored. Papers are invited on any of the above biotic and environmental changes and their relation, if any, to the hypothesized bolide impact.

Paleoceanography/Paleoclimatology (17), Paleontology/Paleobotany (18), Stratigraphy (29).

T20. **The New England–Acadian Shoreline Revisited.**
Joseph T. Kelley, University of Maine.

The coastal-marine geology of our shoreline began with the classic work of D. W. Johnson 75 years ago. This session will highlight the progress that has occurred since Johnson's time. It will also consider the numerous legal and regulatory issues that have evolved along with our understanding of coastal processes and human activities.

Environmental Geology (6), Marine Geology (14), Quaternary Geology/Geomorphology (25).

T21. **Deep Seismic Imaging across Continental Margins: From the Ocean-Continent Boundary to the Beach and Beyond.**
Geophysics Division. Simon L. Klemperer, Stanford University; W. Steven Holbrook, Woods Hole Oceanographic Institution, Massachusetts.

This poster theme session will follow the symposium on the same subject in order to pursue recent advances in seismic imaging and measurement of geophysical properties of the marginal and transitional crust. Poster presentations are desired that will bring together results from recent experiments across a range of margins, U.S. and worldwide, that will exemplify the quality and range of new results, the implications for the structure and evolution of continental margins, and the potential for future work.

Geophysics/Tectonophysics (10), Structural Geology (30).

T22. **Fate and Transport of Contaminants in Boston Harbor and Massachusetts Bay.**
Sedimentary Geology Division, SEPM (Society for Sedimentary Geology). Harley J. Knebel and Michael H. Bothner, U.S. Geological Survey, Woods Hole.

This session will highlight recent marine geological, geochemical, and sediment transport studies of Boston Harbor and Massachusetts Bay. The focus will be on processes that influence the present levels of contaminants in the sediments, on the probable fate of wastes from future discharges offshore, and on techniques applicable to the study of marine contamination near other metropolitan areas.

Environmental Geology (6), Marine Geology (14), Sediments, Clastic (28).

T23. **Advances in Tectonic Models of Precambrian Orogens from Structural Geology and Geochronology.**
Timothy M. Kusky, Boston University; Samuel A. Bowring, Massachusetts Institute of Technology.

Tectonic models for Precambrian orogens have been difficult to constrain. Recent developments in structural geology and U-Pb geochronology have led to a blossoming of applications of modern plate-tectonic models to these complex orogenic belts. Strain and kinematic studies of deformed rocks together with high-precision age determinations on crosscutting rock units enables a precise structural chronology to be established. This symposium will examine how our understanding of Precambrian tectonic style has changed since these techniques have been applied to Precambrian orogenic belts.

Geochemistry, Other (8), Precambrian Geology (24), Structural Geology (30).

T24. **The Geology of Natural Gas Resources: Challenges and Opportunities.**
Stephen E. Laubach, University of Texas at Austin.

The efforts of geologists to help better understand complex gas-reservoir rocks will be a key to gaining access to healthful energy resources in the future. Much of the natural-gas resource is in structurally, stratigraphically, and diagenetically compartmentalized rocks, in coal seams and shales, and in low-permeability, naturally fractured sandstones.

Economic Geology (4), Petroleum Geology (19), Sediments, Clastic (28).

Large recumbent fold in Silurian-Devonian matasedimentary rocks near summit of Mt. Monadnock, New Hampshire. Photo by J. Christopher Hepburn.

T25. **Structure and Geophysics of the Appalachian Orogen.**
Geophysics Division. James Luetgert, U.S. Geological Survey, Menlo Park; David B. Stewart, U.S. Geological Survey, Reston.

The Appalachian orogen is one of the major tectonic features of North America, yet our knowledge of its deep structure is surprisingly limited. Several recent geophysical experiments have begun to address this situation. A major cooperative experiment involving U.S. and Canadian Geological Surveys, U.S. Air Force, and university groups provides a transect across the northern part of this orogen. Canadian workers have headed up recent efforts in the maritime provinces. Smaller but significant efforts have focused on the central and southern parts of this orogen. This session will bring those working on Appalachian structure together to present recent results and focus on outstanding problems.

Geophysics/Tectonophysics (10), Structural Geology (30), Tectonics (31).

T26. **High-resolution Paleozoic Isochrons.**
Paul C. Lyons, U.S. Geological Survey, Reston; Warren D. Huff, University of Cincinnati.

This session will focus on Appalachian high-resolution isochrons such as K-bentonites, tonsteins (altered volcanic ash beds), meteorite impact beds, rapidly deposited marine marker beds, and the like, which have extensive geographic distribution and have been deposited over a short duration (generally <1000 years).

Geochemistry, Other (8), Sediments, Clastic (28), Stratigraphy (29).

T27. **Paleoenvironments in Oxygen-deficient Basins: The Carbon-Sulfur-Iron System and Related Geochemical and Ecological Constraints.**
Society of Economic Geologists. Timothy W. Lyons, University of Michigan; Carlton E. Brett, University of Rochester.

The sedimentary record of the carbon-sulfur-iron biogeochemical system, including such parameters as C/S ratios and degrees-of-pyritization, has demonstrated value for the recognition of depositional redox conditions in ancient marine sequences. In light of the tremendous advances made in recent decades and the wide application of these methods, the timing is right for a systematic reassessment of the promises and pitfalls of C-S-Fe paleo-oxygen proxies and other related geochemical and ecological indicators of paleoenvironment.

Economic Geology (4), Geochemistry, Other (8), Sediments, Clastic (28).

T28. **First Transition Series Metals and Health: Fact and Fiction.**
George R. McCormick, University of Iowa.

Base metals of the first transition series have been a mainstay of U.S. mining and industry. The public press has been long on unsubstantiated harmful effects to health and short on statements of the beneficial effects of these metals on health. Documented studies of both beneficial and harmful effects will be presented in this theme session.

Economic Geology (4), Environmental Geology (6), Geochemistry, Other (8).

T29. **Applications of Modern Geodetic Techniques to the Solution of Geological Problems.**
National Research Council, Committee on Geodesy. Jean-Bernard Minster, Scripps Institution of Oceanography; B. Clark Burchfiel, Massachusetts Institute of Technology.

Talks will focus on the contribution of space-geodetic techniques to the solution of important geological problems, including continental collisions and plate-deformation zones, as well as other geodetic techniques, such as satellite altimetry and airborne gravimetry and geodesy, to elucidate geological issues in both continental and marine environments.

Geophysics, Tectonophysics (10), Remote Sensing (26), Tectonics (31).

T30. **Isotope Paleobiology.**
Richard D. Norris, Woods Hole Oceanographic Institution; Richard M. Corfield, Oxford University, United Kingdom.

Geochemical data have enormous potential for interpreting biotic evolution, ecology, and systematics. These data can be used to infer the ecological history of clades, patterns of ecological radiation, and evolution of life histories, as well as taxonomic relationships. In this session we will ask how these subjects may be explored using light stable isotope and organic geochemical techniques on groups as diverse as protistans and vertebrates.

Geochemistry, Aqueous/Organic (7), Geochemistry, Other (8), Paleontology/Paleobotany (18).

T31. **New Perspectives on the Evolution of Atlantic Continental Rises.**
Dennis O'Leary, U.S. Geological Survey, Denver; C. Wylie Poag, U.S. Geological Survey, Woods Hole.

This session will highlight new technologies, new data, and new interpretations that explicate the Jurassic to Holocene physiography, stratigraphy, and depositional environments of continental rises in the Atlantic Ocean and contiguous smaller seas. Particular emphasis will be given to the interaction of tectonic, paleoclimatic, paleoceanographic, and sedimentary processes that formed these rises.

Marine Geology (14), Paleoceanography/Paleoclimatology (17), Stratigraphy (29).

T32. **Geochemistry and Chronology of Appalachian Mylonites and Shear Zones.**
Nicholas Rast, University of Kentucky; Alexander E. Gates, Rutgers University.

This session will deal with the timing of the generation and movements of shear zones in the Appalachians, together with consideration of dynamic chemical-deformational systems in shear zones, with emphasis on rock-fluid equilibria.

Geochemistry, Other (8), Structural Geology (30), Tectonics (31).

T33. **Environmental Issues in Urban Settings.**
Quaternary Geology and Geomorphology Division, Institute for Environmental Education. John C. Ridge, Tufts University.

Human utilization of Earth's surface is maximized in urban settings. Environmental issues related to water supply, waste disposal, and adaptation to geologic processes must be a part of future planning. Of particular concern in Boston are earthquake hazards, coastal storms, waste disposal, and the geological considerations of tunnel construction.

Engineering Geology (5), Environmental Geology (6), Quaternary Geology/Geomorphology (25).

T34. **Metamorphism, Fluid Flow, and Ore Deposits.**
Society of Economic Geologists. Douglas Rumble, Geophysical Lab, Washington, D.C.; Half Zantop, Dartmouth College.

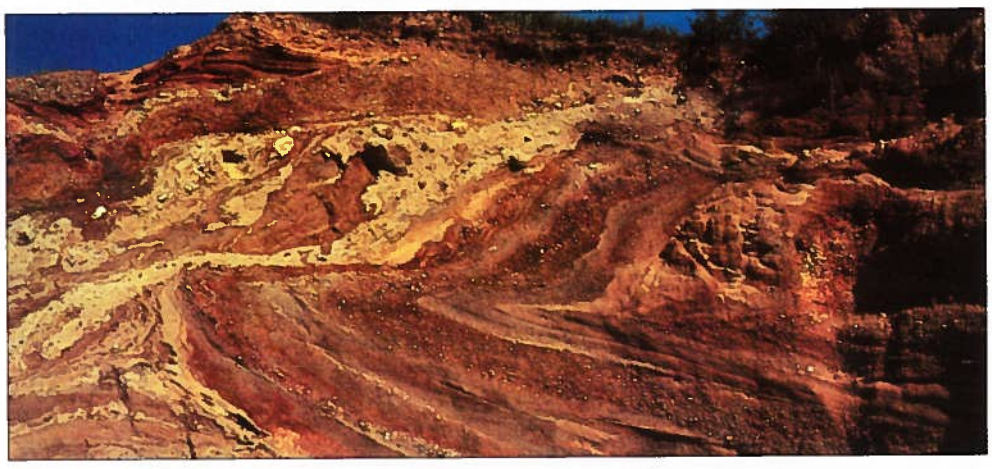
This session will address the question of fluid flow during metamorphism and its relation to metamorphic and metamorphosed ore deposits. Multidisciplinary contributions are encouraged, including field- and theoretically based studies as well as mineralogical, thermodynamic, isotopic, and fluid-inclusion investigations. Both new data and critical reviews are welcome.

Economic Geology (4), Geochemistry, Aqueous/Organic (7), Petrology, Metamorphic (22).

T35. **Flow and Transport in Variable-density Ground Water.**
Hydrogeology Division. Ward E. Sanford, U.S. Geological Survey, Reston; Shirley J. Dreiss, University of California, Santa Cruz.

In many ground-water systems, variations in fluid densities significantly affect physical and geochemical processes. This session will focus on recent laboratory, field, and computational studies of these processes in regions with significant density contrasts, e.g., relatively light or dense contaminant plumes, salt-water fresh-water interfaces, and thermal buoyancy problems. Both oral and poster presentations are encouraged.

Environmental Geology (6), Geochemistry, Aqueous/Organic (7), Hydrogeology (13).



Ice shove features in a Pleistocene end moraine, Addison, Maine. Photo by Thomas K. Weddle.

T36. **Geologic Disposal of Nuclear Waste and the Risks to Public Health and Safety.**
Institute for Environmental Education. Malcolm D. Siegel, Sandia National Laboratories.

More than two decades of research have failed to produce a consensus on the feasibility of the safe geologic disposal of nuclear waste. This theme session will focus on recent geological investigations identifying the risks associated with proposed plans for disposal of high-level, transuranic, and low-level wastes. Papers describing either the existence or absence of risks associated with geologic repositories, surface storage of nuclear waste, and natural uranium deposits are appropriate.

Engineering Geology (5), Environmental Geology (6), Geochemistry, Aqueous/Organic (7).

T37. **Advances in Dating Young Ground Water.**
Hydrogeology Division. D. Kip Solomon, Oak Ridge National Laboratory; L. Niel Plummer, U.S. Geological Survey, Reston.

Ground-water dating greatly enhances our ability to evaluate subsurface flow and transport processes. This session will focus on recent advances in dating ground water recharged within the past 50 years, a time scale of particular relevance to environmentally sensitive shallow ground-water systems.

Environmental Geology (6), Geochemistry, Aqueous/Organic (7), Hydrogeology (13).

T38. **Thermobarometric Studies and P-T Path Determinations in Mountain Belts.**
Frank S. Spear, Rensselaer Polytechnic Institute; Robert J. Tracy, Virginia Polytechnic Institute and State University.

Metamorphic P-T path studies have played an increasingly large role in recent years in tectonic synthesis. This theme session will showcase the application of thermobarometric investigations to reconstruction of the geodynamics of mountain belts around the world. It is expected that the talks in this session will be case studies that emphasize the applicability of thermobarometric work to tectonics, rather than presentations on the development of P-T techniques or calibrations.

Geochemistry, Other (8), Petrology, Metamorphic (22), Tectonics (31).

T39. **Paleoecology of Pre-Carboniferous Terrestrial Ecosystems.**
Paul K. Strother, Boston College, Weston Observatory; William Shear, Hampden-Sidney College, Virginia.

This session will explore the ecology of terrestrial ecosystems prior to the evolution of large forests during the Late Devonian. The biological component includes the presentation of nonmarine fossil assemblages of plants and spores along with terrestrial vertebrates and invertebrates. Paleosol studies, biogeochemical cycles, ecosystem modeling, and sedimentology and stratigraphy of nonmarine deposits represent the geological component. The session will represent a synthesis of what the geologic record tells us about the structure and dynamics of early terrestrial ecosystems.

Paleontology/Paleobotany (18), Sediments, Carbonates (27), Stratigraphy (29).

T40. **Pluton Interiors: Structure and Dynamics.**
Othmar T. Tobisch, University of California, Santa Cruz; Alexander R. Cruden and Patrick Launeau, University of Toronto.

This theme session will consider all aspects of research leading to greater understanding of flow processes involved in emplacement of granitic magmas. We welcome contributions on field-related studies, new methods for quantifying magmatic strains and flow directions, theoretical and analogue modeling of internal flow processes, related petrological research, and geophysical results pertaining to pluton geometry.

Geophysics/Tectonophysics (10), Petrology, Igneous (21), Structural Geology (30).

T41. **New Developments in Quaternary Geology: Implications for Geoscience Education and Research.**
National Association of Geology Teachers, Quaternary Geology and Geomorphology Division. Brian B. Tormey, Pennsylvania State University.

In the decade since Marvin Kauffman and Dale Ritter hosted the 1983 symposium Recent Advances in Geomorphology, many detailed studies and new insights and techniques have affected the course of both geomorphic and Quaternary geological research. This symposium is intended as (1) a reflective view of both the evolving trends and the current foci of geological Quaternary research and (2) a perspective on the practical implications that this past research thrusts upon the significant problems and current practices of field- and laboratory-based Quaternary geoeducation. Presentations are particularly encouraged that link evolving Quaternary geologic trends and foci with new approaches to student field and laboratory research.

Environmental Geology (6), Geology Education (9), Quaternary Geology/Geomorphology (25).

FIELD TRIPS

Boston will serve as the hub for a variety of exciting field trips throughout New England and the Northeast during the spectacular fall foliage season! From "Downeast" Maine to Connecticut or into the Adirondacks of upstate New York, geologists will be viewing hard rocks, soft rocks, modern and coastal sediments, glacial deposits, mineral localities, and environmental problems. Join one or more of these exciting excursions and see how our interpretation of these rocks has changed since the last time GSA met in Boston, more than 35 years ago.

All trips will begin and end in Boston unless otherwise indicated. **With substantially lower airfares on Saturday night stayover flights, you can pay for a premeeting or postmeeting field trip with the savings!** Trip costs are subject to change before registration begins in June, but they are not expected to change significantly. If you register for *only* a field trip, you must pay a $25 nonregistrant fee in addition to the field trip fee. This fee may be applied toward meeting registration if you decide to attend the meeting.

For further information, contact the individual trip leader or 1993 Field Trips Chair Jack Cheney, Dept. of Geology, Amherst College, Amherst, MA 01002, (413) 542-2311 (E-mail Bitnet%JTCHENEY@AMHERST) or Co-Chair Chris Hepburn, Dept. of Geology and Geophysics, Boston College, Chestnut Hill, MA 02167, (617) 552-3642 (E-mail Bitnet%HEPBURN@BCVMS).

Premeeting

Layered Gabbro-Diorite Intrusions of Coastal Maine: Basaltic Infusions into Silicic Magma Chambers.
October 21–24. R. A. Wiebe, Dept. of Geosciences, Franklin & Marshall College, Lancaster, PA 17604, (717) 291-3820, and Marshall Chapman. Cost: $290.

Sequence and Correlation of Tectonic and Metamorphic Events in Southeastern Vermont.
October 21–24. James B. Thompson, Jr., Dept. of Earth Sciences, Dartmouth College, Hanover, NH 03755, (603) 646-2373 and Harvard University, and John L. Rosenfeld. Cost: $365.

A Tectonic-Stratigraphic Transect across the New England Caledonides of Massachusetts.
October 21–24. Cosponsored by *New England Intercollegiate Geological Conference (NEIGC).* Nicolas M. Ratcliffe, U.S. Geological Survey, Reston, VA 22092, (703) 648-6939, and Peter Robinson, Chris Hepburn. Cost: $390.

View northeast from Mt. Lafayette. Mt. Washington of Presidential Range is highest peak on horizon. White Mountains, New Hampshire. Photo by Richard S. Naylor.

Petrologic and Isotopic Studies in Metamorphic Rocks of Eastern Vermont and Western New Hampshire.
October 21–24. Douglas Rumble, Geophysical Laboratory, 5251 Broad Branch, Washington, DC 20015-1305, (202) 686-2483, and J. M. Ferry, C. P. Chamberlain, F. Spear. Cost: $345.

Granite Pegmatites in Northern New England.
October 22–24. Carl A. Francis, Curator, Mineralogical Museum, Harvard University, 24 Oxford St., Cambridge, MA 02138, (617) 495-4758, and William Metropolis, Michael Wise, Anthony Kampf. Cost: $205.

A Transect through the Taconide Zone of Central Vermont.
October 21–24. Rolfe Stanley, Dept. of Geology, University of Vermont, Burlington, VT 05405-0122, (802) 656-3396, and Delbert Martin, Raymond Coish, Jo Laird. Cost: $330.

Sea-level Change, Coastal Processes, and Shoreline Development in Northern New England.
October 22–24. Joseph T. Kelley, Dept. of Geological Sciences, University of Maine, Orono, ME 04469, (207) 581-2162, and Daniel Belknap, Ken Fink, Duncan FitzGerald. Cost: $260.

Evidence from Thermochronology, Geochronology, and Petrology for Late Paleozoic Assembling of Lithotectonic Terranes in South-Central New England.
October 21–24. Robert P. Wintsch, Dept. of Geological Sciences, Indiana University, Bloomington, IN 47405, (812) 855-4018, and John Sutter, M. J. Kunk, J. N. Aleinikoff. Cost: $285.

The Late Glacial Marine Invasion of Coastal Central New England (Northeastern Massachusetts–Southwestern Maine): Its Ups and Downs.
October 22–24. Thomas K. Weddle, Maine Geological Survey, State House Station 22, Augusta, ME 04333, (207) 287-2801, and Carl Koteff, Woodrow Thompson, Cheryl Marvinney, Michael Retelle. Cost: $250.

Age and Petrogenetic Relationships in the Adirondack Highlands, New York.
October 21–24. James M. McLelland, Dept. of Geology, Colgate University, 13 Oak Drive, Hamilton, NY 13346-1398, (315) 824-7202. Cost: $290.

Carboniferous Geology of the Anthracite Fields of Eastern Pennsylvania and New England.
October 21–24. Sponsored by the *Coal Geology Division.* Jane Eggleston, U.S. Geological Survey, 956 National Center, Reston, VA 22092, (703) 648-6464, and William E. Edmunds. Cost: $285.

Geology of the Coastal Lithotectonic Belt, Southwestern Maine and Southeastern New Hampshire.
October 22–24. Cosponsored by *New England Intercollegiate Geological Conference (NEIGC).* Arthur M. Hussey II, Dept. of Geology, Bowdoin College, Brunswick, ME 04011, (207) 725-3219, and Wallace Bothner. Cost: $220.

Petrology and Field Relations of Successive Metamorphic Events in Pelites of West-Central Maine.
October 22–24. C. V. Guidotti, Dept. of Geological Sciences, University of Maine, Orono, ME 04469, (207) 581-2153, and M. J. Holdaway. Cost: $210.

Migmatites of Southern New England: Melting, Metamorphism, and Tectonics.
October 21–24. Eileen McLellan, Dept. of Geology, University of Maryland, College Park, MD 20742, (301) 405-4365, and Bob Tracy. Cost: $360.

Ring Dikes and Plutons: The Deeper View of Calderas.
October 21–24. John W. Creasy, Dept. of Geology, Bates College, Lewiston, ME 04240, (207) 786-6153, and Nelson Eby. Cost: $310.

High-Pressure Taconian and Subsequent Polymetamorphism of Southern Quebec and Northern Vermont.
October 22–24. Jo Laird, Dept. of Geology, University of New Hampshire, Durham, NH 03824-3589, (603) 862-1718, and Walter Trzcienski, Jr. Cost: $345.

Paleoenvironmental Traverse Across the Early Mesozoic Hartford Rift Basin, Connecticut.
October 22–24. Gregory S. Horne, Dept. of Earth Sciences, Wesleyan University, Middletown, CT 06459, (203) 347-9411, ext. 2834, and Jelle de Boer, Peter LeTourneau, Nicholas McDonald. Cost: $265.

Field Evidence and Petrogenesis of the A-type and I-type Paleozoic Plutonic Complexes of Eastern Massachusetts.
October 22–24. Cosponsored by *New England Intercollegiate Geological Conference (NEIGC).* Rudolph Hon, Dept. of Geology and Geophysics, Boston College, Chestnut Hill, MA 02167, (617) 552-3656, and Matt Paige, Chris Loftenius. Cost: $300.

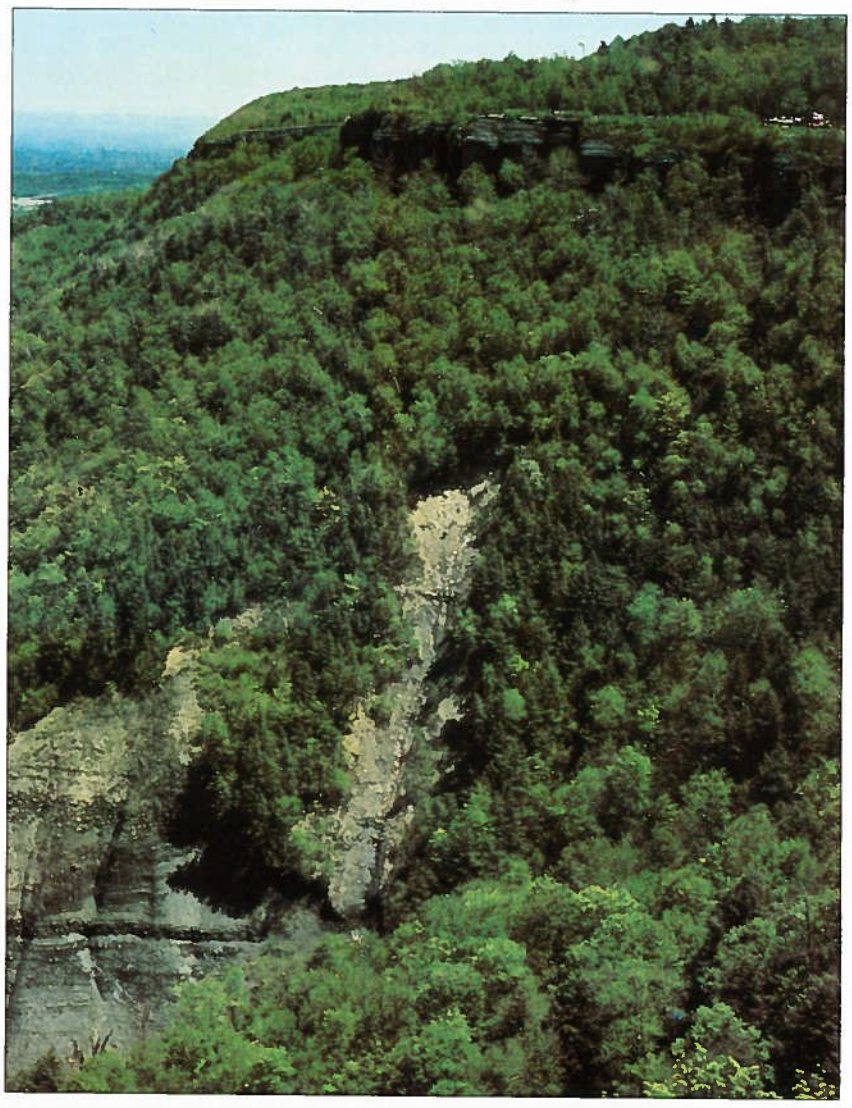
Methods of Characterizing Fluid Movement and Chemical Transport in Fractured Rock.
October 23–24. Allen M. Shapiro, U.S. Geological Survey, 431 National Center, Reston, VA 22092, (703) 648-5884, and Paul Hsieh, Carole Johnson. Cost: $195.

Highlights of Proterozoic Geology of Boston.
October 24. Cosponsored by *New England Intercollegiate Geological Conference (NEIGC).* Nicholas Rast, Dept. of Geological Sciences, University of Kentucky, Lexington, KY 40506-0059, (606) 257-6932, and James Skehan, S. W. Grimes. Cost: $65.

Archaeological Geology of Long Island, Boston Harbor.
October 24. Sponsored by *Archaeological Geology Division.* Barbara E. Luedtke, Dept. of Anthropology, University of Massachusetts, 100 Morrissey Blvd., Boston, MA 02125, (617) 287-6850, and Peter Rosen. Cost: $50.

Pleistocene Geology of the Boston Basin and Its Adjacent Surroundings.
October 24. Cosponsored by *New England Intercollegiate Geological Conference (NEIGC).* William A. Newman, Dept. of Geology, Northeastern University, Boston, MA 02115, (617) 437-4382, and Richard Berg, David Mickelson. Cost: $65.

Dimension Stone Quarries: A New England Resource in Transition.
October 24. Steven J. Stokowski, Jr., Stone Products Consultants, 10 Clark St., Ashland, MA 01721, (508) 881-6364, and Jim Purdy, Ed Myskowski. Cost: $80.



Helderberg Escarpment in eastern New York, John Boyd Thatcher State Park. Escaparpment is Early Devonian limestones over Ordovician turbidites. Photo by Richard H. Bailey.

Half-Day
(held during the meeting)

Boat Tour of Boston Inner and Outer Harbor and Islands.
October 26. John T. Humphrey, Haley & Aldrich, Inc., 58 Charles St., Cambridge, MA 02141, (617) 494-1606, and Jutta Hager. Cost: $15.

Petrologic and Age Relationships of Igneous Rocks in the Pine Hill Area, Medford, Massachusetts.
October 26. Cosponsored by *New England Intercollegiate Geological Conference (NEIGC).* Martin E. Ross, Dept. of Geology, Northeastern University, 360 Huntington Ave., Boston, MA 02115, (617) 437-3263. Cost: $35.

Geology of East Point, a Rocky New England Coastline.
October 27. Cosponsored by *New England Intercollegiate Geological Conference (NEIGC).* Richard H. Bailey, Dept. of Geology, Northeastern University, 360 Huntington Ave., Boston, MA 02115, (617) 437-3181, and Martin Ross. Cost: $35.

Engineering Geology and the Geology in Active Tunnel Projects in the Boston Area.
More information will be available in the final registration issue, June *GSA Today.*

Postmeeting

Coastal Geologic Hazards and Management Strategies along a Complex Microtidal Coastline.
October 28–31. Cosponsored by *New England Intercollegiate Geological Conference (NEIGC)*. Jon C. Boothroyd, Dept. of Geology, University of Rhode Island, Kingston, RI 02881, (401) 792-2191, and Christopher W. Galagan, Denis E. Newcomer. Cost: $385 plus overflight.

Alleghanian and Avalonian Tectonism in Southeastern New England.
October 28–31. Sharon Mosher, Dept. of Geological Sciences, University of Texas, Austin, TX 78712, (512) 471-4135, and Daniel Murray, Don Hermes, L. Peter Gromet. Cost: $275.

Geology and Geomorphology of the Acadian Orogen, Central Maine.
October 28–31. Lindley S. Hanson, Dept. of Geology, Salem State College, Salem, MA 01970, (508) 741-6282, and Dwight Bradley, D. W. Caldwell. Cost: $365.

Highlights of Metamorphic Stratigraphy and Tectonics in Western Maine to Northeastern Vermont.
October 28–31. Robert H. Moench, U.S. Geological Survey, 905 Federal Center, Denver, CO 80225, (303) 236-5651. Cost: $255.

Building Blocks of Boston.
October 29. Cosponsored by *New England Intercollegiate Geological Conference (NEIGC)*. Dorothy Richter, Hager-Richter Geoscience, Inc., 8 Industrial Way, Salem, NH 03079, (603) 893-9944, and Gene Simmons. Cost: $65.

Multiple Glaciations and Deglaciation of a Transect from Boston, Massachusetts, to the White Mountains, New Hampshire.
October 29–30. P. Thompson Davis, Dept. of Natural Sciences, Bentley College, 175 Forest St., Waltham, MA 02154-4705, (617) 891-3479, and Woodrow Thompson, Byron Stone, Robert Newton, Brian Fowler. Cost: $155.

The Avalon and Nashoba Terranes (Eastern Margin of the Appalachian Orogen in Southeastern New England).
October 29–31. Cosponsored by *New England Intercollegiate Geological Conference (NEIGC)*. Christopher Hepburn, Dept. of Geology and Geophysics, Boston College, Chestnut Hill, MA 02167, (617) 552-3642, and Rudolph Hon, Gregory Dunning, Richard Bailey, Kenneth Galli. Cost: $295.

Ground-Water Contamination and Solute-Transport Research at the U.S. Geological Survey's Cape Cod Field Site.
October 29. Denis LeBlanc, U.S. Geological Survey, Water Resources Division, 28 Lord Road, Suite 280, Marlborough, MA 01752, (508) 490-5030, and Kathryn Hess, Steven Coppola. Cost: $55.

Other Field Trips

Registration and information can be obtained from the contact person listed after each trip.

SPONSORED BY SOCIETY OF ECONOMIC GEOLOGISTS

Mineral Deposits of the Adirondack Mountains.
October 19–22. Erich U. Peterson, University of Utah, 717 W. C. Browning Building, Salt Lake City, UT 89112-1183, (801) 581-7238. Cost: $300.

Besshi-type Massive Sulfide Deposits of the Vermont Copper Belt.
October 21–23. John F. Slack, U.S. Geological Survey, National Center, MS 954, Reston, VA 22092, (703) 648-6337, and T. W. Offield. Cost: $400.

SPONSORED BY GSA K–12 EDUCATION PROGRAMS COMMITTEE

Boston Harbor Explorations.
October 24, 4 hours. Howard Dimmick, Stoneham High School, 149 Franklin St., Stoneham, MA 02180, (617) 438-5717. Cost: $30.

Coastal Geology North of Boston.
October 24, 6 hours. Eugene Boulay, McCall Junior High School, 80 Skillings, Winchester, MA 01890, (617) 721-7020. Cost: $26.

Geology of the Boston Basin.
October 24, 8 hours. Richard Staley, F. A. Day Junior High School, 21 Minot Road, Newtonville, MA 02166, (617) 552-7379. Cost: $35.

SPONSORED BY NATIONAL ASSOCIATION OF GEOLOGY TEACHERS

Geosecrets of Downtown Boston: City Geology with a City Geologist.
October 24. James V. O'Connor, University of District of Columbia, Environmental Science Dept., MS 44-04, 4200 Connecticut Ave. N.W., Washington, DC 20008, (202) 282-7373. Cost: $10.

Evolution of Cape Cod Landscapes: Marine and Glacial Field Techniques Applied to Cape Cod.
October 30. Cosponsored with *National Earth Science Teachers Association* and *National Marine Educators Association*. James V. O'Connor, University of District of Columbia, Environmental Science Dept., MS 44-04, 4200 Connecticut Ave. N.W., Washington, DC 20008, (202) 282-7373, and Brian B. Tormey, Richard Williams, Jr. Cost: $40.

PROFESSIONAL HORIZONS

GSA-Sponsored Continuing Education Courses

Registration information and course descriptions will be published in the ***June*** issue of *GSA Today*. For additional information contact Edna Collis, Continuing Education Coordinator, GSA headquarters.

Fees will be approximately $125–$150 for the first day and $100–$125 for the second day. If you register for a GSA short course *only*, you must pay a $25 nonregistrant fee in addition to the short course fee. This fee may be applied toward meeting registration if you decide to attend the meeting. Students will receive a $20 discount on all GSA courses. A *GSA Certificate of Completion* will be given to each registrant.

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

GIS and the Geosciences.
October 23. Richard L. Bedell, Jr., Weston Observatory, Boston College.

Urban Geology: Foundation for Inner City Health.
October 23. Cosponsored by *NAGT, NESTA*, and the *Geoscience Education Division*. James V. O'Connor, University of the District of Columbia.

Asia: A Continent Built and Assembled Over the Last 500 Million Years.
October 23–24. Cosponsored by the *International Division*. Kevin Burke, University of Houston; A.M.C. Şengör, Istanbul Technical University.

Contaminant Hydrogeology: Practical Monitoring, Protection, and Cleanup.
October 23–24. Cosponsored by the *Hydrogeology Division*. Christopher M. Palmer, Gen Tech Environmental, Inc., San Jose, California; Jeffrey L. Peterson, Environmental Consultant, Sonoma, California.

Fracture Mechanics of Rock.
October 23–24. Cosponsored by the *Structural Geology and Tectonics Division*. Terry Engelder, Michael R. Gross, and Mark P. Fischer, Pennsylvania State University.

Alternative Pedagogies in Geological Sciences: A Workshop.
October 24. Cosponsored by the *Geoscience Education Division*. Lauret E. Savoy, Mount Holyoke College; Ann Bykerk-Kauffman, California State University—Chico; Jill S. Schneiderman, Pomona College.

Application of Sedimentological Information to Hydrogeological Problems.
October 24. Cosponsored by *SEPM (Society for Sedimentary Geology)* and the *Sedimentary Geology Division*. Erik K. Webb, Sandia National Laboratory, Albuquerque, New Mexico.

Computer Mapping at Your Desk That Really Works.
October 24. Grant R. Woodwell and Renee E. Wicks, Mary Washington College; Russell A. Ambroziak, U.S. Geological Survey, Reston, Virginia.

Environmental/Engineering Geology and Land-Use Planning—An Interface Between Science and Regulations.
October 24. Cosponsored by the *Engineering Geology Division*. Charles W. Welby, North Carolina State University; Jerome V. DeGraff, USDA Forest Service; Rhea L. Graham, Mining and Minerals Division, State of New Mexico.

Geochemistry and Stable Isotopes of Paleosols.
October 24. Cosponsored by the *Sedimentary Geology Division* and the *Geochemical Society*. Claudia I. Mora and Steven G. Driese, University of Tennessee; David Fastovsky, University of Rhode Island.

Isotope Hydrology.
October 24. Cosponsored by the *Hydrogeology Division*. Carol Kendall, U.S. Geological Survey, Menlo Park; Neil L. Ingraham, University of Nevada, Las Vegas.

Fractals and Their Use in Earth Sciences.
October 29–30. Cosponsored by the *Engineering Geology Division* and the *Geophysics Division*. Christopher C. Barton, U.S. Geological Survey, Denver; Paul R. LaPointe, Golder Associates, Inc., Redmond, Washington; Alberto Malinverno, Schlumberger-Doll Research, Ridgefield, Connecticut.

Geology and Public Policy Forum

The GSA Committee on Geology and Public Policy will hold a forum, *Geoscience Legislation in Congress*. Speakers will report succinctly on recently enacted geoscience legislation, such as the National Geologic Mapping Act and the Energy Policy Act of 1992, and on the status of pending geoscience legislation, including the Clean Water Act and amendments to the Mining Law of 1872. The forum is open to everyone, including guests, press, and the general public, and will feature a question-and-answer session.

Other Short Courses and Workshops

Registration and information can be obtained from the contact person listed after each course.

Health Effects of Mineral Dusts.
October 22–24. Sponsored by the *Mineralogical Society of America.* For information: MSA Business Office, 1130 Seventeenth Street, N.W., Suite 330, Washington, DC 20036, (202) 775-4344, fax 202-775-0018.

Teaching Topics in Earth Science and Geology with Video as a Partner: For Secondary School Teachers.
October 23, 9:00 a.m. to 12:00 noon. Sponsored by the *Annenberg/CPB Project, National Association of Geology Teachers,* and *Southern California Consortium.* Explore the use of video as a tool to teach geology in this "EARTH REVEALED" workshop. For information: Janice Ford, Annenberg/CPB Project, 901 E Street, N.W., Washington, DC 20004, (202) 879-9655.

Taphonomic Approaches to Time Resolution in Fossil Assemblages.
October 24, 8:15 a.m. to 5:00 p.m. Sponsored by the *Paleontological Society.* For information: Susan M. Kidwell, University of Chicago, Dept. of Geophysical Sciences, Chicago, IL 60637, (312) 702-3008; A. K. Behrensmeyer, Natural History Museum, Smithsonian Institution, Dept. of Paleobiology, Washington, DC 20560, (202) 357-3033.

Teaching Introductory Geology with Video as a Partner: For College Teachers.
October 24, 1:30 to 4:30 p.m. Sponsored by the *Annenberg/CPB Project, National Association of Geology Teachers,* and *Southern California Consortium.* Learn to use video in prompting students to interact with geology concepts through the "EARTH REVEALED: Introductory Geology" series. For information: Janice Ford, Annenberg/CPB Project, 901 E Street, N.W., Washington, DC 20004, (202) 879-9655.

DataBase Forum.
October 24, 3:00 to 5:00 p.m. Sponsored by the *Geoscience Information Society.* For information: Kimberly Parker, Kline Science Library, Yale University, 219 Prospect Street, P.O. Box 6666, New Haven, CT 06511-8142, (203) 432-3443.

Preparing Successful Grant Proposals to Fund Curriculum Innovation in the Geosciences.
October 26, 1:30 to 5:00 p.m. Sponsored by the *National Association of Geology Teachers.* For information: Judith L. Hannah, Dept. of Geology, University of Vermont, Burlington, VT 05405-0122, (802) 656-0245.

GeoRef Intermediate/Advanced Workshop.
October 26, 2:30 to 4:00 p.m. Sponsored by the *Geoscience Information Society.* For information: Marilyn Stark, U.S. Geological Survey Library, MS 914, Box 25046, Denver, CO 80225, (303) 236-1004.

SPECIAL PROGRAMS

Employment Service

GSA will again be offering its Employment Interview Service. Each year, this program provides valuable job-matching opportunities in the geosciences. At last year's meeting in Cincinnati, participating employers conducted nearly 400 interviews with 200 applicants seeking employment!

As in the past, booths will be provided for employers to interview applicants registered with the Employment Service, and GSA staff will be on hand to coordinate the scheduling of interviews. In particular, students completing doctoral and masters theses during 1993 are encouraged to check the job offerings.

See the February issue of *GSA Today* for applicant and employer forms and further information, or contact T. Michael Moreland, Employment Service Manager, GSA headquarters.

Graduate School Information Forum

The forum will take place at the Hynes Convention Center in three sessions from 9:30 a.m. to 5:30 p.m., October 25 through 27.

This forum provides a unique opportunity for undergraduate students planning on getting an advanced degree to meet with representatives of graduate schools in an informal environment to discuss interests and explore programs. A list of participating schools will appear in the June and September issues of *GSA Today.*

This year's forum will take place in the poster area of the exhibit hall. Each school will be given use of a 4' x 8' poster board, a table and four chairs. This new format will increase the visibility of the schools and allow the students to move more freely. Cost: $90 per day. Space is limited. If your school is interested in participating, contact Matt Ball, GSA headquarters.

K–12 Program

In its continuing effort to foster improvements in earth science education, GSA invites K–12 earth science teachers to Boston for a program designed around precollege subject matter and teaching approaches. There are short courses, field trips, and technical sessions especially designed by and for K–12 teachers. Please see the appropriate sections within this publication for details. In addition to those listed, there will also be a Saturday premeeting Earth Science Activities Workshop for K–12 Teachers. Earth science educators will have the opportunity to meet with one another and exchange ideas at two luncheons (National Association of Geology Teachers and GSA Geoscience Education Division) and a Monday evening Earth Science Information Share-a-Thon and social hour. Teachers are encouraged to attend any symposium or theme session in the technical program throughout the meeting, to explore video and computer technologies in the *Science Classroom of the Future,* or simply to browse in the exhibits area.

For further information contact Margaret D. Thompson, Dept. of Geology, Wellesley College, Wellesley, MA 02181, (617) 283-3029; Richard Staley, Dept. of Earth Sciences, F. A. Day Junior High School, Newtonville, MA 02160, (617) 552-7379; or Beth Klocek, GSA headquarters.

DIVERSIONS

Bravo Boston GSA Chorale
Tuesday, October 26

This year one of the special events for the GSA Annual Meeting is indeed very special. Many of you may recall the performance by the 1988 GSA Centennial Orchestra of geologists in Denver, heard on and praised by National Public Radio. A past president of GSA wrote these words about the performance: "...the audience 'exploded' as the last chord of the final march died away. Around me, people leaped onto chairs, cheering, many saying 'quite incredible' and 'unbelievable,' sentiments that I shared to the full." Well, once again musical geologists will have the opportunity to come together, this time in a dazzling choral performance in Boston, where the musical arts are a thriving part of the city's culture. **Don't miss the excitement on Tuesday evening!**

The performance will take place in the acoustically renowned Jordan Recital Hall, an intimate and cherished hall, treasured for its turn-of-the-century architecture, and widely used by recording companies and famous artists. The hall is on the campus of the New England Conservatory of Music, an easy 10-minute walk from the Hynes Convention Center. The Bravo Boston GSA Chorale will perform the melodic and moving Mozart Requiem, popularized in the film *Amadeus,* with a professional orchestra and conductor. In addition, the performance will feature two double concertos by Vivaldi, featuring your musical colleagues as soloists. This is an evening not to be missed!

For those wishing to sing with the Bravo Boston GSA Chorale, contact Holly Stein, U.S. Geological Survey, MS 981, National Center, 12201 Sunrise Valley Drive, Reston, VA 22092, (703) 648-5326. You must be an active accomplished singer who reads music. Spouses and guests are also welcome.

For those wishing to attend this very special performance, ticket purchase in advance is highly recommended. Seating is limited, and given the sell-out performance by the GSA Centennial Orchestra, a ticket purchase with your meeting preregistration assures you a seat. You won't want to miss the excitement!

Highlights

JAZZ EVENING
Saturday, October 23

BOSTON SYMPHONY ORCHESTRA AND DINNER
Saturday, October 23

WELCOMING PARTY
Sunday, October 24

GSA PRESIDENTIAL ADDRESS AND AWARDS CEREMONY
Monday, October 25

ALUMNI RECEPTIONS
Monday, October 25

BRAVO BOSTON GSA CHORALE
Tuesday, October 26

BOSTON HARBOR CRUISE AND LOBSTER CLAMBAKE
Wednesday, October 27

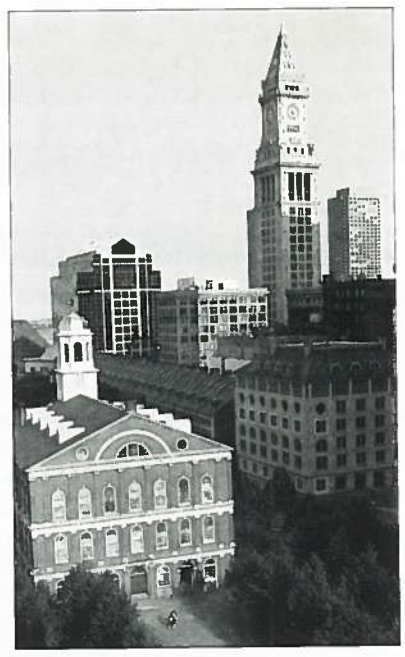
Guest Program

Boston invites you to explore its history, culture, and emerging future. For over three and a half centuries, Boston has been a center of change, progress, and excitement. You can walk in the footsteps of Paul Revere, Benjamin Franklin, and Henry David Thoreau, visit the homes of Louisa May Alcott, Nathaniel Hawthorne, and Ralph Waldo Emerson, follow the Freedom Trail, and visit the Boston Tea Party ship. Its architecture, shopping, sports, and restaurants of every description make Boston an exciting city. You don't need a car—Boston is a great city for walking. Be prepared to enjoy the spectacular fall foliage colors too. Come to Boston and feel the excitement of the past, the present, and the future. It's a city with something for everyone!

Guests are invited to visit the GSA Hospitality Room in the Marriott. Your hosts will be providing a resource center capable of helping you to explore *your* interests. Abundant information on Boston and surrounding areas will be available, as well as details on GSA tours and seminars.

TOURS

- **Lexington and Concord**
  Visit the Battle Green in Lexington, the site where the Minutemen faced the British in the first battle of the American Revolution. Visit the Concord homes of three famous authors.
- **Newport, Rhode Island**
  Tour the Newport Mansions of the Gilded Age and drive along the ten-mile Ocean Drive. Stroll along Cliff Walk and shop in the boutiques and art galleries.
- **Cambridge (Harvard Square, Harvard Yard, and Harvard University)**
  Visit museums, shop, and browse through bookstores with rare, used, new, and foreign books.
- **Walking Tours of Boston's Neighborhoods**
  Tour Newberry Street, Beacon Hill, and the North End.



Custom House Tower and Faneuil Hall. Photo courtesy of Boston Convention and Visitors Bureau, Inc.

- **Old Salem**
  Learn about Salem's historical legacy of witch trials and its maritime tradition.
- **Bird Watching**
  Visit the Parker River National Wildlife Refuge for great eastern species viewing.

SEMINARS

- **Welcome to Boston**
  Enjoy an introduction to the "Athens of America," the city of history and site of cultural and architectural splendor.
- **Thriving on Uncertainty and Rapid Change**
  Develop confidence in dealing with life's surprises.
- **Boston's Architecture**
  Boston is a city of significant architectural tradition. Learn how the "Hub of the Universe" developed as a center of learning, art, science, and commerce and how its buildings promoted its development.
- **Peace Through Music**
  Join us for a thoroughly enjoyable session of relaxing and soothing music. Give your soul the gift of an emotional massage!

REGISTRATION

New! You can preregister for the Boston meeting in JUNE!

Mark your calendar for the JUNE issue of *GSA Today* for registration forms and detailed information! The JUNE issue will be the *only* registration issue.

Take advantage of this early registration opportunity. **Events will fill quickly.** There are savings on meeting registration fees. Registration is required for events. One-day registration is available Sunday through Thursday.

GSA members will automatically receive registration information and forms during the first weeks of ***June.*** If you are *not* a member and would like registration forms and further information, please write or call the GSA Registration Coordinator, GSA headquarters. Nonmembers who become GSA members by October 15, 1993, can **pre**register at the member rate. For membership information, contact GSA Membership Services, GSA headquarters.

Meeting registration fees have not been established as we go to print. However, for your budgeting and travel-authorization requests, please use the ***estimated preregistration fees.*** Final fees will be published in the ***JUNE*** issue of *GSA Today.*

BECOME A GSA MEMBER AND SAVE!

If you are planning to attend this year's Annual Meeting, but are not yet a GSA member, now is the time to join. You will save a substantial amount on your registration fee by paying the member rate—almost exactly the amount you pay to join GSA. That's like joining GSA for free! For membership information contact T. Michael Moreland, GSA headquarters.

ABSTRACTS WITH PROGRAMS

Because the *Abstracts with Programs* is an individual purchase, please order it in advance with your GSA membership, through GSA Publication Sales, (303) 447-2020 or fax 303-447-1133, or on-site at the Hynes Convention Center. Cost: $22.

ESTIMATED PREREGISTRATION FEES:

Professional Member	$150	Student Nonmember	$ 80
One Day	$ 85	One Day	$ 45
Professional Nonmember	$190	Guest	$ 65
One Day	$105	Field Trip/Short Course Only	$ 25
Student Member	$ 60	K–12 Teachers	$ 15
One Day	$ 35		

ESTIMATED ON-SITE REGISTRATION FEES:

Professional Member	$180	Student Nonmember	$ 95
One Day	$ 90	One Day	$ 48
Professional Nonmember	$220	Guest or Spouse	$ 80
One Day	$110	Field Trip/Short Course Only	$ 25
Student Member	$ 75	K–12 Teachers	$ 25
One Day	$ 38		

- **Preregistration deadline is September 24.**
- **Cancellation deadline is October 1.**

Accessibility for Registrants with Special Needs

GSA is committed to making every event at the Annual Meeting accessible to all people interested in attending. If you have special requirements, such as an interpreter or wheelchair accessibility, there will be space to indicate this on the meeting registration form, or you can call Becky Martin, GSA headquarters. Please let us know your needs well in advance.

Getting In and Around Boston

By Air. Logan International Airport is just two miles outside the city. The airport is served by most major airlines. There is convenient public transportation from the airport to downtown Boston and suburban locations. Logan's 1-800-23-LOGAN ground transportation hot line provides round-the-clock schedule information on transportation alternatives to and from Logan.

By Car. Getting into Boston: from the west, Route 90 (Massachusetts Pike) is the most clear route inbound; from the south, Routes 95, 24, and 3 all feed into Route 128 east, which leads into Route 9 inbound; from the north, use Routes 95, 1, and 93. Driving in Boston can be a confusing experience, however. Heavy traffic, narrow and unexpected one-way streets, and the high cost of parking are just a few of the surprises. If driving is necessary, it is helpful to check a detailed Boston street map before setting out.

By Bus, Train, and Subway. The Greyhound Bus terminal is located downtown at 10 St. James Street, Boston, (617) 423-5810. This is near the Arlington Street MBTA subway stop across from the Boston Park Plaza Hotel.

AMTRAK serves Boston, New York, Washington, and nationwide. Back Bay is the most convenient arrival station since it is within three blocks of the Hynes Convention Center, the Marriott Copley Place, and other GSA hotels. For AMTRAK information, call (617) 482-3660 or 1-800-392-6099.

The MBTA Subway Commuter Rail extends from downtown Boston to as far as 60 miles away. It is a popular and convenient way to get around Boston. Commuters become familiar with the system easily, and it is generally the best way to get from the hotels to the convention center. Discounted MBTA passes will be sold on site. For MBTA information call (617) 722-3200.

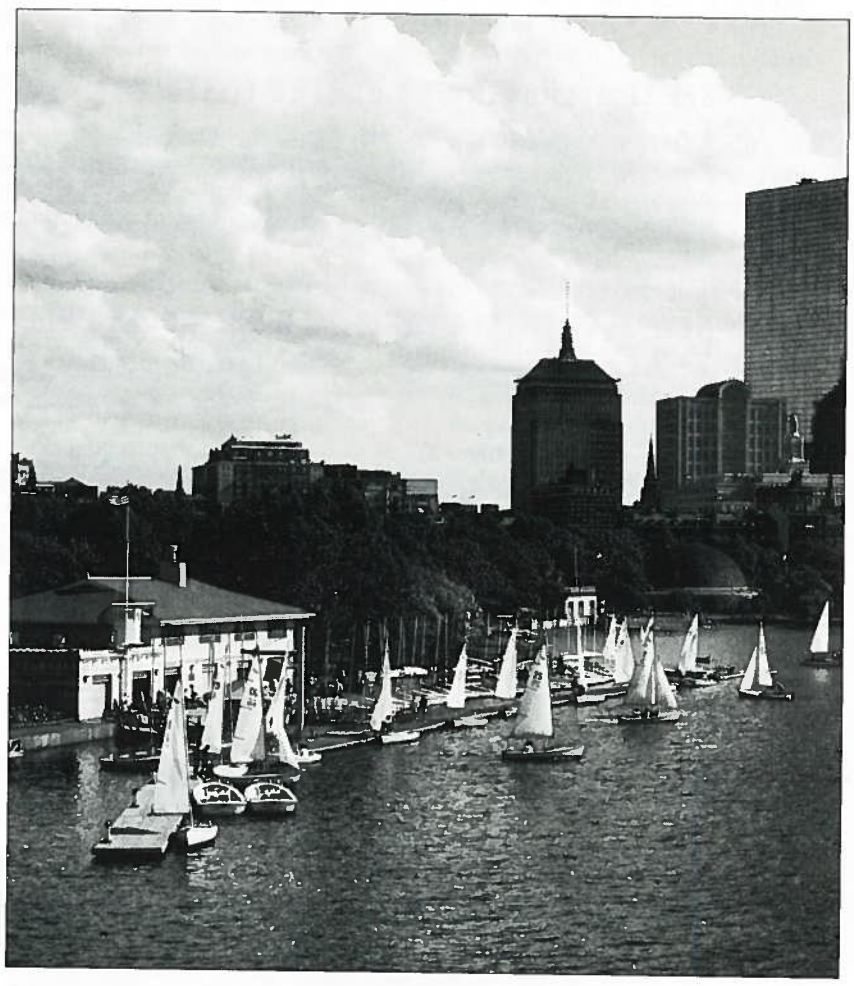


Photo courtesy of Boston Convention and Visitors Bureau, Inc.

Tourist Information

Greater Boston Visitors Bureau
Prudential Tower, P.O. Box 490
Boston, MA 02199
(617) 536-4100

Massachusetts Office of Travel and Tourism
100 Cambridge St., 13th Floor
Boston, MA 02202
(617) 727-3201

Lodging

With the spectacular fall foliage, October is Boston's peak time of year for visitors. Eleven downtown hotels near the Hynes Convention Center have been selected to suit a variety of tastes and budgets.

GSA hotels, tentative single/double rates, and number of rooms blocked:

Boston Marriott Copley Place	$145/$165	600 rooms
Boston Park Plaza Hotel	$119/$130	500 rooms
Boston Back Bay Hilton	$125/$145	250 rooms
57 Park Plaza	$ 99/$ 99	150 rooms
Lenox Hotel	$135/$155	100 rooms
Midtown Hotel	$ 89/$ 99	100 rooms
Copley Square Hotel	$ 95/$105	90 rooms
Tremont House	$105/$120	60 rooms
Westin Hotel, Copley Place	$160/$160	50 rooms
The Colonnade	$138/$138	50 rooms
John Hancock Conference Center	$ 80/$ 90	40 rooms

Activities will take place in the historic Back Bay section of Boston which is the location of the Convention Center as well as GSA's headquarters hotel, the **Boston Marriott Copley Place,** and the Boston Park Plaza Hotel. Back Bay is one of Boston's oldest and most exclusive areas. Scores of cultural and historic landmarks, art galleries, theaters, fine shops, and restaurants are within easy walking distance. The Marriott is a first-class property connected to the Convention Center by enclosed walkways. It is also connected to the Copley Place Shopping Galleries with over 100 fine shops. No other hotel in GSA's block matches the Marriott for accommodations and service.

The key to getting your first choice is to make your reservation early. **New** for 1993, GSA will publish housing information and reservation forms in the **JUNE** issue of *GSA Today.* Because October is Boston's busiest month, we highly recommend GSA meeting attendees get their reservations in ***as early as possible.***

ALTERNATIVE LODGING

Boston is an expensive city, but beating the high cost of lodging is still a priority for GSA staff and the 1993 Annual Meeting Committee.

- Consider properties outside the downtown area. Public transportation by subway and bus is available. The rates typically range from $45 to $65 per night for a single room. A list of suggested properties and phone numbers will be published in **JUNE** *GSA Today,* or call GSA for information.
- Check your library copy of the *Hotel and Motel Redbook,* which lists metro properties. Because of the hundreds of properties in the area, GSA cannot provide a complete list.
- Call 1-800-555-1212 or check the Yellow Pages to learn the 800 number for your favorite hotel chains, such as Super 8 Motel or Comfort Inn, which have properties outside the downtown area.

EXHIBITS

SEE IT ALL–OVER 200 BOOTHS FILLED WITH THE LATEST

■ Geological publications and maps ■ Computers and geological software ■ Scientific instrumentation ■ Microanalysis and camera equipment ■ Gems, minerals, and fossils ■ Resource information from key government agencies ■ Field supplies and gear ■ Earth science program information from major universities

NEW HOURS MAKE EXHIBITS MORE ACCESSIBLE

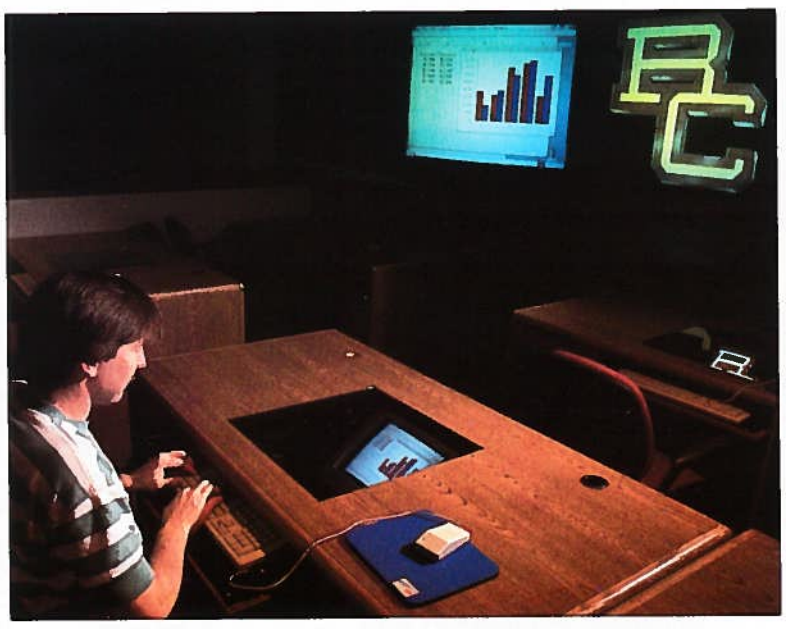
Sunday, October 24	5:00 p.m. to 9:00 p.m.
Monday, October 25	9:30 a.m. to 5:30 p.m.
Tuesday, October 26	9:30 a.m. to 5:30 p.m.
Wednesday, October 27	9:30 a.m. to 3:00 p.m.

NEW EXHIBIT HALL EVENTS

■ Ye Olde GSA Pub ■ Exhibitor product demonstration area ■ Boston Tea Party each afternoon

GSA Exhibit Hall, 1988. Photo by Bill Cronin.

SCIENCE CLASSROOM OF THE FUTURE



Computer technology permeates the domain of personal and graphics workstations and is permanently entrenched as a standard interface between users and their laboratory instrumentation. Due to major advances in multimedia technology, the changes are now reaching our classrooms as well.

The Geological Society of America views computer technology as an integral part of the professional, academic, and instructional activities of its members. It is in this spirit that we are inviting the hardware and software industry to join us during this year's Annual Meeting in Boston, the city where computer technology was born, developed, and continues as a trendsetter of technological innovation.

The Society hopes that the participation of technology vendors will provide a unique platform for its members to gain new knowledge, share their individual experiences with others, and gain insights into how computer technology can help each of us make our daily practices more efficient, our research more productive, and our instruction more effective and inspiring.

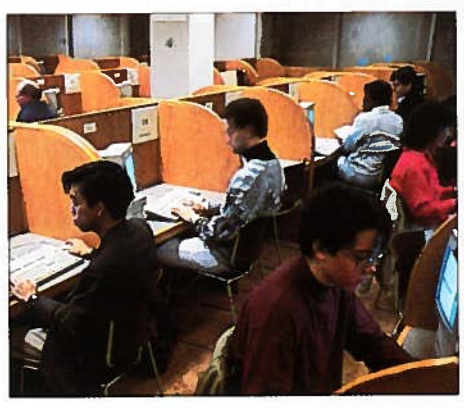
In particular, we want to present the advances in multimedia computing and their direct application to instructional curricula with the mini theme—*Science Classroom of the Future.* We are inviting both hardware and software manufacturers to demonstrate the capability of this exciting technology and give us first-hand experience of a computerized classroom. We are planning live displays of classroom environments to demonstrate how multimedia technology can be applied to make classroom instruction more effective and out-of-classroom learning into a more captivating experience.

If you would like to demonstrate a program or a product related to computer technology in the *Science Classroom of the Future,* call Prof. Rudolph Hon at (617) 552-3656.

BOSTON COLLEGE

Science Classroom of the Future is made possible through an arrangement with the Department of Geology and Geophysics, Boston College. The college originated out of the Jesuit tradition of education and research in the sciences, which since 1540, has accorded preeminence to astronomy, geophysics, geology, and mathematics. Boston College evolved from Weston College Seismological Laboratory, established on the "new" science of seismology, as part of a worldwide collaboration among Jesuit colleges and universities since 1910.

Weston Observatory, founded in 1928, spawned the graduate Department of Geophysics in 1947, and Father Jim Skehan founded the undergraduate Department of Geology in 1957 at Boston College. Both departments merged into the present Department of Geology and Geophysics, now housed in newly renovated, state-of-the-art facilities in Devlin Hall on the Chestnut Hill Campus. The newly renovated laboratory complex at Weston Observatory is a research facility in geophysics and geology, and is the recording center for the 25-station three-component New England Seismic Network. It is also the headquarters of the GIS Center, with fiber-optic links to the departmental computers at the Chestnut Hill Campus, and to the university's Computer Center. The *Science Classroom of the Future* will be modeled on the prototype classroom developed by the Instructional Research and Development Laboratory at Boston College.



INVITED COMPANIES

Accuweather
AGFA Compugraphics
Annenberg
Apple Computer, Inc.
Arlington Public Schools
Assymetrix Corp.
BBN Internet
Boston College
Cable Television
CalComp
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Digital Equipment Corporation
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National Instruments
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Optical Data
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Passport Designs, Inc.
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Tom Snyder Productions
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Warner New Media
WGBH
Wolfram Research, Inc.
Xerox

Forum *continued from p. 94*

and a service that is paid for with volunteer labor largely by a membership with a vested interest. One aims to make a profit, the other aims to provide publications, near cost or sometimes below cost, so that the membership can benefit.

This difference is the source of the complaints: we grow used to the service, and we deny the product-for-profit because some of these things are essential or desirable in our work. The issue is extremely complex! I do not wish to defend the cost of high-priced publications; rather, I wish to make some observations that might promote better ways to deal with our publishing necessities.

1. We are all in this process together. Yes, I edit one of these commercial journals. And Eldridge Moores just published a structural geology textbook that costs five or six times more than the one I bought when I was a student. High-priced textbooks may hurt even more than high-priced journals, because students have little choice other than to buy them, whereas we can go to the library.

Are authors opting to give up their commercial royalties to lower prices? No, and I wouldn't ask them to, but where do you want to draw the line? And what about your rock pick, Brunton compass, field notebook and gear, and computer? Somebody is making a profit on all of these essential tools of our trade too, just as somebody does on just about every product in our homes and businesses. Profit per se is not the problem. Firms supplying a product deserve a fair profit in our system.

2. Do these publishers provide a benefit to us? Around Berkeley, several seminars every semester are based on commercially produced, topical books that cost a lot. So some of these books are being used in the educational process. In my field, a high percentage of the citations in research papers are to these kinds of books, as well. It's probably true in other fields, too. I judge that these books do provide a benefit to us, collectively. Journals seem to be doing that even better. Commercial earth science journals remain full and among the most cited. My journal, *Marine Micropaleontology,* will publish as many pages and plates as the science merits, unlike many society journals, and it is the second most cited paleontology journal in the world. All this seems to me to provide an important benefit. These books and journals are being used; that's the bottom line.

Societies cannot publish everything worth publishing. *Geology* receives more than 700 manuscripts each year, but publishes only about 250. Many of those unpublished manuscripts contain good data and interesting conclusions that we should know about, but GSA cannot publish them. Each society, by and large, puts almost all of its resources into its publications. Yet there are another half-dozen or so commercial journals in each field that regularly publish 400–600 pages of good science every year. Unless we increase our dues enormously, the societies simply could not publish everything that now appears.

Could GSA publish all the books that appear commercially in the earth sciences at the $20–$30 figure cited by Eldridge Moores? I suspect not, because the volume is too great, and even GSA's costs for some books are higher than many of us can easily afford. Check the latest GSA catalog! The key then is "supply and demand." We demand to publish our work and we demand to read what others write. The commercial publishers in part supply that demand.

Times are not the same as when Moores and I were students. Everything costs more! And there are many more of us in the science, and everyone is publishing more for fear of perishing, going unfunded, failing to be promoted, not getting some award or being elected to some academy or honor—in other words, our own self-interests and egos drive the system as much as anything. We are generating lots more paper, but we don't have many more societies to fill the gap. There are lots more things to write about now. All of this is certainly more good than it is bad, but somebody is going to have to pay the suppliers, because as individuals, we can't.

I see some solutions.

1. We could, and perhaps should, put pressure on the publishers to lower their prices. Clearly, some commercial journals and books (I include university presses here too) are way out of line with others, and these may well be making an unfair profit. How do we put pressure on them? Don't submit manuscripts to them. Don't allow your ego to let you edit volumes of papers simply because some publisher asks you to do it. We should never allow publishers to generate books in our fields. Series editors, under contract to these publishers, should not do it either. If we do have a project in mind, we should take it to GSA or another society to see if they will publish it first. If they won't, then we must ask whether or not it is a service to have a commercial publisher do it, and whether or not it will hurt our field. Of course, some of these authors just might like the royalties they receive for commercial work. Authors of articles should submit their work to societies first. That probably means a lot more work for our volunteer editors, but that's part of the service. But the societies can't publish all of it anyway. Write less! Convince your dean that "bean-counting" is not as important as quality.

2. We could cut our subscriptions and book purchases. This is probably not in our own best interests, because we do demand these products.

3. We could continue to rely on our libraries to obtain all the stuff we think we need, but in different ways. We must take some responsibility in generating funding for books and journals. That will be very difficult while academia and industry are hurting. We must view the library in a much larger context. No longer should we expect our departmental or campus library to carry everything. Regionally, do Berkeley, Davis, Santa Cruz, and San Francisco (all University of California [UC] locations in the San Francisco Bay area), to say nothing of Stanford and several California state universities nearby, all need to take the same materials? I think not, especially nowadays when, with the punch of a couple of computer keys, we can examine the contents of any journal and the abstracts of many of the articles. Our libraries must connect to on-line literature services as fast as possible, to examine regional holdings and not duplicate lesser used materials, to coordinate purchases (when legal), and to speed up interlibrary loans. Large, single-system libraries, like UC, might simply tell these publishers that they just won't buy any more from them unless the publishers make their products more affordable. All of us must get our desk-top computers hooked into these systems, so that we can browse the nation's libraries from the comfort of our offices, and download all those interesting references to computer files, rather than wasting time wandering around the stacks with 3 x 5 cards and a pencil. Make the market system work for us. As the demand decreases, the price will come down, or we won't have to worry about it at all.

I don't see an easy solution. We seem to have created the demand, and the commercial publishers have supplied the products. So the goose with the golden egg will probably never die. We must recognize that the structure of science is changed forever, and these publishers are likely to be around until we all go to computer-on-line publication. But if we want to avoid a similar problem in the future, then we had better gain control of the on-line activities before we have a very expensive GeoCompuServe doing it for us. The time is now, for the commercial sector can do it already. I hope GSA is working furiously to give it to us. In the meantime, I hope that *GSA Today* doesn't adopt that "we won't review a book that costs more than $100" policy. It's ineffective and not at all useful. Those $100+ books are exactly the ones that must be reviewed, for how else can we know whether to get a copy? Reviews in *GSA Today* could help us sort through this by providing not only a review, but also a cost-benefit analysis! That's what reviews nowadays need to do. ■

GSA Penrose Conferences

March 1994

From the Inside and the Outside: Interdisciplinary Perspectives on the History of Earth Sciences, March 19–21, 1994, San Diego, California. Information: Leo F. Laporté, Dept. of Earth Sciences, University of California, Santa Cruz, CA 95064, (408) 459-2248, fax 408-459-3074; Naomi Oreskes, Dept. of Earth Sciences, Dartmouth College, Hanover, NH 03755, (603) 646-1420, fax 603-646-3922; Kenneth L. Taylor, Dept. of the History of Science, University of Oklahoma, Norman, OK 73019-0315, (405) 325-2213, fax 405-325-2363.

1993 Meetings

April

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

Computer Simulated Mineral Exploration 22nd Workshop, April 1–30, 1993, Fontainebleau, France. Information: L. Zanone, Ecole des Mines de Paris, CGGM-IGM, 35, rue Saint Honoré, 77305 Fontainebleau Cédex, France, phone (33 1) 64 69 49 30, fax (33 1) 64 69 47 01, telex 694 736 F.

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

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

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

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

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

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

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

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

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

■ **American Association of Petroleum Geologists Annual Convention,** April 25–28, 1993, New Orleans, Louisiana. Information: AAPG Convention Dept., P.O. Box 979, Tulsa, OK 74101-0979, (918) 584-2555, fax 918-584-2274.

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

■ **Industrial Minerals 29th Forum,** sponsored by the California Division of Mines and Geology and the U.S. Bureau of Mines, April 25–30, 1993, Long Beach, California. Information: Ralph Loyd, California Division of Mines and Geology, 801 K Street, Sacramento, CA 95814-3531, (916) 322-9207.

May

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

Pacific Sections 1993 Convention, American Association of Petroleum Geologists, SEPM, Society of Exploration Geophysicists, Association of Engineering

Meetings *continued on p. 109*

ANNOUNCEMENT AND CALL FOR ABSTRACTS

ASSOCIATION OF ENGINEERING GEOLOGISTS 36TH ANNUAL MEETING

San Antonio, Texas - October 9-15, 1993

"EL AGUA Y LA TIERRA"

Attention Non-Members. The Texas Section invites you to attend the **36th Annual Meeting of the Association of Engineering Geologists** to be held at the Hyatt Regency Hotel on the River Walk. In order to encourage participation by our sister organizations, AEG is offering the same low registration fee to both members and non-members. The meeting will offer exciting technical programs, symposia, short courses, and field trips, as well as many guest activities designed to allow participants to experience the culture and enjoyment of the number one tourist destination in Texas!

TECHNICAL PROGRAM AND CALL FOR ABSTRACTS

All interested environmental geologists, hydrogeologists and engineering geologists are invited to submit abstracts on topics related to the meeting theme, "Water and the Earth". Abstracts should be about 250 words in a standard typeface. Speaking time will be limited to 20 minutes including discussion. Abstracts should be submitted ON OR BEFORE MAY 15, 1993. To facilitate ease of transmittal and program preparation, you can send your abstract via electronic mail (E-mail) to Compuserve 70702,2006. You may also send a hard copy if you do not have access to E-mail. For more details contact: Christopher C. Mathewson, Technical Program Chair, Department of Geology, Texas A&M University, MS 3115, College Station, Texas 77843-3115 (409) 845-3224. The planned technical program provides a broad opportunity for learning and exchange of ideas. Special theme sessions are planned in the areas of:

- **Environmental and Engineering Geology of Hazardous Natural Processes**
- **Engineering Geology and Construction**
- **Geology's Role in Protecting the Public Health**
- **Environmental and Engineering Geology of Waste Management**
- **Engineering Geology of the SSC**
- **Ground Water Well Head Protection**

SYMPOSIA

- **Environmental and Engineering Geology of the Rio Grande Valley and the Free Trade Zone**
- **Professional Ethics in Engineering Geology Practice**
- **Remote Sensing in Solid and Hazardous Waste Management**
- **GIS and Computer Techniques in Ground Water Analyses**

SHORT COURSES

- **Safety Evaluation of Dams** taught by personnel of the U.S. Bureau of Reclamation, including a 1/2-day field trip
- **Design and Analysis of Aquifer Tests** taught by Stephen Reynolds, C.P.G., of the U.S. Army Corps of Engineers

FIELD TRIPS

- **Anatomy of a Growth Corridor: Geology, Environment, and Engineering Along I-35 Between Dallas and San Antonio**
- **Hydrogeology of the Balcones Fault Zone, Edwards Aquifer**
- **San Antonio River - Via Riverboat**
- **Environmental and Engineering Geology of the Houston-Galveston Metroplex**
- **Engineering Geology of the San Antonio Missions**

REGISTRATION AND GENERAL MEETING INFORMATION

For information on meeting registration contact Herb Crowder, Henley-Johnston & Assoc., 235 Morgan Ave., Dallas, TX 75203. For general meeting information write to: Association of Engineering Geologists, 36th Annual Meeting, P.O. Box 690641, San Antonio, Texas 78269.

See you in San Antonio!

Let's Hear From You!

The Ad Hoc Committee on Membership Services has developed this questionnaire as a means of gathering information from the members on their interest in the Society's various publications and programs. This survey has already been sent to a random sampling of the membership; however, the Committee would like to hear from any and all interested members. Please take a few minutes to fill out this two-sided form and mail or fax it to:

Membership Services
Geological Society of America
P.O. Box 9140
Boulder, CO 80301
Fax: 303-447-1133

The Geological Society of America
3300 Penrose Place • P.O. Box 9140 • Boulder, CO 80301 • 303/447-2020 • FAX 303/447-1133

To: MEMBER, GEOLOGICAL SOCIETY OF AMERICA

From: Ad Hoc Committee on GSA Membership Services

Subject: WE WANT YOUR OPINION!

Your GSA membership dollar, the Penrose Endowment, and the GSA Foundation support a wide variety of services. In general, meetings, both annual and sectional, are held on a break-even basis, but the various publications and program services are subsidized to differing extents. The GSA Council needs your evaluation of these services. Please return this questionnaire!

PRESENT GSA SERVICES—Please rank the following sixteen items numerically (1-16, 1 = highest) according to their importance to you. Indicate whether you think GSA should expand (+), stay at the same level (0), or reduce (–) services in each area:

	Ranking (1-16)	Emphasis (+ 0 –)
Publications:		
GSA Today	_____	_____
Geology	_____	_____
Bulletin	_____	_____
Book series	_____	_____
Map and Chart series	_____	_____
Videotapes, disks, etc.	_____	_____
Meetings:		
Annual Meeting	_____	_____
Field trips	_____	_____
Short courses	_____	_____
Section meetings	_____	_____
Penrose Conferences	_____	_____
Presidential Conferences	_____	_____
Programs:		
Research grants	_____	_____
SAGE (Science Awareness through Geoscience Education)	_____	_____
IEE (Institute for Environmental Education)	_____	_____
Congressional Fellow support	_____	_____

POSSIBLE NEW SERVICES—Please indicate your opinion; we welcome additional ideas.

A new journal or book series on _____

An "accredited" short course on _____

Extended abstracts volume for annual meeting symposia _____

Additional suggestions: _____

_____

_____

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Meetings *continued from p. 108*

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

GEOTECHNICA 1993, International Trade Fair and Congress for Geosciences and Technology, May 5–8, 1993, Cologne, Germany. Information: KölnMesse, Messe- und Ausstellungs-Ges.m.b.H. Köln, Messeplatz 1, Postfach 21 07 60, W-5000 Köln 21, Germany, phone (0)2 21/821-0, fax (0)2 21/821-25 74, telex 8 873 426 mua d.

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

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

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

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

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

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

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

June

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

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

Society for the Preservation of Natural History Collections Conference, June 7–12, 1993, Victoria, British Columbia, Canada. Information: Liz Taylor, Royal British Columbia Museum, (604) 387-3701 or (604) 356-8791.

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

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

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

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

Meetings *continued on p. 110*

Please provide your major professional interest(s) and GSA Division(s) from the lists below.

Professional Interests: 1)_____ 2)_____ 3)_____

GSA Divisions: 1)_____ 2)_____ 3)_____

Is GSA an important society for people in your field? _____

Why or why not? _____

List the most important professional societies, including GSA, in your professional specialty in decreasing order of importance:

Comments:

List the most important journals, including GSA journals, in your professional specialty in decreasing order of importance:

Comments:

Is GSA assisting in leading geology, as a science and a profession, in those directions that you perceive to be the future of geology? _____ Why or why not? _____

What should GSA do differently? _____

GSA Professional Interests

1) Archaeological geology
2) Coal geology
3) Economic geology
4) Engineering geology
5) Environmental geology
6) Geochemistry
7) Geophysics/Tectonophysics
8) Hydrogeology
9) Mineralogy/Petrology
10) Oceanography/Marine geology
11) Paleontology/Paleobotany
12) Petroleum geology
13) Planetary geology
14) Quaternary geology/Geomorphology
15) Stratigraphy/Sedimentology
16) Structural geology/Tectonics
17) Volcanology
18) Geoscience Education
19) Other

GSA Divisions

20) Archaeological Geology
21) Engineering Geology
22) History of Geology
23) Quaternary Geology & Geomorphology
24) Coal Geology
25) Geophysics
26) Hydrogeology
27) Planetary Geology
28) Structural Geology & Tectonics
29) Sedimentary Geology
30) International
31) Geoscience Education
32) None of interest

Meetings *continued from p. 109*

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

July

International Mining Geology Conference, July 5–8, 1993, Kalgoorlie-Boulder, Australia. Information: The Chairman, International Mining Conference, c/-Kalgoorlie Consolidated Gold Mines Pty Ltd., PMB 27, Kalgoorlie WA 6430, phone 61-90-22 1229, fax 61-90-93 2315.

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

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

Geological and Landscape Conservation International Conference, July 17–24, 1993, Great Malvern, United Kingdom. Information: D. O'Halloran, JNCC, City Road, Peterborough, PE1 1JY, UK, phone 44-733-62626, fax 44-733-893 971.

10th International Clay Conference, July 18–23, 1993, Adelaide, Australia. Information: Conference Secretariat, Elliservice Convention Management, P.O. Box 753, Norwood, SA 5067, Australia, phone 61-8-332-4068, fax 61-8-364-1968.

August

Intraplate Volcanism International Workshop, The Polynesian Plume Province, August 1993, Tahiti, French Polynesia. Information: Workshop Tahiti 1993 Organization Committee, H.G. Barsczus, Centre Géologique et Géophysique, Case 060, Université de Montpellier II, 34095 Montpellier Cedex 5, France, phone 33-67-634-983, fax 33-67-523-908.

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

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

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

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

Mine Design International Congress, Mining into the 21st Century, August 23–26, 1993, Kingston, Ontario, Canada. Information: Peter Scott, Public Relations, ICMD/Relations publiques, CICM, Department of Mining Engineering/Département de génie minier, Queen's University/Université Queen's, Kingston, Ontario K7L 3N6, Canada, (613) 545-2212, fax 613-545-6597.

Hydrothermal Reactions Fourth International Symposium, August 31–September 3, 1993, Nancy, France. Information: 4th ISHR, CREGU, BP-23, 54501-Vandoeuvre-lès-Nancy Cedex, France, telex: 960934, fax 33-83 44 00 29, E-mail: internet CREGU ciril.fr, or FRciiL71.bitnet.

September

Friends of the Pleistocene (Rocky Mountain Cell) Meeting, September 10–12, 1993, Mission Valley–Flathead Lake area, northwest Montana. Information: Dan Levish, Bureau of Reclamation, P.O. Box 25007, D-3611, Denver, CO 80225-0007, (303) 236-8532.

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

Fractography, Geological Society of London Thematic Meeting, September 13–14, 1993, London, United Kingdom. Information: M. S. Ameen, GeoScience Limited, Silwood Park, Buckhurst Road, Ascot SL5 7QW, UK, phone 44-344-872220, fax 0344 872438.

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

10th Annual International Pittsburgh Coal Conference, September 20–24, 1993, Pittsburgh, Pennsylvania. Information: Ann McDonald, Conference Secretary, Pirrsburgh Coal Conference, University of Pittsburgh, 1140 Benedum Hall, Pittsburgh, PA 15261, (412) 624-7440, fax 412-624-1480.

Andean Geodynamics 2nd International Symposium, September 21–23, 1993, Oxford, England. Information: P. Soler, ISAG 93, ORSTOM, CS1, 213 rue Lafayette, 75480 Paris Cedex 10, France, fax 33-1 48 03 08 29. *(Abstract deadline: April 1, 1993.)*

International Association of Volcanology and Chemistry of the Earth's Interior (IAVCEI) General Assembly, Ancient Volcanism and Modern Analogues, September 25–October 1, 1993, Canberra, Australia.

Information: IAVCEI General Assembly, Acts, GPO Box 2200, Canberra, ACT 2601, Australia, phone 61-6-2573299, fax 61-6-2573256.

Global Boundary Events (Interdisciplinary Conference of IGCP Project 293, Geochemical Marker Events in the Phanerozoic), September 27–29, 1993, Kielce, Poland. Information: Barbara Studencka, Muzeum Ziemi PAN, Al. Na Skarpie 20/26, 00-488 Warszawa, Poland, phone 48-22-217-391, fax 48-22-297-497; or Helmut H.J. Geldsetzer, Geological Survey of Canada, 3303 33rd St. N.W., Calgary, Alberta T2L 2A7, Canada, (403) 292-7155, fax 403-292-5377.

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

October

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

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

■ **Geothermal Resources Council Annual Meeting,** October 10–13, 1993, Burlingame, California. Information: Geothermal Resources Council, P.O. Box 1350, Davis, CA 95617-1350, (916) 758-2360, fax 916-758-2839.

International Association for Mathematical Geology, October 10–15, 1993, Prague, Czechoslovakia. Local Chairman: Vaclav Nemec, K. Rybinickum 17, Praha 1–Strasnice, Czechoslovakia; Technical Program Committee cochairmen—North and South America: John C. Davis, Kansas Geological Survey, University of Kansas, Lawrence, KS 66047, (913) 864-3965, fax 913-864-5317, E-mail: john_davis.moore_hall@-msmail.kgs.ukans.edu; Europe, Africa, and Asia: Jan Harff, Institute for Baltic Sea Research, Seestr. 15, 0-2530 Warnemuende, Germany, phone 49 381 58.261, fax 49 381 58.336, E-mail: harff@-geologie.io-warnemuende.dbp.de.

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

New Developments in Geothermal Measurements in Boreholes, sponsored by GeoForschungsZentrum Potsdam, Geothermal Association of Germany, IUGG International Heat Flow Commission, Internationl Association for Mathematical Geology, and the Kansas Geological Survey at The University of Kansas, October 18–23, 1993, Klein Köris, Germany. Information: E. Hurtig, GFZ Potsdam, Talegrafenberg A45, 0-1561 Potsdam, Germany, phone 49.331.310.347, fax 49.331.310.610, E-mail: gth@gfz-potsdam.dbp.de.

■ **Gulf Coast Association of Geological Societies and Gulf Coast Section of SEPM 43rd Annual Convention,** October 20–22, 1993, Shreveport, Louisiana. Information: Roger Berg, Arkla Exploration Co., P.O. Box 21734, Shreveport, LA 71151, (318) 429-2713.

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

■ **World Energy Engineering 16th Congress,** October 26–28, 1993, Atlanta, Georgia. Information: Ruth M. Bennett, 4025 Pleasantdale Road, Suite 420, Atlanta, GA 30340, (404) 447-5083, fax 404-446-3969.

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

November

International Circum-Pacific and Circum-Atlantic Terrane Conference VI, November 5–21, 1993, Guanajuato, Mexico. Information: Fernando Ortega-Gutiérrez, fax 52 (5) 548-0772; or David G. Howell, fax 415-353-3224.

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

■ **24th Annual Underwater Mining Institute,** November 7–9, 1993, Estes Park, Colorado. Information: Karynne Chong Morgan, UMI Conference Coordinator, 811 Olomehani Street, Honolulu, HI 96813-5513, (808) 522-5611, fax 808-522-5618, Internet: morgan@uhunix.uhcc.hawaii.edu, Compuserve: MMTC, 70673,534.

1994 Meetings

January

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

April

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

May

■ **Geological Association of Canada and Mineralogical Association of Canada Annual Meeting,** May 15–18, 1994, Waterloo, Ontario, Canada. Information: Alan V. Morgan, Department of Earth Sciences, University of Waterloo, Waterloo, Ontario N2L 3G1, Canada, (519) 885-1211 (x-3231), fax 519-746-7484.

June

■ **1st North American Rock Mechanics Symposium,** June 1–3, 1994, Austin, Texas. Information: Priscilla Nelson, (512) 471-4929, or Stephen Laubach, fax 512-471-0140.

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

July

■ **FORAMS '94: International Symposium on Foraminifera,** July 5–9, 1994, Berkeley, California. Information: FORAMS '94, Museum of Paleontology, University of California, Berkeley, CA 94720, (510) 642-1821, fax 510-642-1822.

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

■ **Basement Tectonics 11th International Conference,** July 25–29, 1994, Potsdam, Germany. Information: Onno Oncken, Conference Chairman, GeoForschungsZentrum, Telegrafenberg, D-0-1561 Potsdam, Germany, phone 49-331-310601, fax 49-331-310306. *(Abstracts deadline: March 1, 1994.)*

August

■ **V.M. Goldschmidt Conference,** August 29–September 2, 1994, Edinburgh, Scotland. Information: B. Harte or P. Symms, V.M. Goldschmidt Conference 1994, Department of Geology and Geophysics, University of Edinburgh, Grant Institute, West Mains Road, Edinburgh EH9 3JW, Scotland, UK.

September

Cyclicity in Global Geology, Australian Geological Convention Symposium, September 1994, Perth, Australia. Information: Bryan Krapez, C.McA. Powell, Department of Geology, University of Western Australia, Nedlands, W.A. 6009.

October

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

November

■ **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.

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

About People

GSA Member **Janice A. Carlson,** Chief of the Ohio Division of Emergency and Remedial Response, was honored as the Ohio Environmental Protection Agency's 1992 Senior Manager of the Year.

American Institute of Professional Geologists awards for 1992 honored the following GSA members: Fellow and Councilor **Robert H. Dott, Jr.,** University of Wisconsin, Madison—the Ben H. Parker Memorial Medal; Fellow **Kenneth N. Weaver,** Maryland Geological Survey, Baltimore—the Martin Van Couvering Memorial Award; Fellow **Robert R. Jordan,** Delaware Geological Survey, Newark—the Public Service Award; and Fellow **Richard J. Proctor,** Arcadia, California—an Honorary Membership Award.

SEPM honorees at its annual meeting in April will include GSA Fellow **Robert H. Dott, Jr.,** University of Wisconsin, Madison—the William H. Twenhofel Medal; and Fellow **Charles B. Campbell,** Exxon Production Research Company, Florence, Montana—the Francis J. Pettijohn Medal.

Fellow **Farouk El-Baz,** Director of the Center for Remote Sensing at Boston University, has received the 1992 Award for Public Understanding of Science and Technology from the American Association for the Advancement of Science.

GSA Member **Gilbert Hanson,** State University of New York at Stony Brook, has been named president-elect of the American Geophysical Union's Volcanology, Geochemistry and Petrology Section.

Member **Darryl J. Keith,** Environmental Protection Agency, Narragansett, Rhode Island, has been awarded an Office of Research and Development Bronze Medal.

The 1993 officers of the Society for Luminescent Microscopy and Spectroscopy include GSA Member **Michael R. Owen,** St. Lawrence University, Canton, New York (president), and Fellow **Otto C. Kopp,** University of Tennessee, Knoxville (secretary/treasurer).

Fellow **Walter H. Munk,** Scripps Institution of Oceanography, La Jolla, California, was honored in January with the Vetlesen Prize by Columbia University.

Fellow **Frank Press,** National Academy of Sciences, Washington, D.C., is a 1993 Japan Prize winner in the category of safety engineering and disaster mitigation. Fellow **William I. Rose** has been named head of the Department of Geological Engineering, Geology and Geophysics at Michigan Technological University, Houghton. Fellow **Manik Talwani,** Houston Advanced Research Center and Rice University, has been named a foreign member of the Russian Academy of Natural Sciences.

NRC Seeks Applicants for Senior and Postdoctoral Research Associateships

The National Research Council announces the 1993 Resident, Cooperative, and Postdoctoral Research Associateship Programs to be conducted on behalf of 30 federal agencies or research institutions whose 115 participating research laboratories are located throughout the United States. The programs provide opportunities for Ph.D. scientists and engineers of unusual promise and ability to perform research on problems largely of their own choosing yet compatible with the research interests of the sponsoring laboratory.

Approximately 350 new full-time Associateships will be awarded on a competitive basis in 1993 for research in: chemistry; earth and atmospheric sciences; engineering and applied sciences; biological, health, and behavioral sciences and biotechnology; mathematics; space and planetary sciences; and physics. Most of the programs are open to both U.S. and non-U.S. nationals, and to both recent Ph.D. degree recipients and senior investigators.

Awards are made for one or two years, renewable to a maximum of three years; senior applicants who have held a doctorate at least five years may request a shorter period. Financial support is provided for allowable relocation expenses and for limited professional travel during duration of the award. The host laboratory provides programmatic assistance, including facilities, support services, necessary equipment, and travel necessary for the conduct of the approved research program.

Applications to the National Research Council must be postmarked no later than April 15 and August 15 for reviews in June and October, respectively. Initial awards will be announced in April–July and November.

Information on specific research opportunities and participating federal laboratories, as well as application materials, may be obtained from: Associateship Programs (GR430/D3), National Research Council, 2101 Constitution Avenue, N.W., Washington, D.C. 20418, fax 202-334-2759. ■

1994–1995 Fulbright Scholar Awards

Competition Opens for U.S. Faculty and Professionals

The Fulbright Scholar Program for 1994–1995 includes some 1000 grants for research, combined research and lecturing, or university lecturing in nearly 135 countries. Opportunities range from two months to a full academic year; many assignments are flexible to the needs of the grantee. Nearly one-third of Fulbright grants are targeted for research, and many lecturing awards offer research opportunities; multicountry research is also possible in many regions. Virtually all disciplines and subfields participate. Specific openings exist in almost every area of the physical sciences and applied fields. Many offerings throughout the program allow scholars to propose their own lecturing or research projects.

The basic eligibility requirements for a Fulbright award are U.S. citizenship and Ph.D. or comparable professional qualifications; for lecturing awards, university or college teaching experience is expected. Language skills are needed for some countries, but most lecturing assignments are in English. Applications are encouraged from professionals outside academe and from independent scholars. Fulbright seeks good teachers as well as active researchers.

A single, early deadline of *August 1, 1993,* exists for research or lecturing grants to all world areas. Other deadlines apply for special programs. For further information and applications, call or write the Council for International Exchange of Scholars, 3007 Tilden Street, N.W., Suite 5M, Box NEWS, Washington, DC 20008-3009; (202) 686-7877. ■

Memorial Preprints

Charles F. Bassett
Kenneth G. Brill, Jr.

George Vincent Cohee
Ralph L. Miller

John C. Griffiths
Lawrence J. Drew

Norman L. Hatch, Jr.
Rolfe Stanley, Douglas Rankin, David Harwood, and Nicholas Ratcliffe

M. King Hubbert
David B. Doan

Anna Jespersen
Phyllis Dedekam

Arthur Crane McFarlan
Lois Campbell

Ralph LeRoy Miller
Jack H. Medlin

Charles Milton
Harvey E. Belkin and Edward J. Dwornik

Roger Randall Dougan Revelle
Robert L. Fisher

Vernon E. Swanson
Robert J. Weimer

Study in the Russian Federation and the People's Republic of China

The International Education Center annouces its Seventh Annual Fellowship Program for Educators and University Students to the Russian Federation and the People's Republic of China for the summer of 1993. The International Education Center (IEC) specializes in arranging study programs for educators and students. These programs provide an opportunity for a select group to participate in an exciting experience they can bring back to their school and community. This includes half-day visits to places of historic and cultural interest, half-days of short-term instruction in language and culture, and evenings reserved for special cultural or social activities.

The IEC fellowships cover part of the total expenses for the program, including a course completion certificate, awarded by the participating eductional institutions. Teacher union representatives, educators, school board members, state and local education department members, school administrators, working per-diem retirees, school-based support personnel, graduating high school seniors and university students are invited to apply. Program fees include round-trip air transportation from the New York City gateway (to and from Moscow, St. Petersburg, or Hong Kong), most meals, tuition, local transportation, accommodations, resident director, interpreters, cultural and social events, excursions, gratuities, and taxes. Participants are housed in hotels, double occupancy, with private accommodations. Visa fees and airport taxes are not included.

Three programs are being offered this year, all of which have been reduced in price to reflect the 1993 Fellowship, a cash value of $1300.

The *Russian Federation Program* is scheduled for July 7–23 and July 14–30, 1993. This includes 8 days in Moscow and 8 days in St. Petersburg. Program fee is $1995.

The *Russian Family Homestay Program*—dates are flexible, 10 to 28 days, Moscow and St. Petersburg. Program fee starts at $1295.

The *China Program* is scheduled for July 1–17, 1993. This includes 4 days in Hong Kong and 12 days in Xiamen. Program fee is $1995. An extension to Beijing, Xian, and Guilin is available for an additional $755.

Because these are certificate study programs at a foreign university, the programs are tax deductible for educators, and differential course credit might apply.

Educators and their families interested in the program are urged to apply immediately, since Fellowships are limited to a total of 50 participants in each program on a first-come, first-served basis. To apply for the Fellowship, write or call for the **free** brochure and **fellowship application form** immediately: Jack Scheckner, International Education Center, Ltd., Bowling Green Station, Box 843, New York, NY 10274; 1-800-292-4452, 6–9 p.m. Eastern time; fax 718-356-1302. ■

GSA GeoVentures 1993

GEOHOSTEL

Geology, Paleontology, and Cultural History of North-Central and Northwestern New Mexico

Plaza Resolana en Santa Fe, Santa Fe, New Mexico
Five Days and Six Nights: May 29–June 3, 1993

Scientific Leaders
Donald L. Wolberg, New Mexico Bureau of Mines and Mineral Resources
Diane Bellis, U.S. Department of Agriculture, Forest Service

Near Taos; Pilar looking down the Rio Grande.

At the base of the Sangre de Cristo Mountains lies the city of Santa Fe, founded in 1610 by Pedro de Peralta acting on instructions signed in Mexico City by Viceroy Luis de Velasco, the King of Spain's representative in New Spain. The romantic and historic aura of Santa Fe, "The City Different," is unique among American cities and is seen in all aspects of the Santa Fe experience. Santa Fe is also part of and central to a richly diverse geological (and cultural-historical) vista that is challenging both to contemplate and to visit.

Spanish settlers began to arrive in the vicinity of Taos Pueblo to the north of Santa Fe at about the same time that Santa Fe was being established. Through the early years of the 20th century, Taos developed into a haven for artists, potters, and writers, and it remains so today. The Rio Grande Gorge near Taos is 200 m deep and 400 m wide and developed in thick basalts. In the area, Precambrian rocks form the basement beneath late Paleozoic age marine and nonmarine sedimentary rocks.

The north-trending Sangre de Cristo Mountains are about 30 km wide and 320 km long and separate the late Cenozoic Rio Grande Rift on the west from the Raton Basin on the east. In the Santa Fe region, the basement rocks are Precambrian metasedimentary, igneous, and metaigneous. The Jemez Volcanic Field separates the Espanola Basin on the north from the Albuquerque Basin on the south. Volcanism began after formation of the Rio Grande Rift. The Valles and Toledo calderas are major structures within the Jemez Volcanic Field. The Sandias, granitoid rocks capped by Paleozoic sedimentary rocks, rise majestically above Albuquerque.

To the west of Santa Fe lies the San Juan Basin, rich in mineral wealth, especially coal, oil, and uranium. Equally rich in fossil-containing rocks and cultural history, the San Juan Basin preserves the magnificent world-renowned archaeological ruins seen at Chaco Canyon.

Program Schedule

May 29, Saturday	Welcoming get-together
May 30–June 3, Sunday through Thursday	Classes and field trips
June 3, Thursday	Farewell party

Fee and Deposit

Cost: $550 for GSA members. Nonmembers $595.
$125 deposit, due with your reservation, is refundable through March 30, less $20 processing fee.
Total balance due: April 1
Minimum age: 21 years. Limit: 28 persons.

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

These trips are full, but we are taking standbys

Iceland GeoTrip
July 31–August 15, 1993

Wyoming GeoHostel
July 17–22, 1993

CALL TODAY:
Edna Collis or Dottie Weigand • 1-800-472-1988 or (303) 447-2020

GSA ANNUAL MEETINGS

■ 1993

Boston, Massachusetts
Hynes Convention Center
October 25–28

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

Abstract Deadline: July 7
Preregistration Deadline: September 24

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

New for '93

Registration Materials will be in JUNE *GSA Today*—REGISTER EARLY

■ 1994

Seattle, Washington
Washington State Convention and Trade Center
October 24–27

Chairman: Darrel S. Cowan, University of Washington

Call for Field Trip Proposals: Please contact the field trip chairman—Donald A. Swanson, Department of Geosciences, University of Washington, Seattle, WA 98195, (206) 543-1190. *Deadline: May 15, 1993.*

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

■ FUTURE

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

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

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GSA SECTION MEETINGS

■ 1993

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

■ 1994

South-Central March 21–22	University of Arkansas Little Rock, Arkansas
Cordilleran March 21–23	California State University San Bernardino, California
Northeastern March 28–30	SUNY at Binghamton Binghamton, New York
Southeastern April 7–8	Virginia Polytechnic Institute and State University Blacksburg, Virginia
North-Central April 28–29	Western Michigan University Kalamazoo, Michigan
Rocky Mountain May 4–6	Hosted by Fort Lewis College at Tamarron Resort Durango, Colorado

April *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 1993 issues, even if you've already paid your 1993 dues. Call Membership Services today at 1-800-472-1988.

The Geological Society of America
BULLETIN
Volume 105, Number 4, April 1993

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NO. 4
P. 289–384
APRIL 1993

CLASSIFIED ADVERTISING

Published on the 1st of the month of issue. Ads (or cancellations) must reach the GSA Advertising office one month prior. Contact Advertising Department (303) 447-2020, 1-800-472-1988, fax 303-447-0648.

Classification	Per line for 1st month	Per line for each addt'l month (same ad)
Situations Wanted	$1.75	$1.40
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first 25 lines	$0.00	$1.35
additional lines	$1.35	$1.35

Code number: $2.75 extra

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

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

UNC WILMINGTON
Marine Geologist

The Department of Earth Sciences, University of North Carolina at Wilmington, invites applications for a tenure track position in any aspect of marine geology beginning August 1993 at the rank of assistant or associate professor. Salary will be commensurate with qualifications and experience. Candidates must provide quality classroom instruction at the graduate and undergraduate level in their area of expertise, and conduct a vigorous, externally funded research program. Preference will be given to candidates with a history of involvement in the International Ocean Drilling Program as evidenced by publications, external funding, and active participation in ODP.

Interested candidates should send a letter of application and résumé, and arrange to have three letters of recommendation sent to: Chair, Marine Geology Search Committee, Department of Earth Sciences, UNCW, Wilmington, NC 28403. For full consideration applications should be received by April 19, 1993. The position will remain open until filled.

UNCW is an equal-opportunity/affirmative-action employer and we strongly encourage applications from women and minorities.

EARTH AND OCEAN SCIENCES
University of Victoria, British Columbia, Canada

Applications are invited for two faculty positions in the School of Earth and Ocean Sciences. In the current year, preference will be given to solid earth scientists with research interests in earth system science. The focus of the School is in fundamental transdisciplinary studies of the ancient and modern interactions of the solid earth, oceans and atmosphere. These appointments are part of a multi-year expansion program; rank of positions is open; preferred starting date is July 1993.

In accordance with Canadian immigration and Employment regulations, this notice is directed in the first instance to Canadian citizens and permanent residents. The University of Victoria is committed to an employment equity program; women especially are encouraged to apply. Send inquires or applications, with curriculum vitae and names of three referees to Dr. Chris R. Barnes, Director, School of Earth and Ocean Sciences, University of Victoria, P.O. Box 1700, Victoria, British Columbia V8W 2Y2, Canada. Deadline for application is April 15, 1993, or until positions are filled.

ELECTRON MICROPROBE TECHNICIAN

The University of South Carolina (USC) invites applications for a full-time electron microprobe technician to operate and maintain a five spectrometer (4 WDS, 1 EDS) Cameca SX-50 Electron Microprobe.

Primary responsibilities involve routine maintenance, calibration, and operation of the SX-50 microprobe, its support equipment, and computers in the microprobe laboratory, user training, and analytical services for non-USC personnel.

Required skills include (1) principles and operation of electron optical systems, (2) principles and application of X-ray spectrographic analysis, (3) fundamentals of mineralogy and mineral analysis using electron microprobe techniques, (4) ability to operate a variety of computer systems. Basic programming skills are desirable.

Applicants must hold an M.Sc. degree in natural science or engineering, or B.Sc. and at least 3 years experience as an electron probe operator. Starting salary commensurate with degree and experience.

Send resume, copies of university transcripts, and 3 letters of recommendation to Dr. John Shervais, Department of Geological Sciences, University of South Carolina, Columbia, SC 29208. Telephone: (808) 777-4534; fax (803) 777-6610. Applications should be received by 15 April 1993.

The University of South Carolina is an Equal Opportunity employer. Women and minorities are encouraged to apply.

CALIFORNIA STATE COASTAL CONSERVANCY
REQUEST FOR QUALIFICATIONS

The State Coastal Conservancy anticipates a need for environmental consulting services over the next twelve months including architectural and landscape architectural services.

The California State Coastal Conservancy seeks statements of qualifications from individuals and firms providing these services. The Conservancy acts to preserve, restore and enhance California's coastal resources and to solve land use problems on the coast and around San Francisco Bay. The Conservancy undertakes projects in the following areas: (1) public access (e.g., trails; bridges; whole access; parking, recreational and interpretive facilities); (2) urban waterfronts (e.g., pier restoration; commercial fishing; waterfront access; waterfront revitalization; shoreline facilities); (3) resource enhancement (e.g., restoration and enhancement of wetlands and endangered species habitats); (4) coastal restoration (e.g., lot consolidation; transfer of development rights; coastal land acquisition); and (5) agricultural land preservation (e.g., acquisition of interests in coastal agricultural land and resolution of agricultural problems).

For further information please write to Tyronea Marshall, State Coastal Conservancy, 1330 Broadway, Suite 1100, Oakland, CA 94612. Qualifications must be received no later than June 30, 1993.

ENVIRONMENTAL GEOLOGIST

New Mexico Institute of Mining and Technology seeks an Environmental Geologist with the department of Geoscience. Position is tenure track in environmental geology with an emphasis in surficial processes and soils. Although we anticipate filling the position at the Assistant Professor level, senior persons with exceptional qualifications may be considered at the Associate Professor level. Preference will be given to applicants with a strong interest in field studies and whose research interests will enhance existing programs within the department. A Ph.D. in earth sciences or a related field is required at the time of appointment. The successful candidate must have a strong commitment to teaching and research (as demonstrated by the quality of prior research and publications) and is expected to direct M.S. and Ph.D. students. A strong, funded research program is expected. Twenty-five percent of the appointment will be with the Geophysical Research Center, resulting in a reduced teaching load. The position carries responsibility for teaching courses in surficial processes (e.g., geomorphology and soils), as well as in the applicant's field of specialization. In addition, participation in undergraduate core courses and the development of additional courses in environmental geology may be required. Ability to communicate effectively in written and spoken English is essential. New Mexico Tech has a number of strong programs in the environmental area providing numerous opportunities for collaborative research. The successful candidate will contribute to the interdisciplinary Environmental Science program.

To apply, please submit curriculum vitae and a statement of research and teaching interests, and have three letters of reference sent to: New Mexico Institute of Mining and Technology, Human Resources, Wells Hall Box C-028, Socorro, NM 87801.

The position will be available in August 1993. For full consideration complete applications must be received by May 15, 1993; however, applications will be considered until the position is filled. AAEOE.

ENVIRONMENTAL GEOSCIENCES

The Department of Geological Sciences, Indiana University, Bloomington, invites applications for a tenure-track faculty position (rank and salary open). We seek individuals who can establish a competitively funded research program focused on quantitative evaluation of chemical, physical or biological processes and mechanisms in surface and near-surface systems. Preference will be given to scientists who possess research interests that complement and enhance existing departmental strengths, and who can further develop and coordinate our environmentally related programs. Support for a senior scientist may include significant start-up funds, laboratory facilities and an affiliated research personnel position. Submit letter of application and vita by June 15 to: Professor Simon C. Brassell; Chairman, Faculty Search Committee; Department of Geological Sciences; Indiana University; Bloomington, IN 47405-5101.

Indiana University is an equal opportunity/affirmative action employer.

Services & Supplies

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

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 in U.S. institutions to conduct reseach 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.

Applications are available from the JOI office and should be submitted according to the following schedule: Leg 153: MARK 5/1/93; Leg 154: Ceara Rise, 5/1/93; Leg 155: Amazon Fan, 5/1/93; Leg 156: North Barbados Ridge, 5/1/93; Leg 158: TAG, 5/1/93; Shorebased Research (regardless of leg) 12/1/93.

These legs will be staffed during the next few months. Students interested in participating as shipboard scientists must apply to the ODP Manager of Science Operations in College Station, TX. An application form is available in the JOI/USSAC Ocean Drilling Fellowship application packet. 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).

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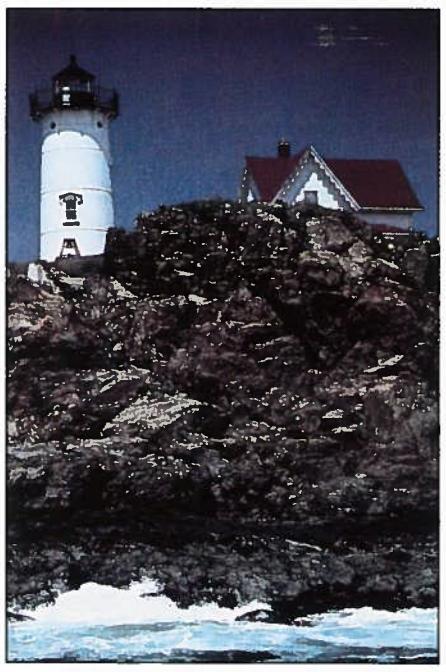

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four publications pertaining to the Himalayas *from the Geological Society of America*

The South Tibetan Detachment System, Himalayan Orogen: Extension Contemporaneous with and Parallel to Shortening in a Collisional Mountain Belt

edited by Burrel C. Burchfiel, Chen Zhiliang, Kip V. Hodges, Liu Yuping, Leith H. Royden, Deng Changrong, and Xu Jiene, 1992

This small volume represents a milestone in the continuing story of progress in the understanding of the world's greatest mountain range, dealing with a most far-reaching discovery: evidence of important normal faulting on the north side of the Himalaya, which first came to light in the early 1980s. The authors report and document for the first time just how extensive and pervasive that normal fault system is. The similarity to normal faulting in regionally extended terrains is remarkable and requires reconsideration of the widespread interpretation that extension follows convergence in orogenic belts. Observations documented here represent a dramatic step forward in the appreciation of the processes of mountain building. They relate not only to the Himalaya but also will help in interpreting other active moutain belts, including the newly recognized mountain ranges of Venus.

SPE269, 48 p., paperback, ISBN 0-8137-2269-1, $18.75 (+ $3 S&H)

Tectonics of the Western Himalayas

edited by Lawrence L. Malinconico, Jr., and Robert J. Lillie, 1989

Here is new light on the overall crustal structure and tectonic evolution of the Himalayan collision zone, focusing on northwestern India and northern Pakistan. This complements previous Himalayan studies that generally dealt with the central part of the belt where collision processes were maximized. The articles on the western Himalaya allow a look at a youthful collisional belt where the collision is oblique, surficial features take an abrupt bend toward the west, and where an island-arc terrain (Kohistan/Ladakh) separates rocks of the Indian subcontinent from those of Asia. Observations are included on the geophysical, petrologic, structural, neotectonic, and stratigraphic data of both foreland and hinterland. An important feature is the use of various geochronological techniques to date sediments, convergence, and uplift. Inclusion of E. R. Gee's Salt Range maps at scale 1:250,000 provides both scientific and historical perspective.

SPE232, 300 p., 1 pocket-plate, indexed, paperback, ISBN 0-8137-2232-2, $40.00 (postpaid)

The Cimmeride Orogenic System and the Tectonics of Eurasia

by A. M. Celâl Şengör, 1984

The author's interest in Tethyan problems goes back more than a decade, when he saw a gap in the regional tectonic literature of Eurasia. What was lacking, he felt, was a synthetic overview of the early history of the Alpine-Himalayan mountain ranges and its expected implications for the "Tethyan paradox," first brought into focus by Alan Smith. This work includes a history of the Tethys concept, a regional review, and an orogenic history of the Cimmeride.

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