



Achchagy-Kyyry-Taas on the Lena River of Siberia. Tectonically undisturbed, the Early Cambrian limestone and dolomite of this section preserve excellent records of paleontological evolution as well as carbon isotopic variations and magnetic reversals. *Photo by Joseph Kirschvink*

The Precambrian/Cambrian Boundary: Magnetostratigraphy and Carbon Isotopes Resolve Correlation Problems Between Siberia, Morocco, and South China

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ABSTRACT

Late Proterozoic and Early Cambrian age platform carbonates from the Siberian platform now have the most complete records of paleontological, magnetostratigraphic, and $\delta^{13}\text{C}$ variations preserved anywhere on Earth. New carbon isotopic data from Siberia extends the known pattern up through the first half of Early Cambrian time (the Late Tommotian up through the middle of the Atdabanian stage). These data reveal a fourth $\delta^{13}\text{C}$ cycle in the Siberian Precambrian/Cambrian boundary isotope curve, and in conjunction with the magnetostratigraphy provide two nonbiological techniques for testing proposed correlations. Similar patterns are present in both the carbon isotope and magnetic reversal stratigraphies in the upper Lie de Vin formation of Morocco, confirming recent biostratigraphic work. A unique match is also present in the comparison between Siberia and an important locality near Kunming in south China, and implies that at least half of the record of Atdabanian time is missing there. Hence, the Chinese section is not suitable as an international stratotype for the Precambrian/Cambrian boundary.

INTRODUCTION

In terms of its subsequent impact on the history of life on Earth, the Precambrian/Cambrian transition is comparable to the Paleozoic/Mesozoic and Mesozoic/Tertiary boundaries. Unlike the latter two, however, the fossil record of this boundary is one-sided, with few mineralized fauna on the Precambrian side to provide a record of the biological events that were transpiring. Because temporal correlation is a prerequisite for understanding any part of the geological record, the questions posed by the Precambrian/Cambrian boundary problem have been the focus of a special International Union of Geological Sciences (IUGS) working group devoted to improving stratigraphic correlation of this time interval

to the point where the international geological community could agree on a stratotype section and horizon (e.g., Cowie, 1985). Primary emphasis has been placed on finding a biostratigraphic level suitable for global correlation of the boundary horizon. However, a consensus of the community has not yet been achieved. With the development of nonbiological correlation methods like stable isotope and geomagnetic polarity stratigraphy, it has become clear that biostratigraphy is not sufficient in many cases to resolve temporal correlation problems. Biostratigraphic correlations of Early Cambrian and Precambrian faunas, which are extremely complex because of high faunal provinciality in the

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Early Cambrian and limited faunas in the Precambrian, are particularly suspect as "time-equivalent" horizons, making the application of alternative methods essential.

In this study we compare the magnetostratigraphic and carbon isotopic signatures of three slightly younger sections of Early Cambrian age that have received considerable attention in the stratigraphic search for a Precambrian/Cambrian boundary. First we report new carbon isotope results from the Zhurinsky Mys and Isit localities, on the Lena River of the Siberian platform, which extend the previous work on strata of latest Precambrian (Vendian) and Tommotian age up through the Tommotian/Atdabanian boundary and into mid-Atdabanian time (Magaritz et al., 1986; Magaritz, 1989). These results demonstrate that there are at least four major cycles in the inorganic marine carbon isotopic pattern, which we informally designate as Siberian carbon cycles I through IV. In addition to the excellent archaeocyathan and small shelly fossil records, the Tommotian and Atdabanian stages of the Siberian platform now have two independent, nonbiological correlation methods (carbon isotope and magnetostratigraphy) to help test intercontinental correlations.

We present new carbon isotopic results from the Tommotian and Atdabanian equivalent horizons in the Anti-Atlas Mountains of Morocco, in a test of recent biostratigraphic and magnetostratigraphic correlations to Siberia. These results support strongly these proposed correlations, and confirm that the polarity interpretations now in use between Siberia, Morocco, and Australia are correct for the Precambrian/Cambrian boundary interval. We use the Siberian reference carbon and magnetic patterns to test proposed correlations between Siberia and the Meishucun section in south China, which has recently also been the subject of carbon isotopic and magnetostratigraphic studies. Our analysis of the data supports the contention that the lower Meishucun section correlates to the approximate region of the Tommotian-Atdabanian interval on the Siberian platform, as proposed by Soviet paleontologists (Cowie, 1985), but we do not find it as easy to suggest correlations with pre-Tommotian strata, as suggested by other authors (for discussions, see Cowie, 1985; Brasier, 1989; Qian and Bengston, 1989). Figure 1 shows the probable Early Cambrian locations for these three important reference sections, plotted upon a paleogeographic reconstruction adapted from Kirschvink (1991).

GEOLOGICAL BACKGROUND AND RESULTS

Siberia

The Siberian Platform contains one of the world's best preserved

Precambrian-Cambrian Boundary Carbon Isotope Sample Localities

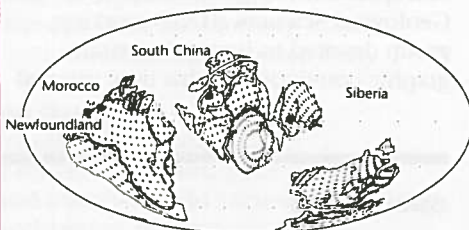


Figure 1. Paleogeographic reconstruction for the Precambrian/Cambrian boundary (adapted from Kirschvink, 1991), showing locations for the sections yielding carbon isotope and magnetic reversal patterns.

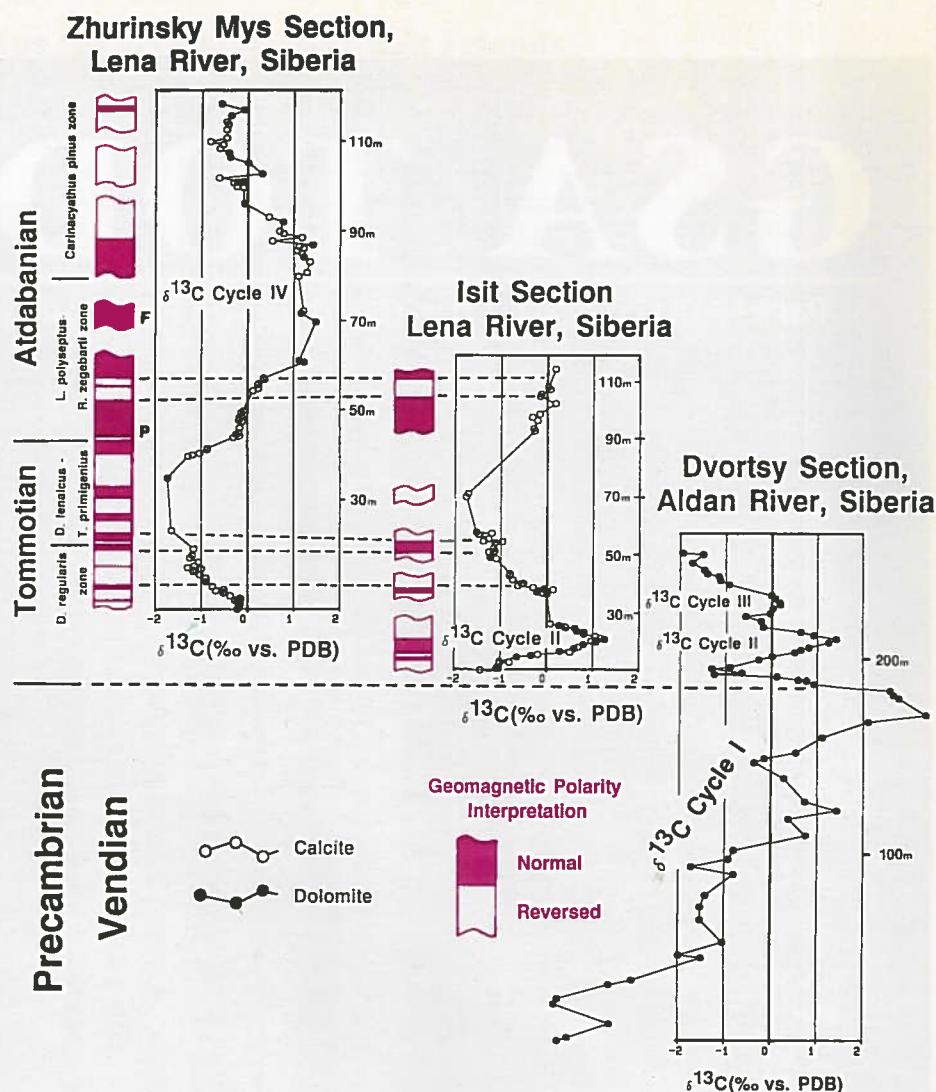


Figure 2. Paleomagnetic, paleontologic, and new carbon isotope stratigraphies from the Zhurinsky Mys and Isit sections on the Lena River, Siberia, compared with that from Dvortsy (Magaritz et al., 1986). The magnetic polarity patterns are from Kirschvink and Rozanov (1984); color and white indicate the revised interpretations for normal and reversed polarity, respectively, as discussed by Kirschvink (1991). In the Zhurinsky Mys section, P in the *L. polyseptum-R. zegebarti* zone indicates the first appearance of profallotaspid trilobites, and F marks the similar horizon for *Fallotaspid* trilobites. Solid symbols in Figures 2-4 show results from isotopic analyses of samples that were dolomitic (>50% as determined by X-ray diffraction), whereas open symbols are for whole-rock samples. Oxygen isotope data run for the same samples (data not shown) generally fall in the -7‰ to -5‰ range; none of the samples display the highly negative values usually associated with contamination from fresh-water or organic materials.

sequences of Late Proterozoic and Cambrian platform carbonates, which lie undeformed on the stable Archean basement of the Aldan Shield. Intensive studies of Early Cambrian faunas from the Siberian platform have allowed strata there to be subdivided into a series of zones and stages (e.g., Rozanov and Missarzhevsky, 1966); the stages around the boundary interval now include the late Precambrian Vendian and the Early Cambrian Tommotian, Atdabanian, and Botomian, type localities being located in cliff exposures along the Aldan and Lena Rivers (Rozanov, 1984). The Tommotian is characterized by the first appearance of widespread mineralized molluscan and archaeocyathan faunas, and the Atdabanian by mineralized arthropods. Our new carbon isotopic data are from the Zhurinsky Mys and Isit localities on the Lena River, from spare material collected for magnetostratigraphic studies (Kirschvink and Rozanov, 1984). At Zhurinsky Mys, a nearly complete section through most of the Pestrotsvet Formation extends from the (archaeocyathan) *D. regularis* zone in the lower half of the Tommotian Stage and continues through to the Atdabanian/Botomian boundary. This sequence overlaps with the Isit section, as shown in Figure 2.

Our sampling focused on the Tommotian and lower Atdabanian part of both sections. Samples poor in organic material were prepared for carbon and oxygen isotopic analysis using methods discussed previously (Magaritz and Kafri, 1981). Calcite/dolomite ratios were determined by X-ray diffraction, by means of standard techniques. Differences in carbon isotope ratios between dolomitic fractions and whole-

rock samples (dolomite + calcite) are minimal, in most cases within analytical error (0.10‰). Oxygen isotopic values, however, do show differences of up to 0.8‰ between these fractions. This similarity in carbon ratios supports the suggestion made in earlier studies (Magaritz, 1985; Magaritz et al., 1986, 1988) that, although the carbonate sequences undergo a stage of dolomitization that may alter the oxygen isotopic signatures, in the absence of organic material this process will not alter seriously the carbon record. Oxygen values from the unaltered calcitic samples show a range of values typical of marine carbonates and do not show the extremely ¹⁸O-depleted values characteristic of fresh-water components or contamination from organic material. Thus, we conclude that the carbon isotopic values measured in the carbonate rocks from this section reflect those that were present in the oceanic waters covering the Siberian platform at the time the carbonates were deposited.

Previous work from the Dvortsy locality on the Aldan River (Magaritz et al., 1986) has shown the presence of three cycles in the δ¹³C values, each characterized by positive swings, as shown here in Figure 2 (δ¹³C cycles I, II, and III). A surprising feature in the extension of these data, however, is the presence of yet another well-defined oscillation in the carbon record, here called the Siberian δ¹³C cycle IV. This cycle occupies the first half of the Atdabanian Stage, and at present it is documented fully only from the Zhurinsky Mys locality. Note that the carbon shift begins at approximately the Tommotian-Atdabanian boundary,

which is marked by the first influx of the earliest trilobites (*Profallotaspis*).

Magnetic polarity patterns for the Zhurinsky Mys and Isit sections from the data of Kirschvink and Rozanov (1984) are also shown in Figure 2 for comparison with the carbon isotope and paleontologic changes. It is now clear that the original interpretation of the geomagnetic polarity made by Kirschvink and Rozanov (1984) was probably reversed in comparison with results from Australia and North America (Kirschvink, 1991; Ripperdan, 1990). These reinterpreted magnetic data show that this new carbon cycle (IV) is characterized by an interval of predominantly normal geomagnetic polarity (with a few short reversed zones) sandwiched between two intervals of largely reversed polarity (with a few normal zones). This period of dominantly normal polarity is the only such interval yet found in the Siberian sections. Although the paleomagnetic results from the late Vendian exposures on the Aldan River are not as reliable as those from the Lena River, owing to a regional dolomitization problem, those few paleomagnetic samples that yield stable results are of reversed polarity, with the exception of a thin normal zone at the Yudoma/Pestrotsvet boundary. The combination of this distinctive magnetic signature, as well as the start of carbon cycle IV, gives the Tommotian/Atdabanian boundary two nonbiological tools with which to test proposed intercontinental correlations.

Morocco

In the Anti-Atlas Mountains of Morocco, a thickness of nearly 3 km of platform carbonates and siliciclastic sediments is deposited on basement of Pan-African (late Precambrian) age. On the basis of new algal and trace fossil discoveries, Latham and Riding (1990) placed the approximate level of the Tommotian/Atdabanian boundary in the upper quarter of the Lie de Vin formation at the Tiout locality studied by numerous other authors (e.g., Debrenne and Debrenne, 1978; Sdzuy, 1978), a position that is in agreement with paleontological studies in the overlying Igoudine Formation (formerly called the Calcaire Superieur [Debrenne et al., 1989]). Figure 3 shows our new stable isotope results from this part of the sequence, based on samples

collected for the magnetostratigraphic work reported by Ripperdan (1990) as well as on others supplied by S. Awramik. These show a pattern in the carbon isotopes similar to that reported previously from this section by Tucker (1986), with an increase in $\delta^{13}\text{C}$ values ranging from -4.0‰ to $+2.6\text{‰}$ in the upper sequence of the Lie de Vin and base of the Igoudine Formation, at approximately the Tommotian/Atdabanian boundary level suggested by Latham and Riding (1990). Thus, this probably correlates with the Siberian carbon cycle IV discussed above, and is consistent with the magnetostratigraphic comparison. This correlation also implies that the first trilobites found in Morocco (e.g., Sdzuy, 1978) can be correlated with the *Pagetiellus anabarus* trilobite zone of the Siberian platform.

South China (Meishucun)

One of the most controversial problems that has arisen in the quest for a Precambrian/Cambrian boundary stratotype is the correlation between the section at Meishucun, near Kunming in the Yunnan Province of south China, and the standard sequences on the Siberian platform. The Chinese strata were deposited in a shallow embayment on the Yangtze platform, and they consist of a series of fine- to coarse-grained dolomites, massive phosphorites, and variable siliciclastic rocks (Luo et al., 1984; Li, 1986; Brasier et al., 1990). Although the sequence is richly fossiliferous, it is plagued with problems of faunal endemism and suspected diastems. Detailed descriptions of the section, including paleontological results and interpretations, are given in Xu et al. (1989). A brief stratigraphic column of this sequence is shown in the left-hand column of Figure 4.

At an early stage of the stratigraphic work, the Precambrian/Cambrian boundary was placed at a dramatic lithologic change at the base of the Qiangzhusian Formation, from phosphatic carbonate to clay and siltstone (Xu et al., 1989). This boundary, now referred to as China C, is characterized by an apparent iridium anomaly and a very large carbon isotope shift toward negative values (Hsü et al., 1985). The first trilobite in China occurs higher in the stratigraphic column (at the

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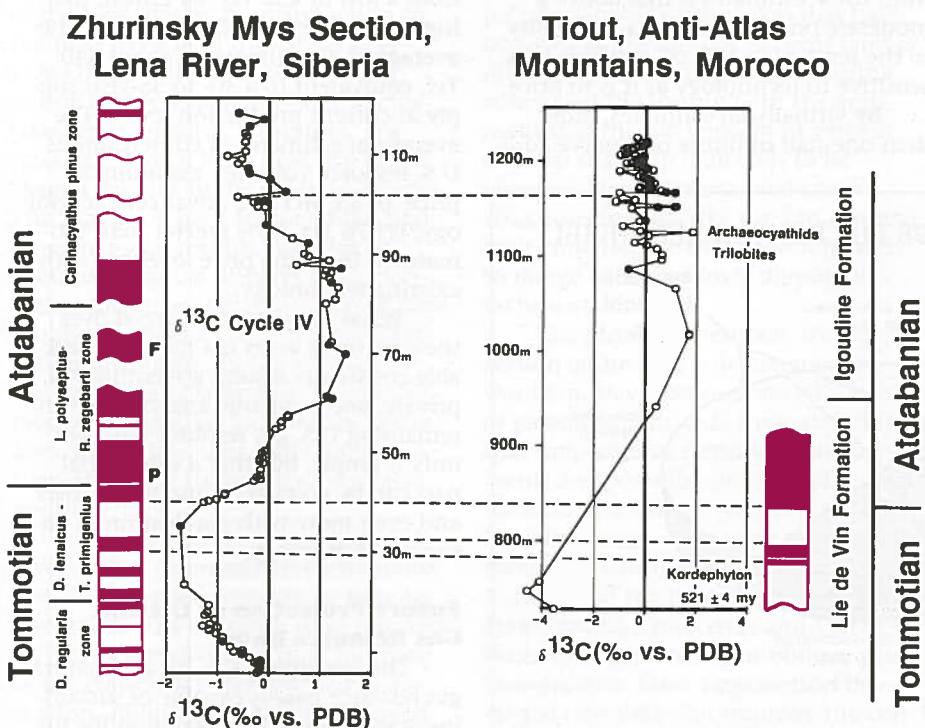


Figure 3. Carbon isotopic results from the upper half of the Lie de Vin formation of Morocco, compared with the magnetic polarity pattern from this sequence from Ripperdan (1990) and the standard carbon and magnetic pattern from Siberia of Figure 2. Stratigraphic positions are in metres relative to the base of the Lie de Vin formation as measured by Monninger (1979). The 522 ± 4 Ma date shown on the Moroccan section is the U/Pb ion microprobe on zircon result from Compston et al. (1990).

Call for Nominations 1991 John C. Frye Environmental Geology Award

In cooperation with the American Association of State Geologists, GSA makes an annual award for the best paper on environmental geology published each year, either by GSA or by one of the state geological surveys. The award is a \$500 cash prize from the endowment income of the Foundation's John C. Frye Memorial Fund. Recipients of the first award, presented in 1990, were Linda Lawrance Noson, Anthony I. Qamar, and Gerald W. Thorsen for their paper "Washington State Earthquake Hazards" (Washington Division of Geology and Earth Resources Information Circular 85).

Nominations can be made by anyone, based on the following criteria: (1) paper must be selected from Geological Society of America or State Geological Survey publications, (2) paper must be selected from those published during the preceding three calendar years, (3) nominations should be sent to the Executive Director of the Geological Society of America, with a paragraph stating the pertinence of the paper, (4) deadline for receipt of nominations is June 30, 1991.

In addition, nominated papers must:

- ◆ Establish an environmental problem or need.
- ◆ Provide substantive information on the basic geology or geologic process pertinent to the problem.
- ◆ Relate the geology to the problem or need.
- ◆ Suggest solutions or provide appropriate land use recommendations based on the geology.
- ◆ Present the information in a manner that is understandable and directly usable by geologists and addresses the environmental need or resolves the problem. It is highly desirable that the paper be directly applicable by informed laypersons (e.g., planners, engineers).

Basis for selection:

- ◆ Must meet the criteria for nomination.
- ◆ Must be judged as best of those nominated based on uniqueness or significance as a model of its type of work and report and its overall worthiness for the award.

The Selection Committee (Earl H. Bennett, John P. Kempton, and Frank E. Kottowski) will make the selection in time for the award to be presented at the AASG meeting during the Annual Meeting of the Geological Society in the fall of the year.

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Bruce F. Molnia

Forum is a monthly 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: Future Energy Needs and Utilization of Fossil Fuel—Implications for National Security, Environmental Controls, and Geoscience Employment

This Forum, which is a condensation of the Geology and Public Policy Forum presented at the 1990 Annual Meeting, will be presented in two parts. Part 1, presented this month, addresses basic issues and summarizes resources. Part 2, which will be presented in the May issue of *GSA Today*, will address Federal programs and human resources.

PERSPECTIVE 1: Background and Issues

Marcus E. Milling, Bureau of Economic Geology, Austin, TX
Steven Schamel, University of South Carolina, Columbia, SC

Well into the 21st century, the primary energy needs of the United States will continue to be met by domestic oil, gas, and coal resources. However, the ongoing dismantling of the nation's energy supply infrastructure threatens the future availability of these domestic resources, and, hence, the energy security, international competitiveness, and standard of living to which we in the United States have become accustomed. Even though existing domestic oil and gas reservoirs contain a huge untapped resource base, we continue to meet a growing portion of our critical energy needs with foreign imported oil. To offset declining domestic production, new interdisciplinary approaches focused on development of technologies for improving recovery efficiency from existing reservoirs must be implemented. There is a growing recognition in industry and government that advanced R&D can play a significant role in arresting the decline of our domestic oil and gas production.

Oil and gas research needs must be given top priority because of their dominant role in U.S. energy usage and because the major future energy problem facing the nation is a shortage of domestic liquid transportation fuels. No other domestic energy supply can meet the demand, in a cost-effective manner, for liquid hydrocarbon fuels at the rate needed in the event of a disruption in supply of imported oil.

Coal is the nation's most abundant fossil fuel and provides the leading source of domestic energy. More than half of domestic electric power is derived from coal. However, key environmental issues are related to increased utilization of coal for meeting energy needs. Concerns for coal-combustion-generated air pollution were addressed in the recently adopted Amendments to the Clean Air Act of 1970.

Geoscience and end-use research offer opportunities to increase efficiency in future utilization of coal in electric power generation, liquid fuel conversion, gasification, and in situ coalbed methane extraction. Growing environmental concerns about the byproducts of coal combustion have limited opportunities for the expanded use of coal. At the same time, because of its relatively high cost and environmental concerns, use of oil shale is not a viable option.

PERSPECTIVE 2: Oil and Natural Gas Projections

William L. Fisher, University of Texas at Austin, TX

Fossil fuels have long been the principal components of the United States' energy supply. Even though alternative energy supplies, including nuclear power will increase, fossil fuels will continue to be dominant through at least the middle of the next century. Oil, with its remarkable versatility, and natural gas, with its efficiency and cleanliness, are the core of the U.S. energy supply base. Natural gas will remain a premium fuel, and oil will remain the essential liquid fuel for at least the next five decades. Therefore, the central questions become: Is the remaining U.S. oil and gas resource base sufficient to meet a substantial part of supply needs, and what kinds of conditions must be met in converting the resource base to producible and consumable reserves?

Views of the Oil and Gas Resource Base

The remaining domestic oil and gas resource base is judged to be ample by most analysts. In the case of natural gas, low- to moderate-cost resources are sufficient to support current and even slightly higher levels of production for the next 50 years. For oil, the prospect of stable production over the next five decades is within technical reach.

A decade ago the perception of the remaining U.S. resource base was quite different. Production of both oil and natural gas had peaked in the early 1970s, and the prevailing resource wis-

dom, based on fixed, rigid models of resource depletion, was that oil and gas production would continue to decline. Price, technology, and advanced geological understanding, it was judged, could modify the inevitable only marginally.

However, since the peak in production, about 115 billion barrels of oil equivalent (Bboe) have been converted to producible reserves, equal to more than one-half the total historical volume before the peak. The total endowment of natural gas in the United States is estimated to be 2200 trillion cubic feet (Tcf), of which about one-third has been produced to date. The total for oil is estimated at about 700 billion barrels (Bbbl), of which only about 22% has been produced (Figure 1). How much of the huge remaining resource volume will be discovered or recovered depends chiefly on combinations of price and technology and the kind of public policy in place for domestic oil and gas production.

Oil Resources

In recent years, a number of estimates of the remaining U.S. oil resource base have been made. Most of these estimates were made in the context of assumed price levels and assumed levels of technology, both highly sensitive parameters to accessing remaining oil resources. In most cases, prices assumed were between the \$25 and \$50 level, coupled with assumptions of either existing or advanced technology.

Four groups have made estimates of oil and gas resources accessible at moderate costs and with varying levels of technology: Texas Governor's Energy Council (TGEC), National Research Council (NRC), American Association of Petroleum Geologists (AAPG), and U.S. Department of Energy (DOE). The average of these estimates, made with assumptions of existing technology and prices ranging from \$20 to \$32, was 71 Bbbl. However, at the same assumed price but with the further assumption of advanced technology, the average estimate was 70% greater, 121 Bbbl. Three of the groups also estimated oil resources accessible at prices of \$40 to \$50 per barrel but assuming only existing technology. The average of these estimates was 125 Bbbl, roughly the same volume accessible at lower prices but with assumptions of advanced technology. The critical conclusion from these estimates is that above a moderate price threshold, accessibility to the remaining U.S. oil resource is as sensitive to technology as it is to price.

By virtually all estimates, more than one-half of future oil reserve addi-

tions will be reserve growth resulting from improved recovery of oil in place, under assumptions of moderate price and advanced technology. Average recovery from existing known oil reservoirs currently stands at 35%, leaving an unrecovered resource target of about 340 Bbbl; increasing average recovery to 45% or 50% is technically feasible. Extraction of currently proved reserves will provide about 23% of estimated accessible resources, and future discovery is expected to provide a like amount.

Natural Gas Resources

Recent estimates of gas resources accessible at different prices and different assumed levels of technology confirm the consensus that U.S. resources of natural gas are large. The first of several recent estimates was made by the DOE in 1988, assuming existing technology and prices of \$3 and \$5 per million cubic feet (Mcf). These estimates were adopted by the TGEC and the AAPG, but these groups also estimated accessible remaining volumes at these price levels and with assumptions of advanced technology. Other recent estimates have been published by the Gas Research Institute (GRI), Enron Corporation, the Potential Gas Committee (PGC), the NRC, the Department of the Interior (DOI), and the DOE.

The average of conterminous U.S. estimates made by DOE, GRI, PGC, NRC, and DOI is 945 Tcf. These estimates all assume resources recoverable with existing technology, independent of price. The lowest estimate is that of DOI. Although this estimate is widely quoted, it should be pointed out that all unconventional gas resources (tight formation, coalbed methane, shale, and so forth) were excluded and that the methodology used by the DOI to calculate future reserve growth yields a figure not one-half of the average of the other five estimates of reserve growth. In the area in which DOI analysts concentrate—conventional, new-field, discovery resources—their mean estimate is near the average of all other published estimates.

The highest resource estimate is that reported by the NRC and based on analyses by ICF Resources Corporation (ICF). This estimate, added to cumulative production, exceeds 2000 Tcf. Estimates of the volume of conterminous U.S. resources judged accessible at \$3/Mcf with existing technology range from a low of 452 Tcf, by Enron, to a high of 604 Tcf, by NRC and ICF. The average of all estimates is about 540 Tcf, equivalent to a 30- to 35-year supply at current production levels. The average of estimates of conterminous U.S. resource volumes, assuming a price of \$3/Mcf and advanced technology, is 876 Tcf, 60% greater than estimates at the same price level but with existing technology.

What has clearly emerged over the past three years is a rather remarkable consensus among governmental, private, and academic analysts that the remaining U.S. gas resource base not only is ample, but that a substantial part can be accessed at moderate costs and even more with application of advanced technology.

Future Projection of Oil and Gas Resource Base

The remaining U.S. oil and natural gas resource base is capable of sustaining stable domestic production for the long term. Central to realization of that capability is a continuing expansion of the geologic knowledge of the oil and

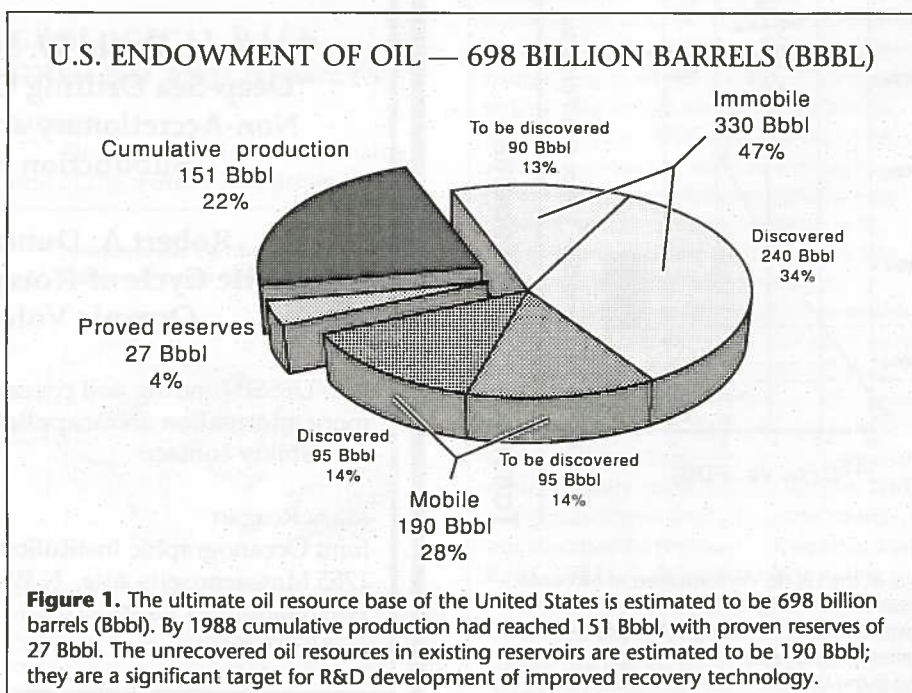


Figure 1. The ultimate oil resource base of the United States is estimated to be 698 billion barrels (Bbbl). By 1988 cumulative production had reached 151 Bbbl, with proven reserves of 27 Bbbl. The unrecovered oil resources in existing reservoirs are estimated to be 190 Bbbl; they are a significant target for R&D development of improved recovery technology.

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Transpressional Tectonics of Convergent Plate Margins

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Until recently, models of convergent plate boundaries were fundamentally two-dimensional and the relation between plate motion and continental deformation was unclear. Regardless of whether convergence was oblique or normal, boundary-parallel contractional belts were thought to be formed by displacements perpendicular to the plate margin. Steep, margin-parallel transcurrent fault systems were recognized in many orogenic belts, but displacements were generally thought to be unrelated and relatively minor with respect to thrust systems. Recently, on the basis of paleomagnetic, stratigraphic, structural, and seismicity data, it has been suggested that margin-parallel displacements may be very large and that they occur simultaneously with margin-perpendicular contraction in fold and thrust belts. These suggestions are not universally accepted; in fact, they have been met with suspicion, disbelief, and even derision. Those sympathetic with these ideas realize that many serious problems remain unsolved. To discuss these problems with geoscientists from different disciplines, a Penrose Conference was held at Western Washington University in Bellingham, August 25–30, 1990. The 82 participants included 12 graduate students. Eight foreign countries were represented: New Zealand and Canada, each by six participants, and Chile, England, France, Germany, Japan, and Norway by one each.

On the evening of Saturday, August 25, Ned Brown (Western Washington University) lectured on the geology of the Cascades as an introduction to the next day's field trip. Short overviews dealt with the interpretation of brittle (Avé Lallemant) and ductile (Hansen) kinematic indicators. The next day, Brown led a field trip to the Skagit Complex in the central Cascades. The Skagit is a high-temperature, high-pressure metamorphic complex of Cretaceous age. It displays early elongation lineations perpendicular to local terrane boundaries and younger elongation lineations, locally marked by the long axes of stretched, prolate pebbles, which parallel local terrane boundaries. Ubiquitous kinematic indicators suggest dextral transcurrent displacements.

Talks on aspects of transpression, given in the mornings and afternoons, were interspersed with ample time for discussion. The evenings were reserved for poster sessions. The final morning of the conference was devoted to discussion. About 15 participants stayed for a postmeeting field trip, led by Ned Brown, to the high-pressure–low-temperature metamorphic Shuskan Complex in the western Cascade Range.

The first lecture session on strike-slip faults began with a comprehensive

review by Art Sylvester. Because one of the best studied examples of strike-slip shear zones lies to the south, the title of this session may as well have been "Everything you wanted to know about the San Andreas fault zone, but..." Anne Meltzer showed excellent seismic reflection lines from offshore central California; these indicate that the Pacific crust extends far eastward underneath the California margin and that it underlies a detachment surface in which both southwest-vergent thrust faults and northwest-trending strike-slip faults root. Branch Russell discussed the extremely complicated Eocene to Holocene tectonics of the southern California borderlands, which consists of numerous internally deformed, displaced, and rotated crustal blocks. The structural complexities necessitate the existence of a 10–15-km-deep detachment. William Lettis and Wood Savage discussed the strain partitioning and Quaternary developments of the south-central California borderland (an evening poster displayed their comprehensive data set for scrutiny). Mark Zoback discussed new ideas related to low frictional strength of the rocks along the San Andreas fault. Stress measurements indicate that the major principal compressive stress axis is oriented almost normal to the San Andreas. Zoback's presentation evoked heated discussion: some argued that stresses are the result of displacement fields, and that stresses can vary considerably from place to place depending on the orientation of a fault plane. Therefore, low frictional strength at the focal depths of the major catastrophic earthquakes that have occurred along the San Andreas fault is difficult to understand. Kris Meisling concluded the session with the argument that the old concept of vertical or steep strike-slip faults has to be changed: three-dimensional reconstructions in areas like the San Andreas fault zone require the strike-slip faults to merge with shallowly dipping detachments.

Late Monday afternoon, the second session addressing paleomagnetism was held. David Stone showed a wealth of paleomagnetic data (new and old) that support large northward displacements and possible rotations of several terranes of southern Alaska. Similarly, Myrl Beck argued for large northward motion of Cordilleran terranes in Canada and the conterminous United States during Cretaceous and Tertiary time resulting from right-oblique plate convergence. Dave Engebretson discussed new data that improve the constraints of relative plate motions between the North American and Pacific basin plates: until about 100 Ma, convergence between the two plates was

Penrose continued on p. 76

WASHINGTON REPORT

Bruce F. Molnia

Washington Report provides GSA membership with a monthly window on the activities of the federal agencies, Congress and the legislative process, and international interactions that could impact the geoscience community. In future issues, Washington Report will present summaries of agency and interagency programs, track legislation, and present insights into Washington, D.C., geopolitics as they pertain to the geosciences.

Science and the FY92 Federal Budget

Early this year, Nobel Prize-winning physicist Leon Lederman, president-elect of the American Association for the Advancement of Science (AAAS), reported that limited support available for the funding of university research has resulted in a deterioration of morale and diminished expectations. Lederman recommended a doubling of the level of Federal support for research to about \$20 billion and the establishment of a multidisciplinary committee to identify new funding sources.

Lederman's report identified only one aspect of the U.S. science dilemma. Numerous reports by committees of the National Research Council, Federal Agencies such as the Department of Education, and professional societies such as the American Geological Institute and the International Association for the Evaluation of Educational Achievement have documented a steady decline in the number of young Americans entering scientific disciplines and a parallel decline in the level of science preparedness of all young Americans. Specifics that document this situation show that:

- By grade five, U.S. students score roughly in the middle of international science tests.
- By grade nine, U.S. students score at the bottom on international science and advanced mathematics tests; minority students demonstrate especially poor proficiency in math and science; 75% of junior high school science teachers fail to meet qualifications standards set by the National Science Teachers Association and the National Association of Teachers of Mathematics.
- By grade 10, fewer than 20% of U.S. students express interest in pursuing an education in natural science or engineering.
- By grade 12, fewer than 10% of U.S. students tested are prepared for college-level science courses.
- At the undergraduate college level, only 60% of incoming freshmen who begin a career in the natural sciences or engineering complete their bachelor level science education.
- At the graduate level, fewer than 10,000 U.S. students annually earn a Ph.D. degree in natural sciences or engineering; 24% of natural sciences and engineering degrees earned in the United States are awarded to foreign students.

Surprisingly, these statistics come from part two (p. 12 and 13) of "The Budget of the United States Government for Fiscal Year 1992," in a section entitled "Investing in human capital and reforming American education." This section contains a strategy developed by an interagency Committee on Education and Human Resources of the Federal Coordinating Council on Science, Engineering, and Technology to make U.S. students first in the world in math and science. The strategy, which

identifies a proposed amount of \$1.94 billion in FY92 for all levels of math and science education, emphasizes pre-college education. The breakdown is \$661 million for precollege math and science education (up \$146 million or 28% from FY91), \$477 million for undergraduate math and science education (up \$60 million or 14% from FY91), and \$803 million for graduate math and science education (up \$19 million or 2% from FY91). Within the precollege education category, priorities are placed on teacher preparation, curriculum reform, and systematic organizational reforms. The proposed FY92 budget contains a \$225 million increase in science and math education funds over the level of funding enacted in the FY91 budget.

In the category of undergraduate math and science education, the budget focuses on improving the quality of the "undergraduate academic experience," particularly through improvements in curricula, faculty enhancements, and student incentives. Forty-two million dollars is identified to support research experiences for undergraduate faculty at leading research universities and national laboratories. Elsewhere, the budget proposes a \$401 million (7%) increase in the Pell Grant program. Of this increase, \$170 million is identified for new Presidential Achievement Scholarships for "high achieving" Pell Grant recipients.

Released in early February, "The Budget of the United States Government for Fiscal Year 1992" weighs more than 2 kg and contains more than 2000 pages. The bottom line is a proposed budget of \$1.446 trillion. At this stage, the numbers contained in the FY92 budget document represent requests prepared by the President's Office of Management and Budget; these may change significantly. Much can and will happen to these budget estimates before they are enacted into law by Congress and finally signed by the President. A case in point is the shutdown of the Federal Government last October due to lack of an agreement between the Congress and the President on the FY91 budget.

Returning to the concerns raised by AAAS's Lederman, the budget contains proposed increases in basic research, in applied research and development, and in space exploration. Yet it falls short of the level of increased research that Lederman has identified as critical. In all, the budget proposes an \$8.4 billion increase in "Federal investment in research and development." This number is somewhat deceptive because more than \$5.4 billion of this increase is in defense-related applied research and development performed by the Departments of Defense and Energy.

In basic research, the budget continues the Reagan Administration's goal of doubling the budget of the National Science Foundation (NSF)

Washington continued on p. 74

Robert L. Fuchs

Special Funds Continue to Grow

Last year we reported on the noteworthy increase in the size of some of the GSA Foundation special funds, as compared to the prior year. Once again, we have revisited this subject and have found that GSA members continue to contribute to these funds, as shown in the accompanying table.

The decrease in the Minority Fund balance was the result of the distribution of \$2250 for research grants under the stipulation attached to a specific gift.

These are not static pools of capital gathering dust in unused ledgers. Income from these funds has been applied to science in the form of research grants and scholarships. In 1990, awards totaling \$6020 from these listed special funds were made to young geoscientists. The amount will be larger in 1991.

Several new funds with special objectives were formed in 1990. The 28th International Geological Congress Fund was formally established at the Dallas Annual Meeting when IGC President Charles Drake and Secretary General Bruce Hanshaw announced the decision of this IGC's governing body to transfer to the GSA Foundation the cash balance remaining upon completion of the 28th IGC business. This new fund, which now exceeds \$325,000, will provide grants to young geoscientists to attend future International Geological Congresses. Also, the fund can provide seed capital for the next IGC in the United States, perhaps in 20-25 years.

Two new funds in honor of deceased GSA members are the Gretchen L. Blechschmidt Fund and the Donald L. Biggs Memorial Fund. The former will provide scholarships and research fellowships for women in the geological sciences and is an important complement to the Women in Science Fund.

Biggs Fund to Support SAGE

The Donald L. Biggs Memorial Fund, formed after the death of Donald Biggs one year ago, has been designated

	January 1990	January 1991	Change
Allan V. Cox Student Research	6,514	7,430	+14%
J. T. Dillon Alaska Research	13,409	18,313	+37%
J. C. Frye Environmental Award	8,100	13,500	+67%
A. Lierman Medlin Award	23,912	25,800	+8%
Minority	9,381	8,670	-8%
Women in Science	1,032	2,065	+100%
D. L. Biggs Memorial	0	3,027	n/a
G. L. Blechschmidt	0	13,840	n/a
Total	62,348	92,645	+49%

to support and enhance the geoscience awareness and education of young people. With this purpose, the Biggs Fund becomes the first special fund, other than the main SAGE fund, to be directed toward GSA's rapidly growing education and public awareness program.

SAGE (Science Awareness through Geoscience Education) is a major initiative of GSA during the 1990s and beyond. Components of the program include Partners for Excellence, films and videos, Congressional Fellow, teacher awards, and GeoHostels. Recently GSA hired Edward E. Geary as Coordinator for Educational Programs.

An undertaking of this magnitude requires major funding, from both program money and income from endowment. The Biggs Fund is the first endowment in what is expected to be an expanding capital base over the years ahead.

In creating the Donald L. Biggs Memorial Fund, Carolyn Biggs said that her husband spent most of his scientific career as a teacher, from instructor to full professor. A lasting memorial that encourages young people to study the earth could not be more appropriate, particularly in light of the immense enthusiasm that GSA members have shown for SAGE.

Contributions to the Donald L. Biggs Memorial Fund may be sent to the Foundation office with the accompanying coupon. Please call the Foundation at (303) 447-2020 for further information. ■

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Joanne Bourgeois
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*Second Century Club—gifts of \$100 or more

Washington continued from p. 73

between 1987 and 1994, providing for a \$406 million (18%) increase over NSF's FY91 budget of \$2.316 billion. A \$291 million increase is proposed for the budget for the superconducting super collider, raising it to \$534 million. The budget proposes an increase of \$227 million (34%) for energy research and development and a \$149 million increase (30%) for high-performance computing and communications.

Under the heading of space exploration, the budget proposes \$5.5 billion for continued development of critical elements of space transportation, including the National Aeronautics and Space Administration's (NASA) space shuttle and expendable launch vehicles. Under the category of space science, the budget proposes a \$361 million (21%) increase in astronomy, unmanned planetary exploration, advanced space communications research, and life sciences. The proposed budget for space sciences is \$2.1 billion.

The budget proposes a total of \$1.186 billion for the U.S. Global Change Research Program (GCRP), a \$232 million (24%) increase over the FY91 enacted level of funding. The budgets of all agencies involved in the GCRP have proposed increases. These include a proposed \$121 million increase for NASA, a proposed \$32 million for NSF, a proposed \$31 million increase for NOAA, and a proposed \$9 million increase for the Department of Interior (DOI). The Earth Observing System program is the single largest beneficiary of the GCRP proposed increases, growing by \$145 million to \$336 million. NASA's total GCRP budget increases to \$773 million.

In spite of the proposed \$9 million increase in its GCRP funding, all DOI research would be cut \$22 million, from \$584 million to \$562 million. DOI, the home of most geological activities in the Federal Government is the only agency whose identified research and development activities decrease in FY92 when compared to the FY91 level of appropriations. ■

About People


Fellow and 1987 GSA President **Jack E. Oliver**, Cornell University, received the 1990 Hollis D. Hedberg Award from the Institute for the Study of Earth and Man; he was also awarded GSA's George P. Woollard Award.

Fellow **Donald L. Turcotte**, Cornell University, received the Alfred Wegener Medal from the European Union of Geosciences.

Member **David S. Charlton** has been appointed Research Program Manager at the Energy and Environmental Research Center, University of North Dakota.

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What is a Theme Session?

Richard W. Berry
Chairman, 1991 Joint Technical Program Committee

Even though theme sessions have been around for several years, signs of confusion about them continue to surface. I am told that theme sessions really are mini-symposia. People say, "of course, getting an abstract accepted for a theme session is more prestigious than for a disciplinary session!" Neither of these is true—at least not as far as the GSA Council, Program Committee, and Joint Technical Program Committee (JTPC) are concerned.

To clarify what a theme session is, let's look at abstracts. There are two distinct categories of abstracts, invited and volunteered. "Invited" abstracts are associated with symposia. The symposia convener not only invites the speakers, but guarantees that, if the abstract is appropriately submitted, the speaker will definitely be presenting that paper.

All other abstracts are volunteered. It is the responsibility of JTPC to arrange volunteered abstracts into groupings that make sense topically. This is done during the JTPC meeting held in August four weeks after the abstracts deadline. Until a few years ago, the arrangement of all abstracts into focused disciplinary groupings took place at the JTPC meeting. GSA Council acted to encourage application of focus to the arrangement of abstracts sooner in the process of building a technical program. When the GSA Council accomplished this by establishing theme sessions, it also opened more opportunities for people to take responsibility for the structure of the Annual Meeting. These persons are theme session advocates.

The only differences between a traditional disciplinary session and a theme session are: (1) when the session focus (structure) is applied, and (2) who are involved in applying the focus. For theme sessions, focus is suggested early in January when theme proposals are due. For traditional disciplinary sessions the focus is applied during the August JTPC meeting. The bottom line is, for theme session or traditional discipline session, all abstracts are volunteered and must all go through the same review process. No abstracts are guaranteed acceptance.

There can be a lot of work associated with theme sessions if advocates wish to encourage specific colleagues to submit abstracts. The GSA Annual Meeting has benefited greatly from the efforts of enthusiastic advocates. Theme sessions are quite different from symposia because (1) no abstracts are guaranteed acceptance, and (2) if insufficient abstracts are received, the theme session will not be held.

Theme sessions differ little from the traditional discipline sessions. There may be additional prestige associated with being invited to submit an abstract to a symposium over having a volunteered abstract accepted on its own merits, but that could be debated. When it comes to peer-reviewed volunteered abstracts, I fail to see any difference in prestige, whether the paper is accepted for a disciplinary session or a theme session. In fact, during the JTPC meeting, papers are organized into coherent groupings that are given titles—themes identified in August instead of January. To those attending the sessions, it will all look the same. ■

What Are You Doing in 2002?

Sue Beggs, GSA Meetings Manager

Planning ahead? GSA's Annual Meeting will be in Denver in 1996 and in 1999, and most likely in 2002. During its May 1990 meeting, the GSA Council approved rotating through Denver every third year. Designation for 1996 and 1999 are definite; 2002 will be decided after the 1996 meeting. Meetings between these years will be held in other cities, repeated once every eight to ten years, which is currently the pattern.

Why the Change? The primary reason for the change is financial. In the past 10 years, annual meetings have run a deficit (or very close to a deficit), the exceptions being Reno (1984), Phoenix (1987), and Denver (1988—the GSA Centennial Year).

As the Meetings Manager, I can personally vouch for our commitment to keeping registration fees and other costs as low as possible. Those of you who paid \$130 professional preregistration last year may find this hard to believe, but if I could personally discuss each budget item, you would understand. An annual meeting budget reflects the same inflationary economics that face you at work and at home. Our fixed costs such as facilities, technical support, transportation, postage, and labor are rising faster than our revenue sources.

Unfortunately, the current fee structure does not bring in enough revenue when we have fewer than 4800 registrants. This is true even when other revenue sources are considered: exhibits, short courses, field trips, and corporate contributions. Short courses and field trips, by the way, at best only break even (due again to our commitment to keeping costs down).

The result of rising fixed expenses and lower than needed attendance is a larger deficit. Likewise, high numbers of registrants mean more revenue from the same fee structure. The good news is that we can count on such numbers when GSA meets in the West.

In addition to increasing revenues, we can also reduce expenses by repeating a single site more frequently. There

ANNUAL MEETING REGISTRATION HISTORY 1976-1990

Year	Site	Total
1976	Denver	5351
1977	Seattle	3956
1978	Toronto	4826
1979	San Diego	4574
1980	Atlanta	4285
1981	Cincinnati	4670
1982	New Orleans	4793
1983	Indianapolis	4153
1984	Reno	6065
1985	Orlando	4409
1986	San Antonio	4452
1987	Phoenix	5201
1988	Denver	7478
1989	St. Louis	4986
1990	Dallas	4513

will be economies at facilities such as convention centers and hotels when a site is repeated frequently. More revenue for them—more often—with less sales effort leads to a better negotiating position for GSA.

The bottom line is that by repeating a western site, we can look for lower costs and higher revenues. If this strategy works, we should be able to afford the Annual Meeting—at least every third year—and help dilute the effects of the deficit years.

Why every third year? First, an interval of 1-4 years was endorsed by 63% of the members participating in our 1989 site survey. (Some even encouraged us to schedule the meeting in Denver every year!) Second, a longer interval begins to lose its economic clout with the facilities. Third, the every-third-year schedule allows enough freedom to rotate frequently to other cities, which a one- or two- year interval would not.

Why start in 1996? GSA is committed to other cities through 1995, so 1996 was the first available year.

What will happen to the field trips? Most of the western sites offer excellent opportunities for field trips. There are, in fact, more field trips than can be accommodated in one meeting. At a repeated site, careful thought would be given to the trip offerings for both 1996 and 1999. The field trips in 2002 might be a repeat of those in 1996 without discouraging potential registrants.

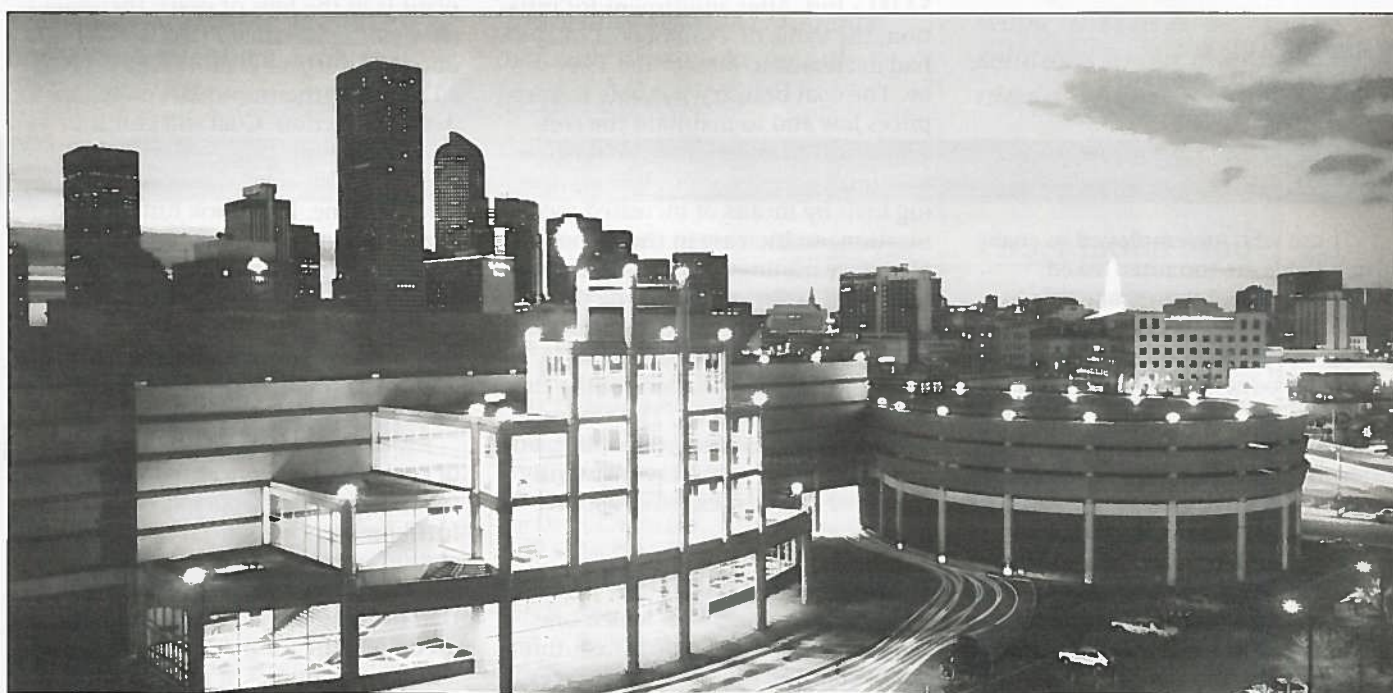
Why Denver? Increased frequency at ANY site that promises strong attendance is possible. We could use almost any western site every third year: San Diego, San Francisco, Seattle, Anaheim, Reno, Las Vegas, Salt Lake City, or Phoenix, for example. We also could use a combination of these western cities. Because of the limited number of cities that can accommodate GSA's meeting and the scheduling conflicts with other geoscience meetings, however, we would be repeating cities anyway.

Denver was selected because:

- Denver sets attendance records: 1976: 5351 and 1988: 7468.
- Denver is located in the approximate center of the United States. Denver's new airport, now under construction, will be the hub for at least two, and perhaps three, major national airlines. This should make routing more convenient and airfares more competitive for the 80% who fly to the meeting.
- The excellent new Colorado Convention Center that opened in April 1990 can house all of GSA's sessions and exhibits under one roof. (The combination hotel/convention center situation that many of you experienced during the 1988 Centennial meeting is a thing of the past).
- The labor environment (including both rates and rules) is much more workable than in some other cities.
- Denver is an excellent starting point for field trips.
- Denver has a strong GSA membership of over 1000 that can provide leadership for committee activities. Two different committees can work simultaneously without drawing on the same resources.
- Because GSA headquarters is in Boulder, it is easier for staff to monitor events in Denver and to provide administrative support to the local committees. ■

PLAN AHEAD: MARK YOUR CALENDARS TODAY GSA ANNUAL MEETING IN DENVER

October 28-31, 1996 • October 25-28, 1999



Colorado Convention Center, Denver

left-oblique and from 100 Ma to the present, it was right-oblique (that evening Engebretson showed a video that incorporated these data).

Monday evening, thirteen posters were displayed. These posters dealt with south-central California (Lettis and Savage); basins in interior Alaska (Schultz); range-parallel displacements in the Alps (Hubbard); a strike-slip fault in Honduras (Gordon); restraining bends (Tyburski); axial extension in folds related to transpression (Jamison); strain partitioning in transpression (Krantz); transpression on Svalbard (Bjornerud); Cadomian orogeny in northwest France (Brown); flower structure formed by Caledonian sinistral transpression in northeast Greenland (Holdsworth); plate kinematics and collisional foredeeps (Bradley); remagnetization and northward transport of Franciscan terranes (Hagstrum); and forearc transpression in southern Alaska (Roeske and Pavlis).

Beginning on Tuesday morning, modern transpressional margins were discussed. Dick Walcott talked about the classic example of strain partitioning resulting from oblique subduction: the Hikurangi margin of North Island, New Zealand. Dick Norris and Jocelyn Campbell discussed very detailed and complex structures related to New Zealand's Alpine fault, and Jarg Pettinga showed a model for the transfer zone of New Zealand's Alpine zone. Dave Scholl proposed a model in which the Bowers and Shirshov ridges and the Aleutian arc were the result of westward "escape" along the curved Alaskan transpressive faults. Dan Karig showed examples of displacement partitioning in Turkey and the Philippines.

Tuesday afternoon and most of Wednesday, the focus was on "ancient" transpressional margins. Geri Eisbacher talked about tear faults and low-angle detachments in the eastern Alps. Mary Sanborn-Barrie discussed deformation zones in the Archean, suggesting strain partitioning due to transpression. Uplift and exhumation of deep-seated metamorphic rocks in the Appalachians were related to strike-slip faulting by Art Snoke. Alain Vauchez presented a collisional and escape model for the southern Appalachians.

On Wednesday, Karen Kleinspehn drew parallels between Tertiary transpression in Spitsbergen and Cretaceous transpression in the Canadian Cordillera. Hill discussed the nature of the Work Channel shear zone in British Columbia. Bob Miller presented data on the crystalline core of the Cascades. Darrel Cowan proposed a transpressional model for the Cordillera during Late Jurassic to Late Cretaceous time. Cowan's model does not require the large north-south displacements as suggested by paleomagnetic data; however, constraints on the amount of displacement required by geologic data (Cowan) and paleomagnetic data (Beck) are consistent within the error of both data sets. Francisco Herve talked about a major transpressional fault in Chile. José Longorio has paleontological evidence for large southward displacements of terranes in the Mexican Cordillera. Jim Pindell delivered his latest version of the plate-tectonic history of the Caribbean, emphasizing the strike-slip nature of the southern Caribbean plate margin, a model that was disputed by Bob Speed. Hans Avé Lallemand proposed that eclogites along the Venezuelan coast were uplifted and exhumed as a result of extension due to an increase in obliquity of plate convergence.

The last organized session, on Wednesday afternoon, dealt with models. Mitsushiro Toriumi proposed a model for the blueschist belts of Japan. John Watkinson discussed strain sequences in oblique collisions. John Oldow presented the "orogenic float" model in which an entire orogenic belt is underlain by a decollement surface or zone stretching from the foreland fold and thrust belt all the way to the subduction zone; shortening has a result in the formation of a lithospheric root. Jim Wright presented new Sr, Nd, and Pb isotopic data from granites in the northern Great Basin, indicating that Jurassic plutons are allochthonous and were decapitated and transported eastward during thrusting in the Sevier belt.

The Tuesday and Wednesday posters (a total of 26) dealt with transpression in New Zealand (Cashman, Kelsey, Berryman, Melhuish); southern Middle America trench (Kolarsky); transpression in offshore northern Hispaniola (Dolan); Archean transpression in Minnesota (Bauer); simple and pure

shear computer models (Tikoff); Precambrian transpression and collision in Labrador (Van Kranendonk); Proterozoic transpression in Antarctica (Goodge, Hansen); Archean gneiss domes; result of transpression (Schwerdtner); Devonian strike-slip in the Canadian Appalachians (Malo); the Carolina terrane, southern Appalachians (Dennis); late Paleozoic collision of Gondwana and Laurentia (Sacks); shoshonites and oblique convergence (Wyman); Gravina belt in southern Alaska (Haeussler); oblique convergence in the Nason terrane (Magloughlin); transpression in northern Trinidad (Algar); Salmon River suture zone in Idaho (Snee); Nevadan sinistral transpression in the western Sierra Nevada (Newton), Jurassic fold nappe, Zacatecas, Mexico (Anderson); timing of strike-slip and thrust faults in southwest British Columbia (Journeay); Carlin trend (McFarlane); South Bullion deposit, Piñon Range, Nevada (Putnam); Skagit-Methow region, North Cascades (Kriens); and COCORP transect, northwestern U.S. Cordillera (Hauser).

On Thursday morning, the last day, we had no presentations, only discussions. The conveners had requested that everyone submit questions for these discussions. From about 30 questions the following six were chosen for discussion:

1. What do kinematic indicators tell us about transpression?
2. How can we reconcile low-friction strike-slip faulting with folds and thrust faults in continental margin fault zones?
3. What is the role of magmatism and regional metamorphism in transpression?
4. How does the thermal and mechanical structure of the lithosphere affect problems of strain partitioning and crustal detachment?
5. How critical is the geometry of the subducted slab in determining the place and spacing of upper-plate faults?
6. How are structures in the "float" related to what is going on beneath?

The day before, each question was given to one participant, who would lead the discussion the next day. To

our satisfaction, most participants stayed on and participated in the discussions. Of course, in the short time available, none of the questions was solved to everyone's satisfaction. The discussions, however, were lively, and we hope that they motivated everyone to look for solutions.

Acknowledgments

The conveners believe that this Penrose Conference was a success because of the enthusiasm of the participants, the hospitality of Western Washington University, and the outstanding organization of Lois Elms. Partial funding came from National Science Foundation Grant EAR-9004192 and from ARCO. ■

Penrose Conference Participants

Antenor Aleman	Michel Malo
Sam Algar	Deb McFarlane
Thomas H. Anderson	Kristian Meisling
Hans G. Avé Lallemand	Anne Melhuish
Robert Bauer	Anne Meltzer
Myrl Beck	Robert B. Miller
Kelvin Berryman	Tommy E. Mogensen
Marcia G. Bjornerud	M. Claiborne Newton III
Dwight C. Bradley	Richard J. Norris
Edwin H. Brown	John S. Oldow
Michael Brown	Scott Paterson
Susan Cashman	Terry Pavlis
Jocelyn K. Campbell	Jarg Pettinga
Darrel S. Cowan	James Pindell
Robert I. Coward	Borden R. Putnam
Dickson Cunningham	Sarah Roeske
Allen J. Dennis	Branch Russell
James Dolan	Paul Sacks
Geri Eisbacher	Mary Sanborn-Barrie
John W. Goodge	William Savage
Mark B. Gordon	David Scholl
Johnathan T. Hagstrum	Richard A. Schultz
Vicki L. Hansen	William Schwerdtner
Peter Haeussler	Lawrence W. Snee
Ernest C. Hauser	Arthur Snoke
Francisco Herve	Robert Speed
Mary Louise Hill	David B. Stone
Robert Holdsworth	Arthur Sylvester
Mary Hubbard	Basil Tikoff
William R. Jamison	Mitsushiro Toriumi
Scott Jenkins	Stacey A. Tyburski
Murray Journeay	Alain Vauchez
Daniel Karig	Martin Van
Harvey Kelsey	Kranendonk
Karen Kleinspehn	Richard Walcott
Radim A. Kolarsky	John Watkinson
Robert Krantz	Alastair Welbon
Bryan Kriens	James Wright
William Lettis	Derek Wyman
José Longorio	Daniel G. Ziegler
Jerry Magloughlin	Mark Zoback

Forum continued from p.72

gas resource base—knowledge that can advance efficiencies, both in exploring for new discoveries and in maximizing recovery from existing reservoirs.

PERSPECTIVE 3: Availability and Future Utilization of Coal Resources

Hal Gluskoter, U.S. Geological Survey,
Reston, VA

Those who are employed in coal-related fields are too often asked: "When is coal going to make a comeback?" The answer is that it does not have to come back; it never went away. U.S. coal production is expected to reach 1 billion short tons in 1990, the largest amount in U.S. history. Coal currently produces 57% of the electricity used in this country. In 1989, electric utilities accounted for 86% of all coal consumed in the United States. The remaining 14% was used in the manufacture of coke and in industrial and residential boilers. Approximately 10% of coal produced in the United States was exported.

Significantly, during the past 40 years, the price paid for a ton of coal in the United States has not followed the same trend as coal production. From 1945 to 1969, the price of coal remained nearly constant at \$4.50 to \$4.00 a ton. After adjustment for inflation, the value of a ton of coal in 1969 had decreased to 60% of the 1949 value. The coal industry was able to keep prices low and to maintain the consumer cost of energy from coal below that from petroleum or other competing fuels by means of increased mechanization, an increase in the amount of surface mining, and a trend toward fewer and larger mines. At the time of the 1973 embargo, the price structure of fossil fuels changed significantly, keeping ahead of inflation for the first time in several decades. The real price of oil, gas, and coal increased, but, on a calorific basis, coal has consistently remained the least expensive source of fossil energy.

Future Use of Coal

Given the ease with which one can err in trying to predict the future use of coal and other energy sources, there may still be something that can

be forecast with some degree of confidence. If one looks ahead a relatively short time—a decade or so—it is possible to ascertain the type of fuel that will be used to produce electricity. The life expectancy of a coal-fired power plant is in the tens of years; therefore, most of the electricity that will be produced in the year 2000 will be generated in plants that now exist or are under construction. Coal will continue to be a significant source—likely the major source—of electric energy for some time to come. If we look further into the future and recognize that fossil fuels are present on this planet in finite amounts and that they are not renewable on the human scale of existence, we can see that eventually there will be a shift to other sources of energy and to new methods of utilizing energy.

Uncertainty about the future use of coal is mostly concerned with an interim period that separates the current fossil-fuel economy from the next generation of fuels; this period is likely to be from 30 to 300 years. The equation that must be solved in order to forecast accurately the future of coal utilization has a large number of unknowns, and we have not yet determined enough

of the constants (knowns) to solve that equation.

There are many factors, negative and positive, that we can consider. A large number of those factors are negative; when they are considered in aggregate, they suggest to some observers that the future for coal utilization is shorter rather than longer. There are problems to be resolved in mining, handling, and shipping coal. The environmental concerns associated with coal combustion—acid emissions, sulfur and nitrogen oxides in the air we breathe, and carbon dioxide in the atmosphere—are all factors that can adversely affect the future of coal utilization and offset the benefits inherent in using coal. In light of all those negative factors, what is it that makes coal desirable? Principally, it is available in large volumes, it is relatively inexpensive, and the techniques for its use are well developed.

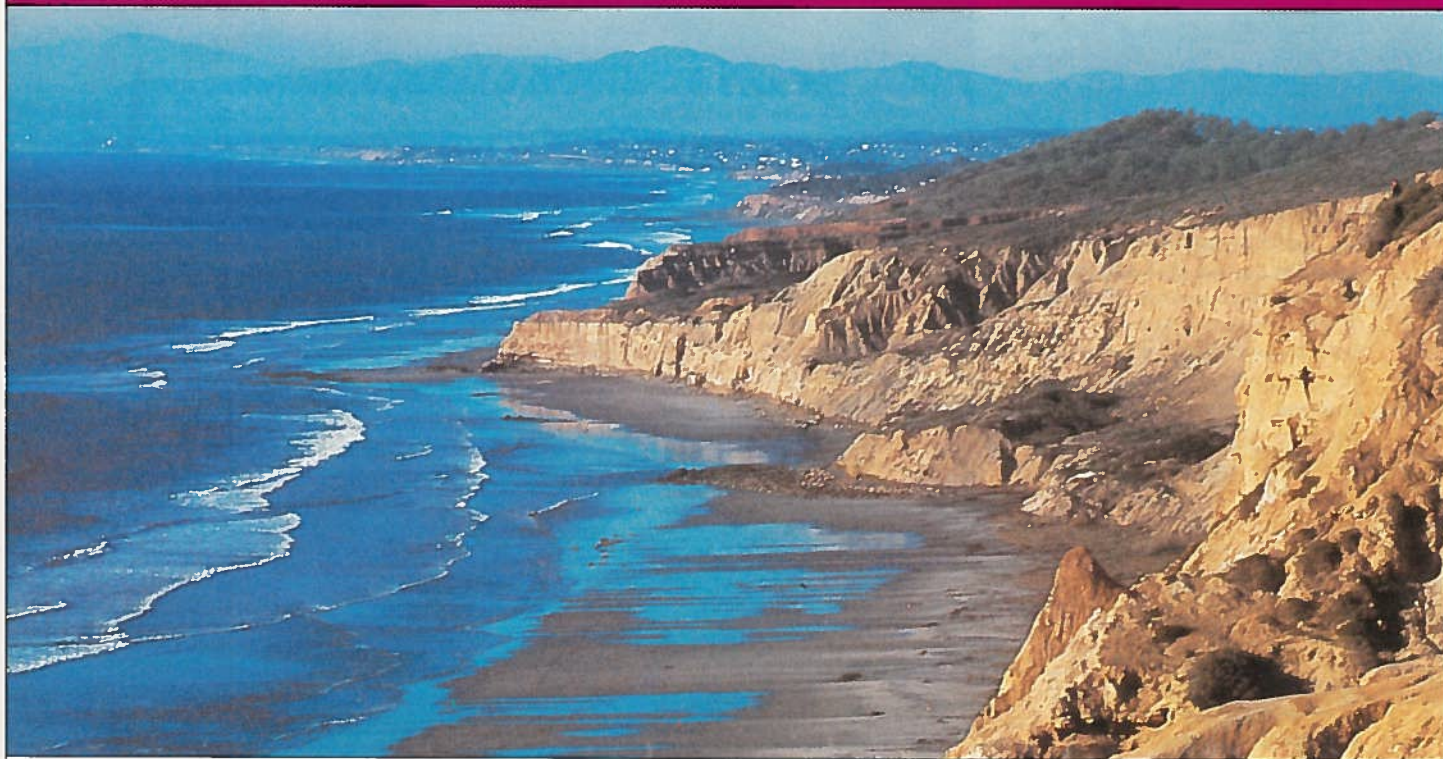
Coal Resource Base

The amount of coal resources that could be produced in the United States is not a constraint on the potential near-

Forum continued on p. 85

1991 ANNUAL MEETING

San Diego, California • October 21–24, 1991



Courtesy of R. Gordon Gastil

THE GLOBAL CHALLENGE

Invitation from R. Gordon Gastil,
General Chair,
1991 Annual Meeting

The Annual Meeting of the Geological Society of America will be held October 21–24, 1991, in San Diego's spectacular new convention center. You must come, and we'll tell you why. First, we are planning one of the finest combinations of technical sessions and field trips ever

offered at a GSA meeting—reason enough.

Of even greater importance, the habitat of humankind is in danger, and it's time that earth scientists step forward boldly to be heard. A special keynote session, "The Global Challenge," will be one of the Monday morning sessions. The special session will be followed during the week by theme sessions on global change, natural disasters, and the limits of natural resources. There will be an open discussion on Monday evening, and

a concluding rapporteur session summarizing the events of the week and challenging us to take the next steps in meeting our global obligations.

It is our vision that GSA will expand its academic membership base to make this a gathering of all who have devoted themselves to the study of Earth. In 1991 we call out not only to those who traditionally attend, but to the young carrying infants, to financially strapped students arriving in vans, to our colleagues in Mexico and

ABSTRACTS DUE JULY 3
For abstract forms (303) 447-8850

TRANSPORTATION, HOUSING,
AND PROGRAM INFORMATION:
(303) 447-2020 or 1-800-472-1988

PREREGISTRATION DUE
SEPTEMBER 20
Registration Forms available
August issue *GSA Today*

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

Canada, to teachers in community colleges and high schools, and to all of those working for energy and engineering firms across the continent.

We should meet not just to exchange data, but to interpret our science to everyone. We should let the world know what we have learned, and how it applies to us all. We want you to come to San Diego to help us focus on Earth as a whole, and to be part of the solutions to our major environmental problems.

TECHNICAL PROGRAM

CALL FOR PAPERS AND ANNOUNCEMENT OF SYMPOSIA AND THEME SESSIONS

ABSTRACTS DEADLINE FOR INVITED AND VOLUNTEERED PAPERS WEDNESDAY, JULY 3, 1991

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 3.

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 San Diego Local 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 2–3 in

Boulder. Speakers will be notified within 14 days following that meeting.

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

1991 Technical Program Chairmen

Richard W. Berry
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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.

Although papers for discipline sessions may be submitted in either oral

or poster mode, symposia and theme sessions will be presented in oral mode only. *The exceptions are theme sessions T31 and T33, which are poster mode only.*

Abstract Forms

All abstracts must be submitted on the 1991 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 survey offices. The abstract form will be used as camera-ready copy for publication of *Abstracts with Programs*.

Speaker/Author Limits

You may be designated speaker (presenter) for only one invited abstract and only one volunteered abstract, regardless of format or mode.



Courtesy of R. Gordon Gastil

GLOBAL PERSPECTIVE THEME

More than anything else, plate tectonics called attention to the need for a global perspective in geology. Global perspective emphasizes the worldwide occurrence of many geologic processes and phenomena as well as the devotion of geological scientists, internationally, to the task of describing and understanding Earth.

The meeting theme also relates to our global environment: atmosphere, hydrosphere, and lithosphere. Geoscientists play a role in preserving the environment of planet Earth while extracting and utilizing resources necessary for the support of society. The rapid growth of environmental geology, as a discipline and a source of employment, attests to the importance of its role in today's world.

The technical sessions and other events directly identified with this theme appear with the global symbol.

Leading off the theme on Monday morning will be a special Keynote Symposium sponsored by the San Diego Local Committee and organized by Patrick L. Abbott, San Diego State University.

THE GLOBAL CHALLENGE: OUR ENVIRONMENT, OUR RESOURCES, OUR RESPONSIBILITIES

Digby J. McLaren
"Events and Their Causes—Uncertainty in the Ecosphere?"

Frank Press
"Natural Hazards: Science Instead of Fatalism"

Lynn Margulis
"Gaia for Geologists: Darwinian Time and Vernadskian Space"

Michael B. McElroy
"Change in Global Environment: Perspectives on Human Influence"

Brian J. Skinner
"A Kilometer and Deeper: Will Geologists Be Ready for the Tough Prospecting Challenges Ahead?"

M. Gordon Wolman
"Water Quantity and Quality: Changes in the Hydrologic Cycle"

INVITED PAPERS (SYMPOSIA)

This format includes only abstracts that have been invited by the convener of a symposium. **Abstracts are sent directly to the convener by July 3.** 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 list of 1991 symposia appears below. A preliminary schedule will be available by May 15. Please call the GSA Meetings Department for information.

S1. **Archaeological Geology of the Archaic Period (8-3 ka) in North America.** *Archaeological Geology Division.* E. Arthur Bettis III, Iowa Dept. of Natural Resources, Iowa City.

S2. **Coalbed Methane: Geology, Recovery Technology, and Resources.** *Coal Geology Division.* Walter B. Ayers, Jr., University of Texas, Austin.

S3. **Georisk Assessment.** *Engineering Geology Division.* Charles Welby, North Carolina State University; Rhea Lydia Graham, Science Applications International Corp., Albuquerque, New Mexico.

S4. **Depositional Environments and the Development of Aquifers.** *Hydrogeology Division.* Mark W. Evans, Emory University; Robert L. Laney, USGS, Reston, Virginia.

S5. **Geology of the Pacific Rim.** *International Division.* Tadashi Sato, Tsukuba University, Tsukuba, Japan; Bruce Hanshaw, Consulting Geologist, McLean, Virginia.

S6. **Geologic Evidence of Late Quaternary Aridification in Western North America: Great Plains, Desert Southwest, and Great Basin.** *Quaternary Geology and Geomorphology Division.* Richard F. Madole and Daniel R. Muhs, USGS, Denver, Colorado.

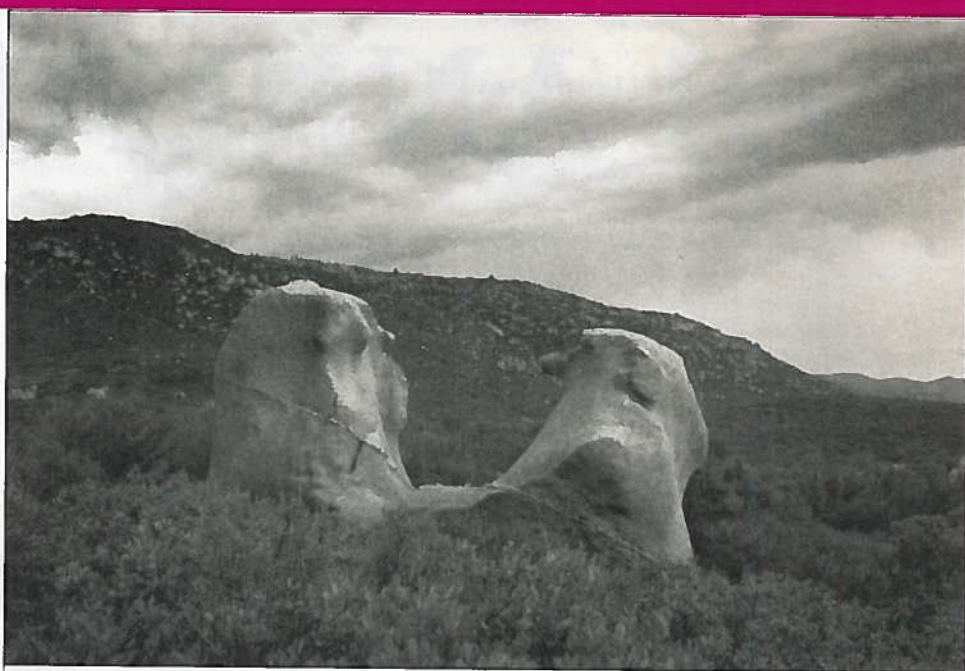
S7. **Fluvial Response to Base-level Changes: Eustatics vs. Tectonics—Part I.** *Sedimentary Geology Division.* Paul L. Heller, University of Wyoming.

S8. **Strike Slip Faulting: Geological and Geophysical Perspectives (full day).** *Geophysics and Structural Geology and Tectonics Divisions.* Art Sylvester, University of California, Santa Barbara; Kristian Meisling, ARCO Oil & Gas Co., Plano, Texas; Gene Humphries, University of Oregon; Matt Golombek, Jet Propulsion Laboratory, Pasadena, California.

S9. **The Global Climate Transition from the Late Paleocene to Early Eocene.** *Cushman Foundation.* Kenneth G. Miller, Rutgers University; Lowell Stott, University of Southern California.

S10. **Lithospheric Contrasts in Northwestern North America: Vestiges of Archean and Proterozoic Crustal Growth.** *Geochemical Society.* Paul A. Mueller, University of Florida; Joseph L. Wooden, USGS, Menlo Park, California.

S11. **International Initiatives in Geoscience Information—A**



Courtesy of R. Gordon Gastil

Global Perspective. *Geoscience Information Society (GIS).* Dena Fracoli, Information Consultant, Fort Worth, Texas.

S12. **Contact Metamorphism.** *Mineralogical Society of America.* Maria Luisa Crawford, Bryn Mawr College; Robert J. Tracy, Virginia Polytechnic Institute and State University.

S13. **New Approaches to Introductory Geology Courses.** *National Association of Geology Teachers.* Noel Potter, Jr., Dickinson College, Carlisle, Pennsylvania.

S14. **Biotic Turnover Examined in a Phylogenetic Context.** *Paleontological Society and Society of Vertebrate Paleontologists.* David Archibald, San Diego State University; Sandra J. Carlson, University of California, Davis.

S15. **Applications of Micro-Analytical Techniques to Economic Geology.** *Society of Economic Geologists.* C. Stewart Eldridge, Australian National University, Canberra.

S16. **Crustal-scale Controls on Ore Deposits (full day).** *Society of Economic Geologists.* Robert J. Bodnar, Virginia Polytechnic Institute and State University.

S17. **Organic Matter Survivable at High Temperatures: Implications for Life.** *Organic Geochemistry Division of the Geochemical Society.* Stephen A. Macko, University of Virginia; Everett L. Shock, Washington University; Michael H. Engel, University of Oklahoma.

S18. **Enhancing Geologic Education through the Arts—A Metageologic Approach.** Ray Pestrong, San Francisco State University; Garry McKenzie, Ohio State University.

S19. **Continental Drift, Plate Tectonics, and Biogeography: The History of a Synthesis of Two Cultures.** *History of Geology Division.* Alan E. Leviton, California Academy of Sciences, San Francisco.

S20. **Venus and Earth: Tectonic and Volcanic Evolution.** *Planetary Geology Division.* Baerbel K. Lucchitta, USGS, Flagstaff, Arizona.

S21. **Geophysics of the Southwestern Cordillera—USA and Mexico.** George R. Jiracek, San Diego State University; Mario Martinez, Centro de Investigación Científica y de Educación Superior de Ensenada, Baja California, Mexico.

S22. **Pangia: Ice-house Processes and Events on a Super Continent.** *Sedimentary Geology Division and Global Sedimentary Geology Program.* George deV. Klein, University of Illinois, Urbana.

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. After each theme description below, the categories are identified by name and number as they appear on the 1991 Abstract Form.

Theme submissions must include:

- the theme number (T1),
- five key words of the theme title (Global Challenge: Predicting Our Future), and
- one category (Environmental Geology—#6 on abstract form).

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 2-3 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*.

THEME TOPICS

T1. **The Global Challenge: Predicting Our Future, How Good Are the Models?** William S. Fyfe, University of Western Ontario, London; Digby McLaren, Royal Society of Canada, Ottawa, Ontario.

Given changes in the global carbon cycle, ozone holes, global soil erosion, chemical poisoning, and the like, are our models adequate to predict probable global

futures? Can this lead to rational behavior? How may we adjust to (1) population of 10-15 billion; (2) accelerating use of fossil energy; (3) vast urban-point source pollution; (4) increasing gross inequity in global resource use; (5) accelerating biota extinction; (6) total deforestation; (7) almost total modification of continental run-off? Abstracts are solicited concerning our role as earth scientists in the light of the immediate threats imposed by social, economic, and ethical imperatives to an orderly and sustainable future.

Environmental Geology (6), Global Geoscience (13), Quaternary Geology (28).

T2. Resources: The Costs and Consequences of Use. Brian J. Skinner, Yale University

The rates at which natural resources of fuels, minerals, soils, and water are used are reasonably well documented. Within reasonable bounds of uncertainty, demographic projections allow estimation of growth in future rates of use of resources. The challenge for geologists is the estimation of the magnitudes, locations, and accessibility of the various resources, plus the costs of recovering and using them, and the possible environmental consequences of doing so. Abstracts are solicited concerning the geological task ahead, which is probably the most difficult and challenging of all the socio-scientific issues facing us all.

Economic Geology (4), Global Geoscience (13), Petroleum Geology (21).

T3. Global Climate Changes—I: The Geologic Record of Climate Dynamics. Tim Herbert, Scripps Institution of Oceanography, La Jolla California; Jeff Park, Yale University.

The session will focus on the time dimension of the paleoclimatic record; that is, on data and methods of data analysis that allow earth scientists to reconstruct fluxes of materials and rates of environmental change. Topics to be considered include biotic crises, changes in ocean circulation and sea level, global temperatures and ice volume, and changes in carbon cycling in Earth history, over time scales of years to millions of years. Particular attention will be given to new methods of dating and reconstructing environmental change in the past.

Marine Geology (16), Paleoceanography/Paleoclimatology (19), Paleontology/Paleobotany (20).

T4. Global Climate Changes—II: The Past, a Key to the Future. Keith Kvenvolden, USGS, Menlo Park, California.

The premise of this interdisciplinary theme is that the geologic past can be a key to the geologic future. Our view of future global climate change should improve by coupling our understanding of detailed dynamics of past climatological factors with our knowledge of present climatology that is, in part, influenced by human activities. Contributions are sought that address global climate changes as reflected in marine and continental records, including the distribution and diversity of organisms, the variation in abundances of elements, molecules, and stable isotopes, and the occurrence of climatically dominated lithofacies.

Geochemistry (8), Global Geoscience (13), Paleoceanography/Paleoclimatology (19).

T5. Global Warming and Geologic Evidence of Aridification During Late Quaternary Time. Quaternary Geology and Geomorphology Division. Dale F. Ritter and Nicholas Lancaster, Desert Research Institute, Reno, Nevada.

This session complements the Quaternary Geology and Geomorphology Symposium. Abstracts are solicited concerning paleoclimatic change to or from drier climate and potential influences of global warming on aridification. Biotic and abiotic evidence from humid and arid regions as well as all terrestrial environments and processes

(e.g., eolian, fluvial, glacial, lacustrine, and mass movement) may be included. Acceptable abstracts will be based on new data or interpretations and should attempt to develop linkages with global circulation models or patterns of climatic changes within and between regions.

Geomorphology (10), Hydrogeology (15), Quaternary Geology (28).

T6. Fluvial Response to Base-level Changes: Eustatics vs. Tectonics—Part II. Sedimentary Geology Division. Paul L. Heller, University of Wyoming.

Response of sedimentary systems to changing base level has been viewed in a sequence stratigraphic framework emphasizing the marine record. Geometries, processes, and time scales of alluvial response to base-level changes are less well understood. The following subjects will be addressed in the context of theoretical, experimental, and field studies: (1) changes in alluvial facies associations and stratal geometries owing to changes in base level; (2) processes controlling sequence development in alluvial systems; (3) time and length scales to which river systems adjust themselves to base-level changes; (4) discrimination in the fluvial record of base-level changes caused by tectonic versus eustatic mechanisms.

Geomorphology (10), Sedimentology (30), Stratigraphy (31).

T7. Processes Controlling the Composition of Siliciclastic Sediments. Mark J. Johnsson, USGS, Menlo Park, California; Abhijit Basu, Indiana University, Bloomington.

Compositional data from siliciclastic sediments commonly provide the only available constraints to the composition of eroded land masses. Studies of orogenic development, paleotectonic and paleogeographic relations, and regional correlation may depend on the interpretation of such data. However, the complex partitioning processes operating during pedogenesis, erosion, transport, and deposition are still poorly understood. This theme session will address these processes and how they interact to determine the compositions of modern and ancient siliciclastic sediments. The emphasis will be on understanding fundamental and comprehensive processes, rather than on studies of specific regions.

Sedimentary Petrology (25), Sedimentology (30).

T8. Global Sedimentary Geology of the Phanerozoic: A Theme Session in Honor of A. B. Ronov. William W. Hay, University of Colorado; Bruce Wilkinson, University of Michigan.

Papers are solicited that cover global aspects of Phanerozoic sedimentary geology, including the mass/age distribution of sedimentary materials and its implica-

tions for the evolution of sedimentary rocks, the composition of Earth's sedimentary shell, ocean, and atmosphere, and geochemical cycles; the spatial distribution of sediments through the Phanerozoic and its implications for climatic change; the relations among sedimentary geology, tectonics, and processes in the deep interior of Earth.

Geochemistry (8), Global Geoscience (13), Sedimentology (30).

T9. Approaches to Sequence Stratigraphic Analysis—Examples from the Tertiary. Janet Coleman, Kansas Geological Survey, Lawrence.

Sequence stratigraphy incorporates data from many disciplines into a coherent framework. Sequences and sea-level fluctuations may be determined from studies of biostratigraphy, seismic stratigraphy, lithostratigraphy (well log patterns, outcrop, core, regional cross sections), stable-isotope stratigraphy, etc., of a stratigraphic section. Presentations are solicited that explain methods used to determine sequences, including new data and data interpretation. Concentration on the Tertiary section will yield a global overview of Tertiary sequence stratigraphy. Contributions are welcome from all disciplines that address the question of derivation of Tertiary sequence stratigraphy. Global Geoscience (13), Sedimentology (30), Stratigraphy (31).

T10. The K-T Boundary—I: Late Cretaceous Extinctions: Catastrophes or Not? Robert M. Sullivan, San Diego Natural History Museum; Spencer G. Lucas, New Mexico Museum of Natural History, Albuquerque.

Geologic evidence has been presented to support a hypothesized asteroid collision with Earth approximately 66 million years ago. This impact event is cited as being linked to (and the cause of) extinctions at the end of the Cretaceous. Does this inferred event coincide with extinctions recorded in the fossil record? New paleontological data and revision of misinterpretations of the Late Cretaceous fossil record indicate that the relation between the impact event and extinctions must be reevaluated. This theme session will present papers on whether uncoupling the two events is warranted.

Paleontology/Paleobotany (20), Stratigraphy (31).

T11. The K-T Boundary—II: Non-marine Fossil Record at the Cretaceous-Tertiary Boundary. Paleontological Society. R. Farley Fleming, University of Colorado at Denver; William A. Clemens, University of California, Berkeley.

This session will focus entirely on the non-marine fossil record at the K-T boundary. This record is invaluable in assessing and constraining the various hypothesized

scenarios for events at the K-T boundary. Presentations are solicited that address patterns of extinction, disruption, and survival as reflected in the fossil record of terrestrial organisms, both plant and animal. Paleontologists working on various nonmarine groups who support either side of the K-T boundary debate (i.e., catastrophists vs. gradualists) are invited to participate.

Paleontology/Paleobotany (20), Stratigraphy (31).

T12. Actinide-series Disequilibria in Igneous and Geothermal Processes. Neil Sturchio, Argonne National Laboratory, Argonne, Illinois; Michael Murrell, Los Alamos National Laboratory, New Mexico.

Recent progress in applying measurements of actinide-series disequilibria to studies of igneous and geothermal processes has been given impetus by advances in mass spectrometric techniques for high-precision measurements of femtomole amounts of actinide-series isotopes. Downhole rock and water samples from scientific drilling programs in recently active volcanic areas are now available. Previously inaccessible environments and unobservable phenomena have been revealed. Important new insights about the mechanisms and rates of igneous and geothermal processes that occur on time scales ranging from minutes to hundreds of thousands of years have been gained from actinide-series disequilibria measurements.

Aqueous Geochemistry (7), Igneous Petrology (23), Volcanology (34).

T13. Solution Mass Transfer and Volume Strain in Crustal Rocks. Mark Brandon, Yale University.

Mass transport and associated volume strain may be important during crustal-scale fluid flow with implications for structural geology, metamorphic petrology, diagenesis, and global chemical budgets. Mass transport ranges between local redistribution from pressure solution deformation to regional-scale fluxes with orogenic metamorphism. Papers are solicited regarding (1) field-based studies that examine magnitude and scale of mass transfer using physical or chemical evidence; (2) experimental studies examining grain-scale processes of dissolution, solution transfer, and precipitation in low-permeability rocks; (3) modeling studies of coupled fluid flow and chemical reaction; and (4) studies that examine tectonic, hydrological, or geochemical implications of large-scale mass transfer.

Hydrogeology (15), Metamorphic Petrology (24), Structural Geology (32).

T14. Site Characterization Studies Related to Ground-Water and Surface-Water Contamination at Sites Operated by the U.S. Department of Energy.

Stephen H. Stow and C. Stephen Haase, Oak Ridge National Laboratory, Tennessee.

The Department of Energy conducted research and weapons production at 15-20 facilities throughout the country for four decades. Radioactive, hazardous, and mixed wastes created complex environmental contamination problems. Recent emphasis is directed at site characterization and environmental restoration with costs near \$200 billion. Owing to diversity of hydrogeologic settings and uniqueness of some of the wastes, there are many geoscience challenges: i.e., vadose zone transport, fracture-flow modeling, coupling of geochemical and transport codes, high-resolution geophysical techniques, hydraulic behavior of dense organics, etc. This session encapsulates for the first time, geoscience issues associated with this environmental effort.

Engineering Geology (5), Environmental Geology (6), Hydrogeology (15).



Courtesy of R. Gordon Gastil

T15. Geology, Hydrogeology, and Tectonics of Southern Nevada in Relation to the Potential Storage of High-Level Nuclear Waste. Steven R. Mattson, Science Applications International Corp., Las Vegas, Nevada.

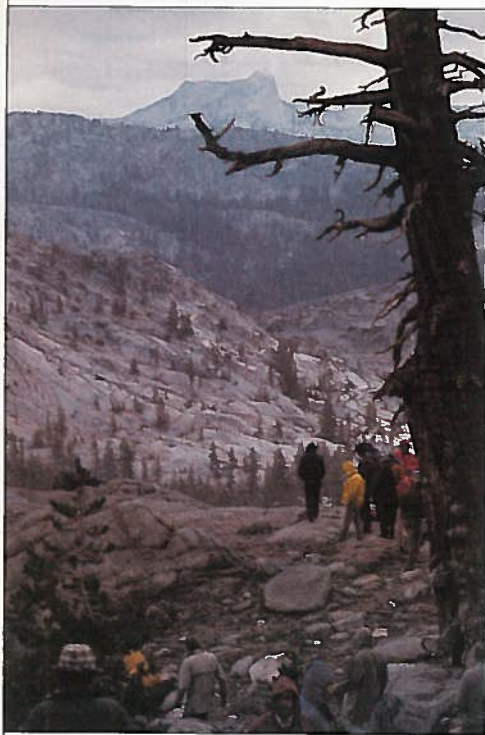
A site located at Yucca Mountain, Nevada, is being considered as the nation's first potential underground repository for high-level nuclear waste. The approximately two-and-one-half square mile site and the surrounding area are being investigated from the point of view of geology, hydrology, tectonics, petrology, geomorphology, geochemistry, and other physical sciences. This theme session will focus on results and effectiveness of studies directed toward meeting licensing criteria for nuclear waste storage contained in documents issued by the NRC and the EPA.

Hydrogeology (15), Tectonics (33), Volcanology (34).

T16. Characterization and Monitoring of Ground-Water Contamination at Hazardous Waste Sites: Research and Case Histories. *Hydrogeology Division.* Claudia Stone, S.S. Papadopulos & Associates, Inc., Rockville, Maryland.

Ground-water contamination is of urgent concern today. Many geologists are active in efforts to clean up the environment, especially in characterizing hazardous waste sites. In particular, significant, high-quality research and field studies are being carried out to define and quantify hydrogeologic boundary conditions and hydraulic parameters that control transport and the fate of contaminants in saturated and unsaturated zones at hazardous waste sites. This session is intended to provide a forum for information exchange and presentation of new ideas on the basis of research and case histories that delve into hydrogeologic characterization and monitoring at hazardous waste sites.

Engineering Geology (5), Environmental Geology (6), Hydrogeology (15).



Courtesy of R. Gordon Gastil

T17. Urban Geologic Hazards. *Engineering Geology Division.* Daryl Streiff, Consulting Engineering Geologist, San Diego, California.

Papers are solicited regarding geologic hazards in the urban environment such as faults, landslides, erosion, high water table, and ground-water pollution. The approach that will be emphasized for all the hazards will include (1) dealing with geologic problems that were not addressed prior to or during development but which occurred after development was completed; (2) how to handle geologic conditions that were addressed during development but whose impact requires reassessment during redevelopment; and (3) accommodating changes in agency requirements which necessitate reevalua-

tion of existing geologic conditions during development, prior to it, or after it has concluded.

Engineering Geology (5), Environmental Geology (6), Hydrogeology (15).

T18. Soil and Ground-Water Remediation Techniques.

Engineering Geology Division. Lyne Perry, Leighton and Associates, San Diego, California.

This theme session will provide information regarding new and proven techniques for the remediation of contaminated soil and ground water. Topics will include case histories of proven remediation techniques as well as innovative new techniques including, but not limited to air stripping, vapor extraction, pump and treat, bio-remediation and associated risk assessment.

Engineering Geology (5), Environmental Geology (6), Hydrogeology (15).

T19. Contamination of Fractured Bedrock Aquifers: Investigation Techniques and Case Histories. Kenneth C. Tyson, Roy F. Weston, Inc., Edison, New Jersey; Andrew Michalski, Whitman Companies, Inc., East Brunswick, New Jersey.

The evaluation of contaminant transport within fractured bedrock aquifers requires conceptual models and investigative techniques that are distinct from those used for contaminant flow in porous media. The session will emphasize investigative techniques and case histories, including recent advances in remote sensing, surface geophysics, borehole geophysics, hydraulic testing, and tracer testing for fracture flow characterization. Innovative sampling techniques, such as discrete interval sampling devices, will also be included. Presentations are solicited that illustrate the application of techniques as well as the complexity of contamination problems in fractured bedrock aquifers.

Aqueous Geochemistry (7), Hydrogeology (15), Structural Geology (32).

T20. Geologic Controls on Multiphase Fluid Flow in Porous Media. David M. Tuck, Princeton University.

Multiphase fluid flow in porous media is an important research topic in the oil industry and for soil scientists. Environmental problems related to the presence of non-aqueous-phase liquid (NAPL) contaminants in the subsurface are making hydrogeologists aware of this topic. It is critical to develop an understanding of the role and influence of geologic variables on processes that govern multiphase flow. Contributions are solicited that examine the influence of geologic and geochemical variables such as particle-size distribution and morphology, small- and field-scale heterogeneity, and mineral-fluid reactions on processes of multiphase fluid flow in porous media.

Environmental Geology (6), Hydrogeology (15), Petroleum Geology (21).

T21. Geophysical Exploration for Ground Water in Arid and Semi-Arid Regions. *Hydrogeology Division.* William F. McCaffrey, USGS, Sacramento, California.

In arid and semi-arid regions of Earth the demand for ground water will continue to grow. Surface geophysical methods provide an effective means of exploring for ground water in arid and semi-arid regions prior to the start of drilling operations. Abstracts are solicited regarding subsurface information that can be obtained from various surface geophysical methods such as the location and depth to bedrock, general stratigraphy of the sediments above bedrock, depth to the water-table surface, location of potential barriers to both horizontal and vertical ground-water movement, and potential water-quality problems.

Engineering Geology (5), Geophysics (11), Hydrogeology (15).



Courtesy of R. Gordon Gastil

T22. Multivariate Statistical Methods in the Geosciences.

Hydrogeology Division. Charles Brown, USGS, Reston, Virginia.

Geologic, hydrologic, and environmental data and information have become voluminous over the past decade, and a major role of the geoscientist is to interpret these large data sets. Multivariate methods, such as multiple regression, factor and principal components analysis, cluster analysis, discriminant analysis, multiple and canonical correlation, and other methods allow us to consider changes in many measured properties simultaneously and are extremely powerful tools for analyzing large multidisciplinary data sets. Contributions are solicited that will evaluate the relevance of these methods in analyzing geoscientific and other environmental data.

Computers (3), Global Geoscience (13), Hydrogeology (15).

T23. Failure Mechanisms of Megaslides. *Engineering Geology Division.* Martin Stout, California State University, Los Angeles; Michael Hart, Geocon, Inc., San Diego, California.

An interesting and controversial feature of extremely large landslides, or megaslides, is their mechanism of failure. Many such slides have traveled far greater distances than normal frictional resistance would allow. This session will be a forum for examining the various hypotheses for mechanism of failure and achieving a better understanding of the phenomenon.

Engineering Geology (5), Quaternary Geology (28), Structural Geology (32).

T24. Active Margin of Antarctica—Proterozoic to Holocene. David Kimbrough, San Diego State University; Bruce Luyendyk, University of California, Santa Barbara.

The Transantarctic Mountains, Marie Byrd Land, and the Antarctic Peninsula (Antarctica's "active margin") records processes of mountain building, continental growth, and tectonics from late Proterozoic to Holocene time. Multinational field and laboratory research has led to expansion of knowledge and new ideas regarding the region's geologic evolution. The theme session will emphasize (1) Proterozoic and early Phanerozoic evolution of the Transantarctic Mountains; (2) Paleozoic-Mesozoic evolution of Marie Byrd Land and the Antarctic Peninsula; (3) Cenozoic volcanism, xenoliths, and deep crustal structure; (4) accretion history and intracontinental correlation of West Antarctica terranes; and (5) timing and significance of continental extension in West Antarctica.

Igneous Petrology (23), Structural Geology (32), Tectonics (33).

T25. Cenozoic Extension in the Cordillera: Geometry, Timing, Mechanisms, and Regional Controls. William Dickinson and Jon Spencer, University of Arizona.

Recent field mapping, basin analysis, varied geochronology, and theoretical studies have clarified patterns and mechanisms of Cordilleran extensional tectonism, but relations to crustal thickness, lithospheric rheology, magmatic activity, plate interactions, and motions of masses within the mantle remain uncertain. Contributors are encouraged to discuss results that establish the configurations and histories of key fault systems or associated depocenters in definitive ways, regional relations that offer clues to causes of crustal extension and controls of structural style; or theoretical insights that influence the tectonic interpretation of geological, geochemical, or geophysical data.

Geophysics/Tectonogeophysics (11), Structural Geology (32), Tectonics (33).

T26. Mesozoic Stratigraphic and Structural Evolution of Northwestern Mexico. Claudio Bartolini, Gold Fields Mining Corp., Yuma, Arizona; Mariano Morales M., Universidad de Sonora, Mexico.

The emphasis will be on stratigraphic, sedimentologic, paleontologic, and structural development of Mesozoic regions in Sonora, Mexico, particularly (1) the Triassic region of central Sonora; (2) Jurassic-Early Cretaceous Bisbee Basin (northern Sonora); (3) Late Cretaceous Cabullona area (northern Sonora); and (4) Alisitos arc-related(?) Cretaceous localities (west-northwest Sonora). This theme session presents an opportunity for a forum concerning the Mesozoic geologic evolution of northwestern Mexico and elaboration of its regional Mesozoic paleogeographic and paleotectonic settings.

Stratigraphy (31), Structural Geology (32), Tectonics (33).

T27. Jurassioic Magmatism and Tectonics of the North American Cordillera. David Miller, USGS, Menlo Park, California; Cathy Busby-Spera, University of California, Santa Barbara; Steven Reynolds, Arizona Geological Survey, Tucson; James Wright, Rice University.

A major series of magmatic and tectonic events is chronicled by the Jurassic rock record of western North America (British Columbia to Mexico). These magmatic-tectonic events were first to affect continental crust far inboard of the magmatic arc producing voluminous magmas in and east of the arc since the arc was established in early Mesozoic time. Recent wide-ranging studies of paleogeography, structure, igneous petrology, continental-margin tectonics, and isotope geology provide fertile material for interdisci-

plinary examination of events of this time period. Results should stimulate much new thinking about continent-margin tectonics and magmatic arc development around the world.

Igneous Petrology (23), Stratigraphy (31), Tectonics (33).

T28. Tectonics of Modern and Ancient Accretionary Prisms.

J. Casey Moore, University of California, Santa Cruz; Darrel Cowan, University of Washington; Daniel Karig, Cornell University; Michael B. Underwood, University of Missouri, Columbia.

This theme session is intended to attract contributions on modern and ancient convergent margins, including but not restricted to southeast Asia, Taiwan, Japan, Alaska, Cascadia, Costa Rica, Peru, and Chile. Papers are solicited concerning geophysical, submersible, and drilling programs at modern margins which will set the stage for a comparison with current studies in uplifted prisms. The session will illustrate state-of-the-art studies of superficial to moderately deep tectonic processes in this most dynamic of structural environments. Contributions are welcome in any subdiscipline bearing on processes in accretionary prisms, including sedimentology, structural geology, petrology, hydrogeology, geochemistry, and geophysics.

Marine Geology (16), Metamorphic Petrology (24), Tectonics (33).

T29. Landscapes of Tectonically Active Strike-Slip, Normal, and Reverse Faults.

William Bull, University of Arizona; Thomas Rockwell, San Diego State University.

Papers are solicited that focus on studies of

late Quaternary geomorphic processes and landscapes as they relate to different styles and rates of tectonic crystal deformation. Specifically, papers encouraged are on studies that quantify the locations, times, and magnitudes of tectonic events, such as fault surface ruptures, as well as papers relating to the present state of diffusion-equation modeling of fault scarps, expressions and quantification of landforms in different climatic settings as they relate to tectonic activity, responses of streams and hillslopes to uplift, coseismic geomorphic processes, and the relative importance of tectonic, climatic, and lithologic controls on landscape evolution.

Geomorphology (10), Quaternary Geology (28), Tectonics (33).

T30. New Views of the Moon: the Lunar Frontier Revisited.

Donald A. Morrison, Johnson Space Center, Houston, Texas.

Galileo is the first spacecraft to provide geologic data for the Moon since Mariner 10 in 1973. The advent of the Space Exploration Initiative now raises the possibility of a return to the Moon in the near future. The session will address the current state of lunar science, with emphasis on major questions and the ways in which a long-term return to the Moon might address them. Results from Galileo will serve as a framework for additional presentations that are solicited on topics such as lunar chronology, volcanism, crustal evolution, geophysics, and impact processes.

Geochemistry (8), Geophysics (11), Planetary Geology (26).

T31. Southern California Areal Mapping Project—Accom-

plishments, Work-in-Progress, Goals (POSTER SESSION). Vickie Todd, University of California, Riverside.

SCAMP is a consortium of USGS, CDMG, and university researchers who have joined forces to develop an integrated regional geological and geophysical data base to meet a variety of societal needs and advance our understanding of the geologic evolution of southwestern California. This effort involves compilation of existing geologic mapping on nineteen 30' x 1" quadrangles (1:100,000 scale) in map and digital form, new mapping at 1:24,000 scale, and interdisciplinary research on topics such as the evolution of Tertiary sedimentary basins; pre-Cenozoic sedimentation, metamorphism, and magmatism; and neotectonics and dynamic surface processes.

Igneous Petrology (23), Stratigraphy (31), Tectonics (33).

T32. Baja California: Geologic History of the Peninsula and Gulf of California. Judy Terry Smith, Consulting Geologist, Palo Alto, California; José Luis Ferman and Jorge Ledesma, Universidad Autónoma de Baja California, Ensenada, Baja California, Mexico.

This session will focus on Cretaceous to Pliocene structural events, stratigraphy, and paleontological syntheses applied to the geologic history of Baja California. Presentations are solicited that bring new data and/or fresh interpretations concerning this part of the geologic history of Baja California.

Paleontology/Paleobotany (20), Stratigraphy (31), Structural Geology (32).

T33. Geology of the Future—Now (POSTER SESSION). *Sigma Gamma Epsilon.* Daniel F. Merriam, Wichita State University; Charles J. Mankin, University of Oklahoma.

Students involved in learning how to do research and beginning their research projects today will be the professional leaders of tomorrow. Their new approaches and embryonic research will usher in the 21st century. A sampling of these exciting areas and a look to the future from a spectrum of widely diverse subjects will be presented by these young investigators. Earth science students are encouraged to take part in this theme session. All students may submit abstracts; SGE members will be eligible for the SGE Best Poster Award.

Environmental Geology (6), Stratigraphy (31), Other (35).

T34. Earth Scientists and Science Educators: Common Ground. *National Earth Science Teachers Association.* Leslie C. Gordon, USGS, Menlo Park, California.

This theme session will focus on what is currently happening in the field of precollege earth science education and what trends indicate for the future. Contributions to this theme session are solicited that explore the relationship between academic research scientists and precollege classroom teachers, including presentations that highlight exemplary earth science education programs that are built around such cooperative ventures between earth scientists and science educators. Geology Education (9).

FIELD TRIPS

San Diego is a hub from which the diverse geologic environments of California, the American southwest, Mexico, and the offshore islands of the continental borderland can be easily reached. A spectacular array of field trips has been planned for the 1991 GSA Annual Meeting in San Diego that will take advantage of this location and thus appeal to a broad spectrum of geoscientists. We hope that you will choose to participate in one or more of these excursions.

All trips begin and end in San Diego unless otherwise noted. Further details will be given when registration begins in August 1991. Costs are preliminary estimates.

For further information contact the 1991 Field Trip Chairman, Michael J. Walawender, Dept. of Geological Sciences, San Diego State University, San Diego, CA 92182, (619) 594-6543, or the individual trip leaders.

PREMEETING

Mesozoic and Cenozoic Geologic Evolution of the Mojave Desert Block and Environs.

October 16–20. Roy K. Dokka, Dept. of Geology and Geophysics, Louisiana State University, Baton Rouge, LA 70803, (504) 388-2975, Darrell J. Henry, Christopher J. Travis, Timothy M. Ross, Michael M. McCurry, Carl Jacobsen, and Michael O. Woodburne. Cost: \$275.

High-Resolution Sequence Stratigraphy of Coal-Bearing Delta Complexes, Ferron Sandstone (Cretaceous), Western Interior, and Optional Geological Overflight Over the Southwestern United States.

October 17–19. Michael H. Gardner and Timothy A. Cross, Dept. of Geology and Geological Engineering, Colorado School of Mines, Golden, CO 80401, (303) 273-3883, and John H. Shelton

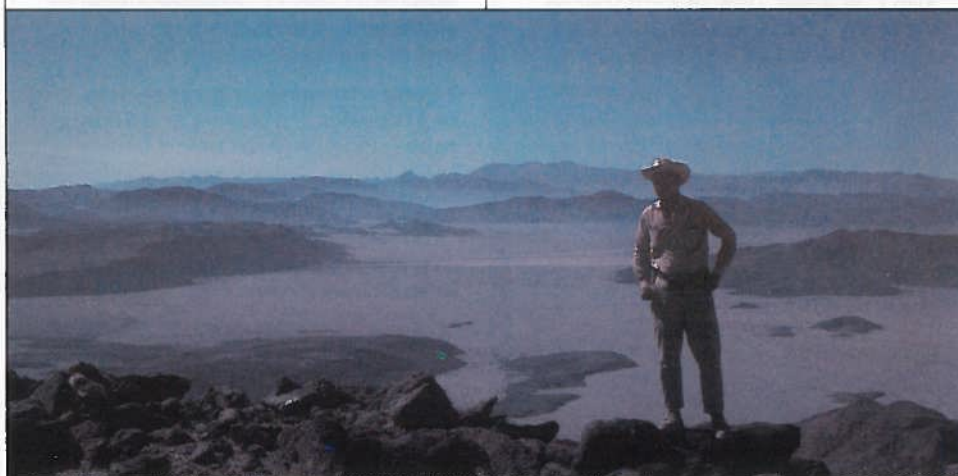
(overflight). Cost: \$330. Optional overflight October 20. Cost: \$700.

Miocene to Holocene Extensional Tectonics and Volcanic Stratigraphy, Northeast Baja California, Mexico. October 18–20. Joann M. Stock, Dept. of Earth Sciences, Harvard University, 20 Oxford St., Cambridge, MA 02138, (617) 495-8033, Arturo Martin Barajas, and Francisco Suarez Vidal. Cost: \$195.

Plate Tectonic History of the Central California Margin. October 18–20. Mark Cloos, Dept. of Geological Sciences, P.O. Box 7909, University of Texas, Austin, TX 78713-7909, (512) 471-4170, Eric James, and Michael J. Apted. Cost: \$250. Trip begins in San Francisco.

Igneous and Metamorphic Features of the Smartville Complex, Northern California. October 18 (evening)–20. Howard Day, Dept. of Geology, University of California, Davis, CA 95616, (916) 752-2882, Raymond Biersdorfer, James S. Beard, and Eldridge M. Moores. Cost: \$185. (With optional airfare from Sacramento to San Diego, \$216.) Trip begins and ends in Sacramento.

Tectonic and Magmatic Evolution of the Central Death Valley Region. October 18–20. Lauren Wright, Dept. of Geosciences, Pennsylvania State University, University Park, PA 16802, (814) 238-2603, Ed DeWitt, Michael Ellis, Jim Otton, Ren Thompson, and Bennie Troxel. Cost: \$275. Trip begins in Las Vegas.



Courtesy of R. Gordon Gastil

Upper Cretaceous Submarine-Fan Deposits, San Diego. October 19. Patrick L. Abbott, Dept. of Geological Sciences, San Diego State University, San Diego, CA 92182, (619) 594-5591, Tor Nilsen, and John Warne. Cost: \$45.

Geologic Hazards in San Diego. October 20. Patrick L. Abbott, Dept. of Geological Sciences, San Diego State University, San Diego, CA 92182, (619) 594-5591, William J. Elliott, and Michael W. Hart. Cost: \$60.

Gem-bearing Pegmatites of San Diego County. October 18–20. Eugene E. Foord, U.S. Geological Survey, Mail Stop 905, Denver Federal Center, Denver, CO 80225-0046, (303) 844-4169, Anthony R. Kampf, David London, and James E. Shigley. Cost: \$245.

Lower Cambrian Depositional and Sequence Stratigraphic Framework of the Death Valley and Eastern Mojave Desert Regions. October 17–20. Anthony R. Prave, Dept. of Earth and

Planetary Sciences, City College of New York, New York, NY 10031, (212) 650-6471, John Cooper, and Chris Fedo. Cost: \$260. (With optional airfare to San Diego, \$309.) Trip begins and ends in Las Vegas.

Modern Eolian Processes of the Algodones Dune Field, California. October 19–20. Sponsored by the *Sedimentary Geology Division*. Michael Sweet, BP-Exploration, 5151 San Felipe, Houston, TX 77210, (713) 552-8604, Gary Kocurek, and Karen Havholm. Cost: \$190.

Active Folding and Reverse Faulting in the Western Transverse Ranges, Southern California. October 18–20. Edward Keller, Dept. of Geological Sciences, University of California, Santa Barbara, CA 93106, (805) 893-3471, Robert Yates, Tom Rockwell, Gary Huftile, Scott Lindvall, Robert West, Xiaolin Zhao, and Ricardo Zepeda. Cost: \$230.

Mesozoic Evolution of Basement Terranes in the San Gabriel Mountains, Southern California. October 19–20. Andrew Barth, Dept. of Geology, Indiana/Purdue University, Indianapolis, IN 46202, (317) 274-1243, Daniel May, and Carl Jacobsen. Cost: \$150.

Quaternary Geomorphology and Geochronology of Owens Valley, California. October 17 (evening)–20. Alan Gillespie, Dept. of Geology, University of Washington, Seattle, WA 98195, (206) 543-2079, Paul Bierman, Doug Clark, and Kelin Whipple. Cost: \$255. Trip begins in Reno.

Active Faulting and Volcanism in the Trans-Mexican Volcanic Belt. October 16 (evening)–20 (morning). Max Suter, Institute of Geology, National University of Mexico, Apartado 70-296, Mexico DF 094510, (905) 548-87-47, G. Aguirre, and C. Siebe. Cost: \$220. (With optional airfare from Mexico City to San Diego, \$440.) Trip begins and ends in Mexico City.

Ground-Water Basins Along the Eastern Sierra Nevada: Tectonics, Water, and Politics. October 18–20. Wesley R. Danskin, U.S. Geological Survey, WRD, 5735 Kearney Villa Road, Suite O, San Diego, CA 92123, (619) 557-6700, Christopher D. Farrar, and Shirley J. Dreiss. Cost: \$225. Trip begins in Reno.

Archaeological Geology of the Point Conception–Vandenberg Areas, California. October 18 (evening)–20. Sponsored by the *Archaeological Geology Division*. Donald Johnson, Geography Dept., University of Illinois, Urbana, IL 61801, (217) 333-0589, and Michael Glassow. Cost: \$205. Trip begins in Santa Barbara.

HALF-DAY MINI TRIPS

(held during the meeting)

Geology of San Diego. October 22 or October 23. Faculty and staff, Dept. of Geological Sciences, San Diego State University, San Diego, CA 92182, (619) 594-5586. Cost: \$10.

The Downtown San Diego Blob. October 23 (morning). David Huntley, Dept. of Geological Sciences, San Diego State University, San Diego, CA 92182, (619) 594-5483, Robert Hawk, Gary Pischke, and Barry Pulver. Cost: \$10.

POSTMEETING

Remote Sensing and Planetology at JPL. October 25. Ronald G. Blom, Radar Sciences Group, Jet Propulsion Laboratory, Mail Stop 300-233, 4800 Oak Grove Dr., Pasadena, CA 91109, (818) 354-4681. Cost: \$25.

The Catalina Schist: Metamorphic and Fluid-flow Processes in a Paleo-Subduction Zone. October 25–27. Sorena S. Sorenson, Dept. of Mineral Sciences, National Museum of Natural History, Smithsonian Institution, Washington, DC 20560, (202) 357-4010, Gary E. Bebout, and Mark D. Barton. Cost: \$320.

Geological Overflight of Southern California. October 25. John P. Ford, Radar Sciences Group, Jet Propulsion Laboratory, Mail Stop 300-233, 4800 Oak Grove Dr., Pasadena, CA 91109, (818) 354-6735, Roy K. Dokka, and Ronald Blom. Cost: \$450.

A Petrologic and Structural Transect Across the Peninsular Ranges Batholith, Southern California. October 25–27. Michael J. Walawender, Dept. of Geological Sciences, San Diego State University, San Diego, CA 92182, (619) 594-6543, Gary M. Girty, and Marc Lombardi. Cost: \$275.

Zoned Plutons of the Eastern Peninsular Ranges, Baja California Norte. October 25–26 or October 25–29. R. Gordon Gastil, Dept. of Geological Sciences, San Diego State University, San Diego, CA 92182, (619) 594-6443, Joan Calhoun, and Susan Gunn. Cost: \$170 (2 days only) or \$370 (all 5 days).

Mesozoic Geology of Cedros Island, Baja California, Mexico. October 25–28. David L. Kimbrough,

Dept. of Geological Sciences, San Diego State University, San Diego, CA 92182, (619) 594-1385, Cathy Busby-Spera, Douglas Smith, and Richard Sedlock. Cost: \$535 (airfare included).

Eocene Depositional Systems in San Diego. October 25–26. Sponsored by the *Sedimentary Geology Division*. Patrick L. Abbott, Dept. of Geological Sciences, San Diego State University, San Diego, CA 92182, (619) 594-5591, Jeff May, John Warne, and Martin Link. Cost: \$135.

Landslides in the Peninsular Ranges, Southern California. October 25–26. Michael W. Hart, Geocon Inc., 6960 Flanders Dr., San Diego, CA 92121, (619) 558-6900. Cost: \$135.

Geologic Structure, Transpression, and Neotectonics of the San Andreas Fault in the Salton Trough, California. October 25–27. Arthur Sylvester, Dept. of Geological Sciences, University of California, Santa Barbara, CA 93106, (805) 893-3156, and Michael Rymer. Cost: \$240.

Late Cenozoic Sedimentation and Tectonics Along the Western Margin of the Salton Trough, California. October 25–27. Dennis Kerr, Bureau of Economic Geology, University of Texas, University Station, Box X, Austin, TX 78713-7508, (512) 471-1534, Charles Winker, and Susan Kidwell. Cost: \$275.

A Hydrogeologic Overview of the Regional Ground-Water Flow System in Relation to Yucca Mountain, Nevada. October 25–27. Devin Galloway, U.S. Geological Survey, 2800 Cottage Way, Room W-2234, Federal Building, Sacramento, CA 95825, (916) 978-4648, Elisabeth Ervin, Michael Chornack, and Alan Riggs. Cost: \$180. (With optional airfare from Las Vegas to San Diego, \$264.) Trip begins and ends in Las Vegas.

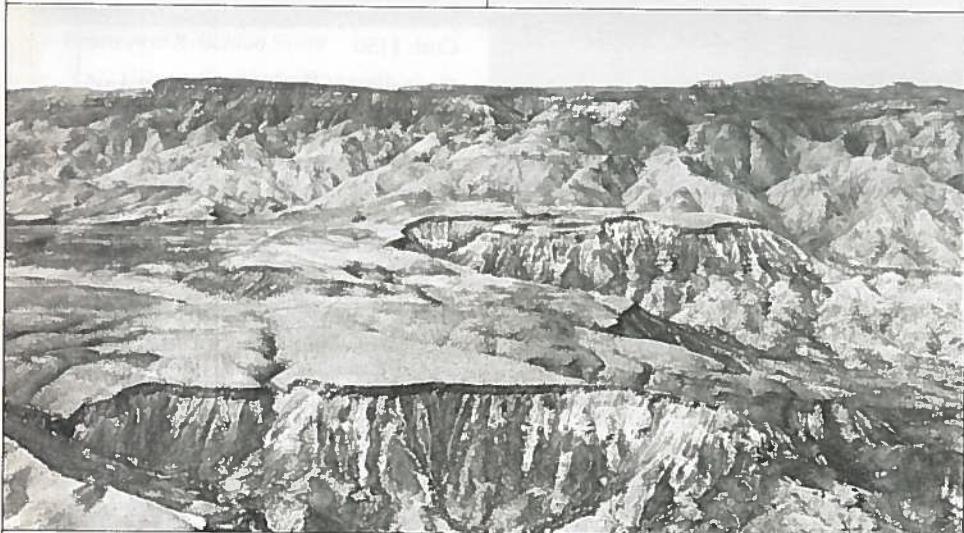
Low-Angle Detachment Faulting and Rapid Uplift of Mid-Crustal Mylonitic Rocks in the Whipple Mountain Metamorphic Core Complex. October 25–27. Gregory A. Davis, Dept. of Geological Sciences, University of Southern California, University Park, CA 90089-0740, (213) 743-6126, and Lawford Anderson. Cost: \$250.

SEG-Sponsored Field Trips

Industrial Mineral Deposits of the Mojave Desert. October 18–19. Thomas P. Anderson, California Division of Mines and Geology, 107 S. Broadway, Suite 1065, Los Angeles, CA 90012, (213) 620-3560. Cost: \$200.

Active and Fossil Rhyolite-Hosted Epithermal Systems. October 18–19. Alan E. Williams, Dept. of Earth Sciences, University of California, Riverside, CA 92521, (714) 787-4611 and Wilfred A. Elders. Cost: \$200.

Active and Fossil Hydrothermal Mineralization in the Salton Trough Rift. October 25–26. Michael A. McKibben, Dept. of Earth Sciences, University of California, Riverside, CA 92521, (714) 787-3444. Cost: \$200.



Courtesy of R. Gordon Gastil

PROFESSIONAL HORIZONS

GSA-SPONSORED SHORT COURSES/FORUM

Advanced registration for GSA Short Courses begins in May with the publication of the 1991 Short Course Brochure. To receive a copy of the brochure or for more information on any of the courses listed below, contact Edna Collis, Course Registrar, GSA headquarters.

Fees will be approximately \$100–\$125 for the first day, \$75–\$100 for the second day, and \$50–\$75 for the third day. Actual fees, course details, and registration information will be published in the May issue of *GSA Today*. 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).

Concepts, Strategy, and Software for Practical Three-Dimensional Contaminant Transport Modeling.

October 18–20. Cosponsored by the *Hydrogeology Division*. Chunmiao Zheng and Gordon D. Bennett, S.S. Papadopoulos & Associates, Inc., Rockville, Maryland.

Description and Analysis of Fluid-Mineral Equilibria Using the SUPCRT91 Software Package.

October 18–19. James W. Johnson, Lawrence Livermore National Laboratory, Livermore, California; Eric H. Oelkers, University of California, Berkeley; Everett L. Shock, Washington University.

Deformation and Kinematics of High Strain Zones.

October 19–20. Cosponsored by the *Structural Geology and Tectonics Division*. Carol Simpson and Declan G. De Paor, Johns Hopkins University.

Fractals and Their Use in Earth Sciences.

October 19–20. Christopher C. Barton, USGS, Denver, Colorado; Paul R. LaPointe, ARCO Oil and Gas Co., Plano, Texas; Alberto Malinverno, Lamont-Doherty Geological Observatory, Palisades, New York.

Quantitative Sedimentary Basin Modeling.

October 19–20. Cosponsored by the *Sedimentary Geology Division*. Paul L. Heller and Charles L. Angevine, University of Wyoming; Christopher Paola, University of Minnesota, Minneapolis.

Thermochronology: Applications to Tectonics, Petrology, and Stratigraphy.

October 19–20. John F. Sutter, USGS, Reston, Virginia; Peter K. Zeitler, Lehigh University; Robert D. Tucker, Royal Ontario Museum, Toronto.

Assessing the Mobility of Chemicals in the Vadose Zone.

October 20. Cosponsored by the *Engineering Geology Division*. Donn L. Marrin, InterPhase, San Diego, California.

Computer-aided Illustration in Geology.

October 20. Cosponsored by the *National Association of Geology Teachers*. Gary A. Novak, California State University, Los Angeles.

Earthquakes and Earthquake Preparedness.

October 20. Cosponsored by the *Geophysics Division* and the *National Association of Geology Teachers*. Kenneth L. Verosub, University of California, Davis.

Hydrogeologic and Environmental Applications of Stable Isotopic Systems.

October 20. Richard W. Hurst, California State University, Los Angeles.

Applications of Radar Remote Sensing: Terrestrial and Planetary.

October 25. Cosponsored by the *Planetary Geology Division*. Gerald G. Schaber, USGS, Flagstaff, Arizona; Tom Farr, Jet Propulsion Laboratory, Pasadena, California.

Contaminant Hydrogeology: Practical Monitoring, Protection and Cleanup.

October 25–26. Cosponsored by the *Hydrogeology Division*. Christopher M. Palmer, Exceltech, Inc., Fremont, California; Jeffrey L. Peterson, GeoStrategies, Inc., Hayward, California.

Sedimentary Basin Systems.

October 25–26. Cosponsored by the *Sedimentary Geology Division*. George deV. Klein, University of Illinois, Urbana.

Geology & Public Policy Forum

The GSA Committee on Geology and Public Policy will hold a forum on earthquake effects and preparedness. Specialist presentations will be followed by an open question-and-answer session. This forum will be the seventeenth in a series and will be open to everyone including guests and the general public. For information, contact the Meetings Department, GSA headquarters.



Courtesy of R. Gordon Gastil

OTHER SHORT COURSES/WORKSHOPS

Contact Metamorphism.

October 18–20. Precourse reception the evening of October 17. Sponsored by the *Mineralogical Society of America*. For information: MSA Business Office, 1130 Seventeenth St., N.W., Suite 330, Washington, DC 20036, (202) 775-4344.

Sequence Stratigraphy and Biostratigraphic Patterns: An Integrated Approach to Defining Basin History.

October 19, 8:00 a.m. to 5:00 p.m. Sponsored by *SEPM* and the *Paleontological Society*. For information: SEPM, P.O. Box 4756, Tulsa, OK 47159-0756, (918) 743-9765.

Analytical Paleontology.

October 20, 8:15 a.m. to 5:30 p.m. Sponsored by the *Paleontological Society*. For information: Philip W. Signor, Dept. of Geology, University of California, Davis, CA 95616, (916) 752-0846.

Geoscience Information on CD-ROM Workshop.

October 20, 1:30 to 4:30 p.m. Sponsored by the *Geoscience Information Society*. For information: Barbara DeFelice, Dartmouth College, Kresge Physical Sciences Library, Hanover, NH 03755, (603) 646-3845.

GeoRef Workshop.

October 23, 8:00 to 10:00 a.m. Sponsored by the *Geoscience Information Society*. For information: Barbara DeFelice, Dartmouth College, Kresge Physical Sciences Library, Hanover, NH 03755, (603) 646-3845.

3-DAY TECHNICAL AND SCIENTIFIC EXHIBIT. OPENS MONDAY.

All registrants and guests welcome.

Monday, October 21 9:00 a.m. to
6:00 p.m.
Tuesday, October 22 9:00 a.m. to
5:30 p.m.
Wednesday, October 23 8:00 a.m. to
5:30 p.m.

State-of-the-art scientific equipment and services will be brought into the exhibit hall by international exhibitors. Draw on the problem-solving knowledge and information that exhibitors will gladly provide.

Get involved with demonstrations of computer hardware and software, hazardous-waste research, X-ray diffraction and measurement equipment, powder diffraction equipment, camera equipment, isotope ratio mass spectrometers, microanalysis equipment, publications, maps, gems and jewelry, mineral and fossil specimens, field supplies, and camping equipment. Talk with the many universities and educational organizations about their current resources and programs.

GSA thanks those dedicated exhibitors who return to the exhibit hall year after year. Their combined efforts have made the exhibits a growing success!

GSA encourages participation by new and innovative companies—particularly those with products and services involving computer sciences, hazard assessment and mitigation, and other environmental challenges.

We will talk with any organization or university with products and services appealing to geologists! If you are interested in participating, or if you would like to see a particular exhibitor invited, please contact Kathy Ohmie-Lynch, Exhibits Manager, GSA headquarters. Call or write today while booths are still available.

HIGHLIGHTS

Tennis Tournament

October 20

Save Sunday morning for the Tennis Tournament. Round-robin doubles will be played on Marriott's well-maintained rooftop courts. No busing! The tournament will be run by Marriott tennis pro Dave Bacon. San Diego lays claim to last year's GSA tennis winner, who will stand all challengers. Tune up your racket. Entry will be limited; first-come, first-served.

Welcoming Party

October 20

The San Diego Welcoming Party will be on Sunday evening, 6:00 to 9:00 p.m., overlooking San Diego Bay at sunset. This informal event is a great way to meet friends and plan the week's activities. Start the week right!

Keynote Symposium

October 21

"The Global Challenge: Our Environment, Our Resources, Our Responsibilities" is a special symposium on Monday morning, 8:30 a.m. to 12:00 noon, at the Convention Center. It is sponsored by the San Diego Local Committee as the keynote program of the Global Perspective theme.

Global Challenge Roundup

October 21

On Monday from 5:00 to 6:00 p.m., there will be an open session for anyone and everyone to offer their thoughts on the global environmental challenges. This will involve the speakers from the morning session as well as others who will be making major contributions to the global challenge program.

Alumni Receptions

October 21

Everyone knows someone at the popular Alumni Receptions. This year the parties start at 7:00 p.m. at the Marriott Hotel. Catch up with current and past colleagues and meet new friends. If you would like to schedule an alumni function, have your department chairman contact Vanessa George, Events Coordinator, GSA headquarters, by June 1.

GSA Presidential Address and Awards Ceremonies

October 22

In a change from previous years, this prestigious event will be held from 6:00 to 7:00 p.m. on Tuesday. After giving her address, President Doris M. Curtis will award the Penrose, Day, and Donath Medals. Two separate special evening events will immediately follow.

Dance the Night Away

October 22

Gnarly? Far out? Maybe not, but it's Tuesday night—and time for fun. Overlooking San Diego Bay, this is a California party, where you can dance until you drop. It's an outdoor social evening "under the sails" atop the Convention Center. Listen or dance to live music from a band promising variety from the rockin' 60s on up. Beverages, light snacks, and a good time are promised.

San Diego Bay Dinner Cruise

October 22

Leave the landlubbers and the loud music at the Convention Center. Board for a Moonlight Dinner Cruise on the bay. Lights of the city shimmer while a southern California meal and wine are quietly served. Dinner seating will be limited, so be sure to register early.

Volleyball Players Take Notice

October 21, 22, 23 afternoons

Volleyball enthusiasts from San Diego State's Department of Geological Sciences are promoting a for-fun geologists' volleyball tournament. If you would like to enter a team (or be placed on a team), write to: 1991 Volleyball, c/o GSA. Let us know if you want to field a 4- or 6-person team. Ringers accepted—if they are working geologists or geology students.

Sunrise Run

October 23

Leave global concerns behind and take on a personal challenge instead. At sunrise on Wednesday, runners in the 5K Fun Run will bolt from the Convention Center start line and head along the San Diego Bay. The salty air and blue sky will make the early rise n' shine worth it. A perfect mid-meeting break.

Border Brigade

October 23

¡Andale, amigos y amigas! Party on Wednesday evening. Travel by bus across the border to Tijuana for a great meal at a well-known restaurant in Mexico. Follow dessert with a brief shopping spree that will yield all kinds of south-of-the-border finds at duty-free shops!

Global Perspective

Rapporteur Session

October 24

Early Thursday afternoon, there will be a closing two-hour session to report and to "rap" about the week's events. We hope that the next steps in facing up to the global challenge will be clear. If so, this will be the best memory of the San Diego meeting.

T.A.C.

October 24

T.A.C. (Thursday Afternoon Club) was such a rousing success last year, the 1991 Local Committee feels that due to health reasons (theirs), it should be repeated again this year! The send-off will start about 3:30 p.m. with free beer and snacks. Be on hand for a laid-back California farewell.

EMPLOYMENT SERVICE

Once again, GSA will be offering its Employment Interview Service. The popularity of this program continues to rise: at last year's meeting in Dallas, participating employers conducted nearly 600 interviews with 260 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 available to assist in scheduling interviews.

Students completing doctoral and masters theses during 1991 are encouraged to check the job offerings.

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



GUEST PROGRAM

San Diego is a special city offering a wonderful array of attractions in a beautiful setting. The Guest Committee has planned tours to show off the city's best, and informative seminars you won't want to miss. Most of these programs are suitable for family attendance.

The Guest Program tours include a cruise on San Diego's harbor following an introductory tour of the city; a behind-the-scenes look at the world-famous San Diego Zoo in spectacular Balboa Park; a safari at the San Diego Wild Animal Park; and a trip to the historical Presidio and the original site of the Mission San Diego de Alcalá, before visiting Old Town courtyards for shopping and a delicious Mexican lunch.

Also planned is a walking tour of the downtown Gaslamp Quarter filled with art galleries and boutiques, ending with high tea at the elegant Horton Grand Hotel; and a trip to Tijuana, Mexico, for a morning of shopping bargains and lunch in a rambling hacienda. Children will enjoy some of these tours and are welcome.

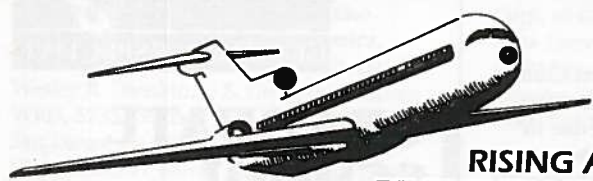
The Guest Program also offers a series of enlightening seminars that cover earthquake preparedness, the intriguing history of San Diego, and, for the southern California fans, the trends in non-field gear fashion.

In addition, guests are encouraged to participate in the rest of the meeting by taking a short course, visiting the exhibits, or attending technical sessions. Guests may attend the keynote symposium on Monday morning and go on the one-day or half-day field trips to learn about San Diego's environmental concerns.

You've heard about the beauty, charm, and warmth of San Diego. Plan to be there. Register early to get in on the events of your choice. Be sure to see the details and registration information that will appear in the August issue of *GSA Today*. If you plan to be out of town in August, have a friend register for you.

SAN DIEGO HOSTS TOP GEOLOGY SENIORS

The San Diego Local Committee is sponsoring a group of top undergraduate seniors at this meeting. Arrangements have been made to fund transportation, lodging, meals, field trips, and registration through a cooperative effort between geology departments and the Local Committee. The project is meant to expose the best and brightest of the seniors to broader visions in geology. The program has been, by necessity, carried out by invitation only. Funding is being generously provided by GSA's exhibitors and by corporations in the San Diego area.



**RIISING AIRFARES?
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Call CAIN TRAVEL GROUP Today

(official travel agency for the San Diego meeting)

Cain offers 45% off coach, will meet or beat any fare quote, and will handle at no extra charge the special discount fares advertised in your area.

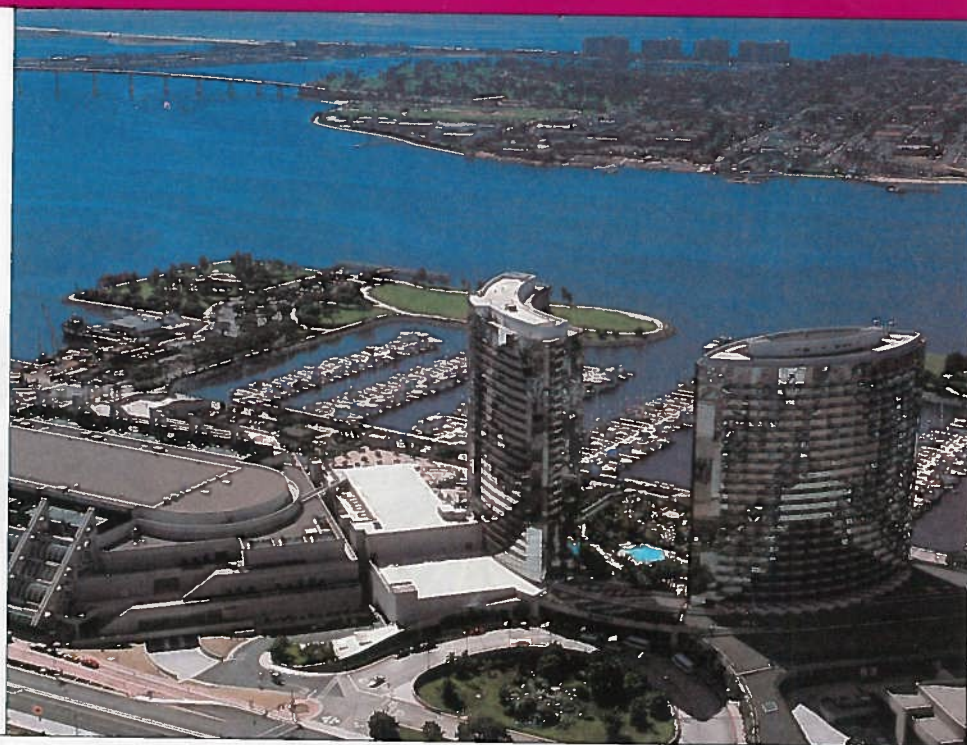
1-800-346-4747 toll-free

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8:30 AM-6:00 PM MST, Monday-Friday

You can't lose. Book today. If airfares drop,

Cain will automatically reissue your ticket at the lower rate!

(Students: American Express has been offering low discount coupons. Check your campus bookstore, then call Cain.)



Marriott towers with Convention Center on left.

TRAVEL AND LODGING

Getting To San Diego

By Air. San Diego International Airport—Lindbergh Field—is one of the few airports to be only 15 convenient minutes from the Convention Center. Most hotels have free shuttle pick-up. San Diego is currently served by Aero California, Air Resorts, Alaska Airlines, America West, American, Continental, Delta, Midwest Express, Northwest, Pan American, Sky West, Southwest, States West, Trans World, United, and USAir. Consider staying over Saturday night in San Diego for significant airfare savings.

By Car. San Diego is about a 2½-hour drive from downtown Los Angeles via freeway route Interstate 5, which stretches from Canada to the Mexican border. Interstate 8 serves drivers from Yuma, Arizona, and beyond from the East Coast. Interstate 15 provides access from Nevada, Utah, Idaho, and Montana.

By Train and Bus. Amtrak passenger trains provide service to and from Los Angeles. Greyhound and Trailways provide bus service. Call the offices in your area to get the best rates.

Getting Around In San Diego

An excellent freeway system makes travel by car or bus easy throughout the county. San Diego Transit Corporation buses serve the metro area. Taxi service, inexpensive rental cars, and tour buses are readily available. In San Diego, call The Transit Store, 233-3004, for schedule information.

San Diego Trolley. The modern San Diego Trolley provides an excellent, inexpensive service in the downtown

area; between downtown and the Mexican border; and to San Diego's East County.

GSA Shuttle. The shuttle will supplement trolley access to the San Diego Convention Center and to the Marriott Hotel & Marina which will be home to all the meeting events. The shuttle will provide a convenient, day-time, free shuttle serving the GSA-selected downtown hotels and the Convention Center. The shuttle will also operate on Sunday, Monday, and Tuesday evenings.

LODGING

Tight budget? We're on your side, and we know the problems, inside and out. We're fighting for the best possible rates including discounts of 30% or more. We've booked 12 properties that include a good cross section of lodging in the downtown area that should appeal to almost everyone's budget and taste. If you don't have your own transportation, these hotels will make the most sense for you.

Participating hotels include San Diego Marriott Hotel & Marina, Radisson Hotel Harbor View, Pan Pacific Hotel, Ramada Hotel Downtown, Comfort Inn Downtown, Howard Johnson Hotel-Balboa Park, Best Western Bayside Inn, Holiday Inn Harbor View, Holiday Inn on the Bay, Kingston Hotel, Omni Hotel San Diego, and Horton Grand Hotel.

The most outstanding property in the luxury class is GSA's headquarters, the Marriott Hotel & Marina, which is truly an impressive property. Immediately adjacent to the Convention Center and Seaport Village, it offers first-class services, dining, and a resort atmosphere on San Diego Bay. Rates at \$125 single and \$149 double are the best group rates available in October and worth the cost by California standards.

Over and above the 1000 rooms at the Marriott, there are 700 single rooms priced between \$70 and \$85, and 425 single rooms between \$50 and \$69. There is an excellent set of options within this

group, including four-star properties and basic motels. All meet GSA's standards for rate reliability, cleanliness, service, and location.

We have reserved 300 rooms in various small Travelodge properties either downtown or within three miles of the downtown area and negotiated a special flat rate of \$45 for one to four people. You may need to provide your own transportation.

Be sure to register in August to get the hotel you want. Hotel information and reservation forms will be available in the August issue of *GSA Today*. All housing, except suites, will be processed by the San Diego Housing Bureau. Please call the GSA Housing Coordinator for suite information.

ALTERNATIVE HOUSING

Beating the high cost of housing is a high priority of GSA staff and the 1991 Local Committee. Here are some alternatives:

- Call 1-800-555-1212 or check the Yellow Pages to learn the 800 number for your favorite hotel chains, such as Motel 8 or Comfort Inns, which have properties outside the downtown area.
- Check your library copy of the Hotel and Motel Redbook, which lists metro properties. Because of the hundreds of properties in the area (some good, some bad), GSA does not provide a general list.
- Consider camping or taking the trolley to/from El Cajon. The San Diego Local Committee has researched low-cost alternatives, including camping or other motels south of San Diego. Tent and RV camp grounds are available near the San Diego County foothills or on Mission Bay. Advanced reservations are required, and nightly fees range from \$16 to \$30. For additional information, contact Vanessa George, GSA Housing Coordinator.

CHILD CARE

Families should consider bringing their children to San Diego because of the variety and quality of family activities within the metropolitan area.

Due to prohibitive insurance costs and the legal issues that surround child care, daycare service will not be provided by GSA. We want to make it as convenient as possible, however, for families to make arrangements. Several alternatives are available. Please call the GSA Meetings Coordinator for advice.

CALIFORNIA/SAN DIEGO INFORMATION

Abundant information and friendly service are available at the following contact numbers:

State of California
Visitor Packet
1-800-862-2543

San Diego Visitor Information Center
11 Horton Plaza
San Diego, CA 92101
(619) 236-1212

REGISTRATION

PREREGISTRATION DISCOUNT APPLIES THROUGH SEPTEMBER 20. Save by registering early.

Attention Students: Your fees are 62% less than professional fees.

Fight inflation: (1) Become a GSA member. (2) Register before September 20.

GSA members automatically receive registration information and forms within the first few weeks of August. Registration will begin at that time. If you are not a member and would like registration forms and further information sent, please write or call the GSA Registration Coordinator, GSA headquarters.

Meeting registration fees have not been established at this early date. However, for your budgeting and travel authorization requests please use the following estimates of preregistration fees. Final fees will be announced in August.

JOIN GSA TODAY. ENJOY THE MEMBER DISCOUNT.

Professional Member	\$ 130
One Day	75
Professional Nonmember	170
One Day	95
Student Member	50
One Day	30
Student Nonmember	70
One Day	40
Spouse or Guest	50

August preregistration is suggested for many of the short courses, field trips, guest tours, and special events because of participation limits.

Because the *Abstracts with Programs* is not included in the registration fee, please purchase it in advance with your GSA membership, through GSA Publication Sales, or on-site at the Convention Center.

San Diego
GLOBAL PERSPECTIVE

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JOI/USSAC Ocean Drilling Graduate

Fellowship

Joint Oceanographic Institutions, Inc./U.S. Science Advisory Committee is seeking doctoral candidates of unusual promise and ability who are enrolled in U.S. institutions to conduct research compatible with that of the Ocean Drilling Program. Both two-year and one-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. Applications are available from the JOI office and should be submitted according to the following schedule:

ODP Cruise	Application Deadline
Leg 140: 504B or Hess Deep	May 1, 1991
Leg 141: Chile Triple Junction	May 1, 1991
Leg 143: Atolls & Guyots A	May 1, 1991
Leg 144: Atolls & Guyots B	May 1, 1991
Leg 145: North Pacific Transect	September 1, 1991
Leg 146: Cascadia	September 1, 1991

All Shorebased Research (regardless of leg) January 1, 1992

Graduate students interested in applying for participation as a shipboard scientist on one of these legs should contact Robin Smith at the JOI office immediately for more information and to receive an application packet.



JOI/USSAC Ocean Drilling Fellowship Program
Joint Oceanographic Institutions, Inc.
1755 Massachusetts Avenue, NW, Suite 800
Washington, DC 20036-2102
(202) 232-3900

Forum continued from p. 76

term utilization of coal. The United States is one of the top three coal-rich countries of the world. The other two are the USSR and the People's Republic of China.

Although in general, coal will continue to be used in the future, this nation has some alternatives to an increase in or even the continued use of coal for the generation of electricity. The most obvious is nuclear power. The people of the United States may decide that, in our best national interests, nuclear energy, with all its associated problems, is the lesser of several evils. To date, however, a trend in that direction has not made itself evident.

Another factor that would have a positive impact on coal utilization involves technological advances that would result in more efficient, cleaner burning of coal. Although clean coal technologies do not answer all the objections to coal burning, they would be environmentally more acceptable.

Predicting the future use of coal worldwide is further complicated by the wide discrepancy in per capita energy use between developed and developing countries. Energy consumption in the United States and other highly industrialized and developed countries has leveled off, primarily owing to the use of energy-efficient technologies in those countries. However, the energy consumption of a developing country

rises with the economic growth of that country; although U.S. energy consumption has remained fairly level for the past 10 to 15 years, world energy consumption has risen dramatically (Figure 2).

It is recognized that the U.S. contribution to the global nature of environmental problems is relatively small. U.S. coal-burning power plants are responsible for at most only 3% of worldwide emissions of all greenhouse gases.

The factors that will affect the future of coal and, therefore, the fate of coal geology and of the practitioners of the science are in part "pure economics," in part the perception of the concerned public as to its best environmental interests, and in part political. National security interests are best served by adequate, dependable supplies of critical minerals and energy resources. The more significant increases in the recent history of oil and coal prices were the results of major worldwide political events and not technological factors or "normal" market reactions. Of all the disparate factors that influence the world's energy markets, the most difficult to predict are the national paroxysms of the major oil-producing regions. The resulting instability in the energy economy of the world has had a greater impact on coal science and coal scientists than any of the technological or environmental factors mentioned previously. The most recent of these paroxysms—war in the Middle East—is likely to cause the synfuels-from-coal pendulum to swing in the direction of increased coal utilization. ■

GSA members' reactions to Forum topics are encouraged. Members are invited to respond to positions presented in Forum and to submit alternative views. Letters from the membership will be published in the Forum Feedback section. Responses up to 500 words (double-spaced) should be sent to the Forum editor. Upcoming Forum topics will be presented to *GSA Today* readers with sufficient lead time for all who wish to participate. Future Forum topics may include:

- What should GSA do to enhance the role of minorities and women in the geosciences?
- Are the geological sciences properly represented in the U.S. Global Change Research Program?
- Should all professional geologists be licensed?
- Are there alternatives to Yucca Mountain?
- Should GSA assume a more visible advocacy role?
- What is the role of GSA in pre-college and informal science education?

WORLD ENERGY CONSUMPTION

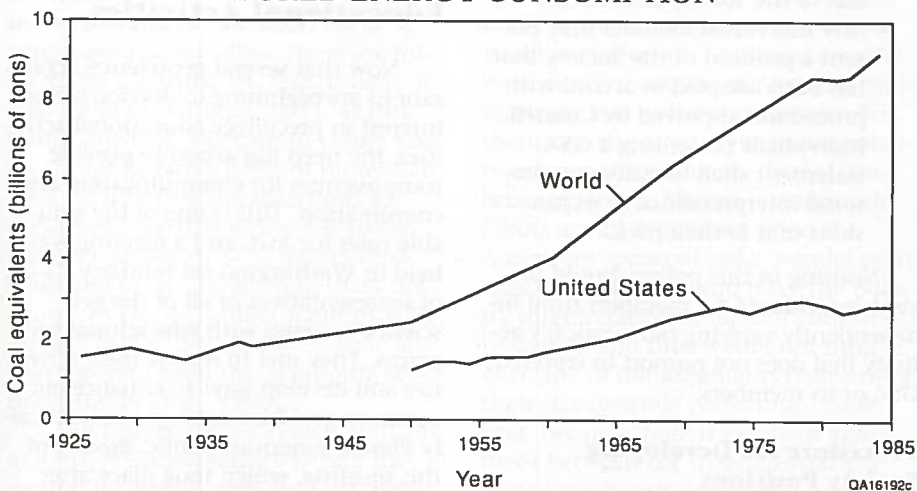


Figure 2. Total world energy consumption has increased by over 300% in the past 35 to 40 years. Most of the energy increases over this period were in developing countries. Consumption in the United States during the past 10 to 15 years has leveled off.

Developing and Promoting Testimony on Geologically Significant Public Policy Matters

Doris M. Curtis, President, Geological Society of America

The GSA Committee on Geology and Public Policy is charged with developing and disseminating information from the geological sciences to promote the use of such information in the discussion and formulation of decisions regarding public policy. A first step toward fulfilling that charge was taken in 1988 when the committee recommended to Council adoption and distribution of guidelines for participation of GSA members as individuals in the legislative process; in May of that year Council adopted those guidelines, and printed them as a pamphlet available to all GSA members.

A further step was taken in 1990, with the adoption by Council of an advocacy policy. The following recommendations comprise guidelines from the committee for development of GSA-endorsed positions and their presentation to policy makers. These guidelines are a second step in fulfilling the Society's responsibility to provide a direct source of information to policy makers through timely participation of the Society in legislative matters. At the May 1990 meeting of Council, these guidelines were approved along with the recommendation that they be printed in *GSA Today*, and be made available as a pamphlet. It was also suggested that Council seek the reaction of the membership to adoption of the policy that the Society take advocacy positions.

After reading the guidelines, Council asks that you return the tear-out form provided below indicating whether you agree or disagree with the Council decision on this matter. Your comments are welcome. The deadline for receipt of all forms is **April 30**, so that Council may consider the reaction of the membership on this issue at their meeting in early May.

Guidelines for the Development of GSA-Endorsed Positions

Providing Scientific Society Testimony

GSA-endorsed testimony, provided by Council (or the Executive Committee, for Council), is an officially endorsed viewpoint presented with supportive data. Such testimony is likely to be more inclusive in content than testimony provided by individuals and, by internal review, is made to reflect widely shared viewpoints of the GSA membership. Because it usually takes substantial time to develop such positions and have them endorsed by the various constituencies involved, efficient procedures are needed for the clearing of requests for Society-endorsed positions and identification

of the most effective means of preparing and presenting such positions. In addition, alternative procedures are needed where lead times are very short.

- I. GSA-endorsed testimony may be presented as follows: (a) In person by a representative, usually the president or other officer, at a public hearing; or (b) In written form by authorized persons without personal appearance.
- II. GSA may arrange for testimony, written or verbal, by an expert (usually a member of the Society). This can be done through the president of the Society, the section chairperson, or the Committee on Geology and Public Policy working in concert with the president. One or more members with qualifications in the area being dealt with by the legislative hearings are selected to present information in person or by letter on the subject to the committee. Expert testimony is highly useful in providing factual information from a reputable source (acknowledged as such by the Society) without committing GSA to official endorsement of the individual's presentation. Because of the speed and versatility possible through this option, it is frequently used by other societies in responding to short-notice requests for expert testimony in a specialized area of geology. Sections will be asked by Council or the Committee on Geology and Public Policy to nominate persons to present testimony in their respective specialties. In this option, the person presenting testimony may indicate that his or her appearance "has been arranged by GSA" but that "GSA is not necessarily endorsing these remarks."
- III. GSA may collaborate with other interested earth science and educational societies or groups in developing and presenting testimony on mutual concerns, which involves an officially designated representative of the Society working with similarly appointed persons from other organizations. Such a group may act as follows: (a) Independently as a group of scientists and not necessarily in the name of their respective societies; or (b) As representing the official position of their respective societies on jointly developed statements. In this instance, clearance of positions of the joint effort is expected from the individual governing boards.
- IV. GSA may present no testimony. The decision to take this stance should be acknowledged if a specific request for assistance is sent to the Society by a legislative body or administrative agency directly. A statement that cites the reasons for not providing the information for consideration but indicates a continuing interest in subjects related to the Society's interests can keep the door open for future input.

Quality vs. Quantity of Responses

Because of the volume of proposals for legislation and agency regulations each year, it is often impractical and counterproductive for most scientific research and educational organizations to attempt to address every bill

that has implications for science. Many organizations find it more effective to concentrate their efforts on a few selected priorities.

The officially endorsed public input from a tax-exempt scientific organization like GSA should strive for presentation of conclusions based on a consensus of professional experience and scientific documentation. GSA should avoid presentation of viewpoints on topics not directly related to the organization's area of expertise.

Other Limitations of Involvement by GSA

Caution is needed in submitting testimony or comment that is uninvited or that may be construed as lobbying or other partisan political activity in the name of a tax-exempt society before federal, state, or local legislative bodies. GSA, in common with other professional societies in the scientific and education fields, is classified under IRS section 501(c)(3) for most of its Society functions. Under this designation, statements should stress professional benefit to GSA and educational value for the public at large.

Advocacy and the Geological Society of America

The Geological Society of America is an association of scientists, scholars, and interested lay public established for the purpose of advancing geological science. The Society shares a collateral responsibility to assure that the results of geological research are made available to benefit all of humanity. The Society encourages its members to exercise their individual sense of responsibility in addressing political and social issues. The Geological Society of America strives to preserve its special position as an objective source of analysis and commentary for the full spectrum of geological science. Accordingly, the following policies guide the Geological Society of America in its role as an advocate:

- The Geological Society of America has a responsibility to its members to adopt a position of advocacy on earth science issues based on intrinsic merits and needs.
- To the extent that the understanding and application of earth science is relevant to public policy, GSA as a responsible scientific association should make relevant information available to all parties interested in the issue.
- As a scientific society, GSA should not take or advocate public positions on issues that extend beyond the range of available geological data or recognized norms of legitimate scientific debate. Public positions adopted by GSA and statements issued on its behalf must be based on scientific issues and should reflect the interests of the Society as a whole.
- Any individual member may present a position of the Society that has been adopted in accord with procedures approved by Council. Individuals presenting a GSA statement shall identify any personal interpretations or expansions of it as their own.

Nothing in this policy should prevent individual GSA members from independently carrying out advocacy activity that does not purport to represent GSA or its members.

Procedure for Developing Society Positions

1. Position statements will be restricted to those issues that fall within the policies approved by Council.

2. Requests for position statements are to be referred immediately to the chairperson of the Committee on Geology and Public Policy.

3. If a request appears to fall within Society policies, the chairperson of the committee will recommend that the president of the Society appoint an independent panel charged with drafting a statement. The panel will include at least one member each from the Committee on Geology and Public Policy, the originator of the request, and, where appropriate, Council.

4. Council and the GSA membership will be informed that the panel is working on the issue and that comments are welcome.

5. The panel will prepare a statement for circulation to Council.

6. Members of Council (or the Executive Committee, when timeliness is critical) will be asked to vote or to comment on the proposed statement. This vote will ordinarily be taken at regularly scheduled meetings. Concurrence of two-thirds is required for adoption.

7. All adopted position statements will be published in *GSA Today* as soon as possible.

8. Once a statement has been approved, the Committee on Geology and Public Policy, in communication with Council, will be responsible for seeking the most effective means of presenting the Society's position in a timely fashion. ■

**MAIL THE RESPONSE COUPON TODAY!
Your Opinion Counts**

SAGE REMARKS

Allison R. (Pete) Palmer

Guidelines for Partners

The draft of GSA's SAGE Program guidebook for educators and geoscientists who participate in the Partners for Excellence program has been circulated to the guidebook subcommittee of the Education Committee and to representatives of NAGT and NESTA. Their suggestions are being incorporated into the final version, which will be available later this year. Particular thanks go to Molly Miller for permission to pirate parts of the excellent booklet prepared by SEPM, "A Sedimentary Geologists' Guide to Helping K-12 Earth Science Teachers: Hints, Ideas, Activities, and Resources," that is available for \$6.75 (including shipping and handling) from SEPM, P.O. Box 4756, Tulsa, OK 74159-0756.

Coordination of Educational Activities

Now that several geoscience organizations are beginning to develop serious interest in precollege educational activities, the need has arisen to provide some avenues for communication and coordination. This is one of the valuable roles for AGI, and a meeting was held in Washington on February 22-23 of representatives of all of the geoscience societies with educational programs. They met to review their activities and develop ways to enhance our common goal for a more geoscientific literacy American public. Results of this meeting, which took place after the deadline for this issue, will be reported next month. ■

Request for Membership Opinion on the New GSA Advocacy Policy

I Agree I Disagree

With the recently adopted Council policy that the Society take advocacy positions through the development and promotion of testimony on geologically significant public policy matters.

Please express your opinion and return this form **NO LATER THAN APRIL 30** to:
Advocacy Opinion Poll, Geological Society of America, P.O. Box 9140, Boulder, CO 80301

Signature (optional) _____

Please return with your comments.

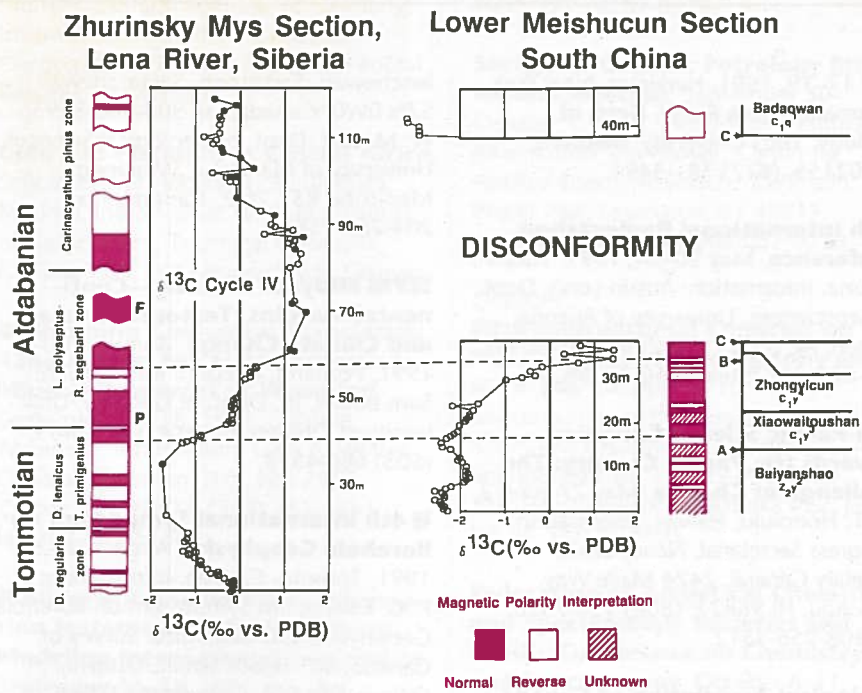


Figure 4. Comparison of the carbon and magnetostratigraphic results from the lower Meishucun section in south China with the reference patterns from the Siberian platform. The Baiyanshao, Xiaowaitoushan, Zhongyicun, and Dahai are members of the Yuhucun Formation, and the Badaowan is the basal member of the Qiangzhushian Formation.

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base of the Yuanshan Member), referred to as the China D level (Zhang, 1984). Two other levels, termed China A and China B, have been suggested on the basis of the first occurrence of shelly fauna and of a faunal diversification event, respectively. The China B horizon is favored for the boundary point, should this section be selected for the international stratotype (Cowie, 1985).

Carbon and oxygen isotope data for this sequence have been published by Brasier et al. (1990), and the carbon results are replotted here in slightly modified form in Figure 4. We have eliminated from our pattern results from ten samples that are characterized by highly negative $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ values, as these probably indicate the presence of a diagenetically altered carbon isotope record and hence do not reflect the isotopic signature of the surface ocean waters at the time they formed. Nine of these samples correspond to the phosphorites in the Zhongyicun Member, and the other is at the China C horizon at the base of the Badaowan Member. It is important to note that three independent studies on material taken from the China C horizon have all found $\delta^{13}\text{C}$ values of around -6‰ (Hsü et al., 1985; Xu et al., 1989; Brasier et al., 1990) accompanied by a drop in ^{18}O content ($\delta^{18}\text{O} = -12.5\text{‰}$). Thus, it is clear that Hsü et al.'s (1985) model of the "Strangelove ocean" was based on a sample of carbonate that did not retain its original carbon or oxygen isotope compositions.

After removing these samples, we are left with the carbon pattern shown in Figure 4. At the base of the sequence in the Baiyanshao Member, the $\delta^{13}\text{C}$ values are around -2‰ . These are followed by a gradual ^{13}C enrichment of 4‰ up to the China C level. At this point, however, the carbon values take an abrupt negative jump of more than 4‰ ; no intermediate directions are preserved. Above this, the Badaowan Member carbonate $\delta^{13}\text{C}$ values drop gradually from -3.5 to -6‰ (data not shown in Fig. 4). Similar patterns without the highly depleted $\delta^{13}\text{C}$ zone are also reported from the Maidiping section (Brasier et al., 1990).

We interpret the China C horizon as a major disconformity within the section for several reasons. First, field evidence indicates a depositional break, marked by a ferromanganese- and

phosphorite-encrusted disconformity (Voronin et al., 1982; Brasier et al., 1990). Second, detailed studies of carbon isotope stratigraphy in other boundary intervals have shown repeatedly that abrupt jumps in the carbon record are commonly associated with nondeposition or erosional events, since the isotopic composition of carbon in the ocean requires a few tens of thousands of years or more to respond to massive perturbations (Baud et al., 1989; Magaritz et al., 1988; Magaritz and Holser, 1990). Third, the trace-metal anomalies at this horizon (interpreted previously as impact debris) can also be generated by weathering during an erosional or nondepositional event, particularly if other ferromanganese metals are concentrated. Finally, as discussed below, sediments on opposite sides of this boundary have opposite magnetic polarities. If a stratigraphic break is longer than the average duration of a magnetozone, there is an equal chance of finding a reversal at the horizon.

Wu et al. (1989) reported a detailed magnetostratigraphic study of the Meishucun section. Although only about 10% of the samples exhibit stable behavior upon demagnetization, both normal and reversely magnetized samples were present. Unfortunately, Wu et al. were not able to determine which direction corresponded to either normal or reversed polarity, as there is not now a complete apparent polar wander path for the Yangtze platform. However, Ripperdan (1990) and Kirschvink (1991) noted that all of the latest Proterozoic and Cambrian paleomagnetic data for south China fit on the Australian apparent polar wander track, in the correct sequence, if the Yangtze platform is fit adjacent to the northwestern margin of Australia, thus resolving this polarity ambiguity. Furthermore, the relative magnetic polarity interpretations for the Early Cambrian of Siberia, Morocco, and south China are all dependent upon the Australian apparent polar wander path; hence, any error would force the polarity interpretation of all four continents to switch, and thus would not influence any of our arguments concerning their stratigraphic correlation. However, because there is excellent agreement between the magnetostratigraphy of the North American Cambrian/Ordovician boundary interval (in western Newfoundland) and that of Australia

(Ripperdan, 1990), an error in polarity interpretation of the Australian path is unlikely. The Meishucun magnetostratigraphic pattern is thus largely of reversed polarity in the Baiyanshao Member, switching to dominantly normal polarity in the lower part of the Xiaowaitoushan Member, as shown in Figure 4.

Figure 4 also shows our best match between the reference magnetic and isotopic patterns from the Siberian platform and those from the Yangtze platform. This correlates the positive shift in the Meishucun $\delta^{13}\text{C}$ values with the bottom half of Siberian carbon cycle IV, as shown. This correlation also makes a reasonable match with the magnetic polarity pattern, correlating the reversed to normal shift near the Tommotian/Atdabanian boundary in Siberia with the similar change in the lower part of the Xiaowaitoushan Member. Thus, as shown in Figure 4, the China A horizon correlates with the middle of the Siberian *D. lenaicus* archeocyathan zone, and the China B and C horizons (below the China C disconformity) correlate into the middle part of the *R. zegebarti*-*L. polyseptus* zone.

Other correlations are perhaps feasible but are not as easy to support using both the carbon isotope and magnetic data. Nothing in the $\delta^{13}\text{C}$ pattern from the Vendian-aged Yudoma Formation in Siberia (carbon cycle I) matches well with the Meishucun data, and although the data are scanty, most of carbon cycle I appears to be of reversed polarity. One possibility might be to correlate the Meishucun section with the base of the Siberian carbon cycle II in the lower half of the Tommotian Stage, but the magnetic polarity pattern there is largely reversed, with a few short normal zones, conflicting with that from Meishucun. Hence, if one rejects the correlation of the Meishucun with the Tommotian/Atdabanian interval outlined in Figure 4, we would be forced to conclude that it does not overlap in time with anything in the $\delta^{13}\text{C}$ record from the Siberian platform.

Following the lead of Luo et al. (1984), several authors have used correlation diagrams between Meishucun and Siberia which imply that Meishucunian faunal zones I and II are pre-Tommotian, in disagreement with the analysis presented above. Most of these faunal comparisons are based on the first occurrences of fossils with incompletely known stratigraphic ranges, however, and most of the correlations are not at the species levels, but rather at higher taxonomic "group" levels, such as the *Chuaria* group, trilobite first appearances, the Vendotaeniid flora, and the *Protohertzina anabarica* group (Brasier et al., 1990). None of these first-occurrence events has been shown to be synchronous on a global scale. In conjunction with the putative presence of Atdabanian faunal elements in the vicinity of the China B marker (Cowie, 1985), the correlation shown here in Figure 4 seems to be the simplest interpretation of all available data.

Strata above the disconformity at the China C horizon are not as easy to correlate with the present Siberian $\delta^{13}\text{C}$ pattern, as they go continuously from values of about -2.5‰ to -6‰ (Brasier et al., 1990) and nothing like this is present in the Siberian pattern. Hence, the China C disconformity must remove the strata correlative with everything from the middle of the *L. polyseptus*-*R. zegebarti* archeocyathid zone through at least the end of the *Carinocyathus pinus* zone of the Atdabanian Stage. We are at present extending the

Siberian carbon pattern to younger rocks in an attempt to test this hypothesis.

DISCUSSION

The Siberian carbon isotopic record is at present the most continuous and complete for the Precambrian/Cambrian boundary interval. In comparison with others in the geological time scale, it is clear that the magnitude of the sharp drop in $\delta^{13}\text{C}$ values at the base of the Tommotian Stage (the top of Siberian carbon cycle I shown here in Fig. 2) is an event comparable to that at either the Permian/Triassic or the Cretaceous/Tertiary boundaries. Faunal changes in both the Permian/Triassic and the Cretaceous/Tertiary boundaries were accompanied by rapid drops in the $\delta^{13}\text{C}$ values (Hsü et al., 1982; Magaritz et al., 1988; Baud et al., 1989; Magaritz and Holser, 1990). Magaritz (1989) has argued that this type of shift in the carbon isotopes probably arises from a massive change in the biosphere, produced perhaps by entrenched ecological systems being disrupted by mass extinctions, climatic shifts in productivity, or factors as yet unknown. In the process, however, the total amount of isotopically light carbon locked in the biomass will decrease, producing a sharp drop in the $\delta^{13}\text{C}$ values of the inorganic marine carbon reservoir. The cause for this drop in Siberia is unknown.

In terms of the selection of an international boundary stratotype section and horizon, the Precambrian/Cambrian boundary working group has narrowed their search to three areas: the Aldan River in Siberia, the Meishucun section in south China, and the Burin Peninsula in Newfoundland (Cowie, 1985). As the International Stratigraphic Commission has emphasized that boundaries of the geological time scale should be based on the major changes in the history of life on this planet (Hedberg, 1978; Cowie, 1986), it seems clear that the Precambrian/Cambrian boundary should be located in one of these sequences at a level that corresponds to the top of carbon cycle I. It should be clear, from the above analysis and from the data of Brasier et al. (1990), that the Meishucun section does not contain the top of Siberian carbon cycle I: it contains a relatively gentle rise in $\delta^{13}\text{C}$ values that probably correlates with the base of Siberian carbon cycle IV. The section also contains a major stratigraphic break at the China C horizon, only about 5 m above the proposed boundary at the China B horizon. Both of these are unacceptable attributes for an international boundary stratotype section.

Of the remaining candidates, carbon and oxygen isotopic data for the Newfoundland sequence are not yet available. However, the boundary interval in this sequence, identified on the basis of trace fossils, is located in the Chapel Island Formation, which is characterized by deep-water claystone, not shallow-water carbonate rock. Although there are occasional carbonate nodules within the sequence, they clearly formed during diagenesis, and their isotopic compositions may therefore be influenced by ^{13}C -depleted organic matter derived from the surrounding claystone. Detailed studies of both the carbon and oxygen isotopes should resolve this question, and perhaps provide a better basis for correlation with the reference $\delta^{13}\text{C}$ curves from the Siberian platform. Unfortunately, there appears to be little hope for obtaining magnetostratigraphic

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1991

April

10th Annual Princeton-Conoco Symposium in Geosciences: Deformation of Earth Materials, April 5-6, 1991, Princeton, New Jersey. Information: Alan Henry, Dept. of Geological and Geophysical Sciences, Guyot Hall, Princeton, NJ 08544; (609) 258-4109; E-mail: alhenry@pucc.

American Association of Petroleum Geologists Annual Meeting, April 7-10, 1991, Dallas, Texas. Information: Charles F. Dodge, General Chairman, 607 Meadows Building, 5646 Milton, Dallas, TX 75206; (214) 363-2937; or AAPG Convention Department, P.O. Box 979, Tulsa, OK 74101; (918) 584-2555.

Engineering Geology and Geotechnical Engineering, 27th Symposium, April 9-13, 1991, Logan, Utah. Information: James McCalpin, Dept. of Geology, Utah State University, Logan, UT 84322-4505; (801) 750-1220.

Permian Basin Section—SEPM Annual Field Seminar: Sequence Stratigraphy, Facies, and Reservoir Geometries of the San Andres/Grayburg/Queen Formations, Guadalupe Mountains, New Mexico and Texas, April 11-13, 1991, Permian Basin, Texas. Information: Sally Meador-Roberts, PBS-SEPM 1991 Annual Field Seminar, P.O. Box 1595, Midland, TX 79702; (915) 684-7122.

Association of American Geographers Annual Meeting, April 13-17, 1991, Miami, Florida. Information: AAG, 1710 16th Street NW, Washington, DC 20009-3198; (202) 234-1450.

International Conference on Environmental Pollution, April 15-19, 1991, Lisbon, Portugal. Information: ICEP Conference Office, ICTR Secretariat, 11-12 Pall Mall, London SW1Y 5LU, England; phone 01-930-6825; telex 925312 REICO G; fax 01-976-1587.

GSA North-Central Section, April 18-19, 1991, Toledo, Ohio. Information: Lon Ruedisili or Mark Camp, Dept. of Geology, University of Toledo, Toledo, OH 43606.

International Symposium on Geophysical Hazards in Developing Countries and Their Environmental Impacts, April 21-27, 1991, Cairo, Egypt. Information: T. S. Murty, Hazards-91, c/o Institute of Ocean Sciences, P.O. Box 6000, Sidney, B.C. V8L 4B2, Canada; (604) 356-6311; telex 04-97281; fax 604-356-6390; Mohammed I. El-Sabh, Hazards-91, Dept. Océanographie, Université du Québec, 300, Allée des Ursulines, Rimouski, Québec G5L 3A1, Canada; (418) 724-1707; telex 051-31623; fax 418-723-7234.

GSA Rocky Mountain and South-Central Sections, April 22-24, 1991, Albuquerque, New Mexico. Information: G. Randy Keller, Dept. of Geological Sciences, University of Texas, El Paso, TX 79968-0555; (915) 747-5501; John Geissman or Wolfgang Elston, Dept. of Geology, University of New Mexico, Albuquerque, NM 87131; (505) 277-4204.

European Geophysical Society XVI General Assembly, April 22-26, 1991, Wiesbaden, Federal Republic of Germany. Information: EGS Office, Postfach 49, 3411 Katlenburg-Lindau, Germany;

phone 49-5556-1440; fax 49-5556-4709; telex 965564 zil d.

Association of Exploration Geochemists 15th International Geochemical Exploration Symposium, April 29-May 1, 1991, Reno, Nevada. Information: Harold Bonham, 15th IGES, P.O. Box 9126, Reno, NV, 89507; (702) 784-6691; fax 702-784-1709.

Eighth Thematic Conference on Remote Sensing for Exploration Geology, April 29-May 2, 1991, Denver, Colorado. Information: Robert H. Rogers, ERIM Thematic Conferences, P.O. Box 8618, Ann Arbor, MI 48107-8618; (313) 994-1200.

May

■ **Caltech Mantle Plume and Hotspot Symposium**, May 2-4, 1991, California Institute of Technology. Information: Don L. Anderson or Dee Page, Seismological Laboratory, California Institute of Technology, Pasadena, CA 91125; (818) 356-6901 or (818) 356-6903; fax 818-564-0715.

African Colloquium of Micropaleontology, May 6-8, 1991, Libreville, Gabon. Information: Comité d'Organisation de Colloques, D.G.H.B.P. 2199, Libreville, Gabon; tel 241-76-39-23; fax 241-76-39-17.

Society for the Preservation of Natural History Collections, 6th Annual Meeting, May 6-11, 1991, Ottawa, Ontario. Information: G. R. Fitzgerald, Canadian Museum of Nature, Earth Sciences (Paleobiology), P.O. Box 3443, Station D, Ottawa, Ontario K1P 6P4, Canada.

14th Annual Spring Systematics Symposium: Origin of Anatomically Modern Humans, May 11, 1991, Chicago, Illinois. Information: Sophia L. Brown, Symposium Coordinator, Department of Geology, Field Museum of Natural History, Roosevelt Road and Lake Shore Drive, Chicago, IL 60605-2496; (312) 922-9410, x298.

Third International Seminar on Coastal Parks and Protected Areas, May 11-June 5, 1991, Florida and Costa Rica. Information: John R. Clark, University of Miami-RSMAS, 4600 Rickenbacker Causeway, Miami, FL 33149-1098; (305) 361-4620; telex 317454; fax 305-361-9306; Easylink mailbox 62845425.

International Symposium on Land Subsidence, May 12-18, 1991, Houston, Texas. Information: Ivan Johnson, A. Ivan Johnson, Inc., 7474 Upham Ct., Arvada, CO 80003; (303) 425-5610.

Fifth National Outdoor Action Conference on Aquifer Restoration, Ground Water Monitoring, and Geophysical Methods, May 13-16, 1991, Las Vegas, Nevada. Information: Fifth National Outdoor Action Conf., National Water Well Association, P.O. Box 182039, Dept. #017, Columbus, OH 43218; (614) 761-1711.

Brazil Gold '91, May 13-17, 1991, Belo Horizonte, Brazil. Information: Organizing Committee, Av. Afonso Pena, 3880-3/5 andares, 30130 Belo Horizonte MG, Brazil; or Charles Thorman, U.S. Geological Survey, Box 25046, MS 905, Denver Federal Center, Denver, CO 80225; (303) 236-5601; fax 303-236-5603.

■ **54th Annual Meeting of Northeast Friends of the Pleistocene**,

May 17-19, 1991, Herkimer, New York. Information: Jack Ridge, Dept. of Geology, Tufts University, Medford, MA 02155; (617) 381-3494.

14th International Radiocarbon Conference, May 20-24, 1991, Tucson, Arizona. Information: Austin Long, Dept. of Geosciences, University of Arizona, Tucson, AZ 85721; (602) 621-8888; fax 602-621-2672; telex 650-3839821.

XVII Pacific Science Congress—Towards the Pacific Century: The Challenge of Change, May 27-June 2, 1991, Honolulu, Hawaii. Information: Congress Secretariat, Nancy Lewis, Secretary General, 2424 Maile Way, Honolulu, HI 96822; (808) 956-7526, fax 808-956-3512.

Geological Association of Canada—Mineralogical Association of Canada Annual Meeting held jointly with the Society of Economic Geologists, May 27-29, 1991, Toronto, Ontario. Information: J. J. Fawcett, Dept. of Geology, Earth Sciences Center, University of Toronto, 22 Russell St., Toronto, Ontario M5S 3B1, Canada; (416) 978-3027; fax 416-978-3938.

June

Gordon Conference on Estuarine Processes, June 24-28, 1991, New Hampton, New Hampshire. Information: A. M. Cruickshank, Gordon Research Center, University of Rhode Island, Kingston, RI 02881, (401) 783-4011.

July

Second International Conference on Industrial and Applied Mathematics (ICIAM 91), July 8-12, 1991, Washington, D.C. Information: SIAM Conference Coordinator, Dept. CC0990, 3600 University City Science Center, Philadelphia, PA 19104-2688; (215) 382-9800; fax 215-386-7999; E-mail siamconfs@wharton.upenn.edu.

11th International Symposium on Ostracoda, July 8-13, 1991, Warrnambool, Victoria, Australia. Information: Peter J. Jones, Bureau of Mineral Resources, P.O. Box 378, Canberra A.C.T. 2601, Australia; phone (06) 249 9737; fax 06-257-6465.

Former ENSO Phenomena in Western South America: Records of El Niño Events, July 10-13, 1991, Lima, Peru. Information: ENSO 1991 International Symposium, ORSTOM, Apartado 18-1209, Lima 18, Peru; fax 51-14-40-87-73.

Sixth International Symposium on the Ordovician System, July 15-19, 1991, Sydney, Australia. Information: Earth Resources Foundation, Edgeworth David Building, University of Sydney, Sydney, N.S.W., Australia, 2006; phone (02) 692 2038 (Int. 61+2); fax 02-692 0184 (Int. 61+2).

August

150th Anniversary Conference on the Permian System, August 5-10, 1991, Perm, USSR. Information: A.E.M. Nairn, Perm Conference, Earth Sciences & Resources Institute, University of South Carolina, Columbia, SC 29208; (803) 777-6484; fax 803-777-6437; telex 9102501347 USC ESRI UQ.

Sedimentary and Paleolimnological Records of Saline Lakes, August 13-16, 1991, Saskatoon, Saskatchewan. Information: Robin W. Renaut, Dept. of Geological Sciences, University of Sas-

katchewan, Saskatoon, Saskatchewan S7N 0W0, Canada; fax 306-966-8593; W. M. Last, Dept. of Geological Sciences, University of Manitoba, Winnipeg, Manitoba R3T 2N2, Canada; fax 204-261-7581.

SEPM Midyear Meeting—Continental Margins, Tectonics, Eustasy and Climate Change, August 15-18, 1991, Portland, Oregon. Information: Sam Boggs, Jr., Dept. of Geology, University of Oregon, Eugene, OR 97403; (503) 686-4573.

■ **4th International Symposium on Borehole Geophysics**, August 18-22, 1991, Toronto, Canada. Information: P. G. Killeen, 4th Symposium on Borehole Geophysics, c/o Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario K1A 0E8, Canada; (613) 996-2312; fax 613-996-9295; telex 053-3117 EMAR OTT. (Abstracts deadline: April 10, 1991.)

Third U.S. Conference on Lifeline Earthquake Engineering, August 22-23, 1991, Los Angeles, California. Information: American Society of Civil Engineers, Specialty Conference Dept., 345 E. 47th St., New York, NY 10017; (212) 705-7139.

1st International Meeting of Young Geologists, August 22-28, 1991, Budapest, Hungary. Information: Anna Balog, Dept. of Geology, Technical University of Budapest, H-1521 Budapest, Hungary; phone (36-1) 16-67-370; fax 36-1-16-66-808; telex 225931.

■ **International Symposium on Origin, Sedimentation and Tectonics of Late Mesozoic to Early Cenozoic Sedimentary Basins at the Eastern Margin of the Asian Continent and Workshop of IGCP 245: Nonmarine Cretaceous Correlations**, August 25-30, 1991, Fukuoka, Japan. Information: Hakuyu Okada, Dept. of Earth and Planetary Sciences, Kyushu University, Fukuoka, 812 Japan; 92-614-1101; fax 92-632-2736.

■ **Fourth International Conference on Seismic Zonation**, August 26-29, 1991, Stanford, California. Information: 4th International Conference on Seismic Zonation, John A. Blume Earthquake Engineering Center, Department of Civil Engineering, Stanford University, Stanford, CA 94305-4020.

■ **Antarctica in Global Change: Ocean Drilling Perspective**, August 28-31, 1991, Santa Barbara, California. Information: James Kennett, Marine Science Institute, University of California, Santa Barbara, CA 93106; (805) 893-3764; fax 805-893-8062.

September

International Symposium on Computer Applications in Geoscience, September 2-6, 1991, Beijing, China. Information: Zhang Bojun, 31 Xue Yuan Rd., Beijing 100083, China; phone 2012233, ext. 312; fax 2024674; telex 222484 GBCC CN.

Geometry of Naturally Deformed Rocks (John Ramsay Meeting), September 9-11, 1991, Zürich, Switzerland. Information: E. Pour, Geologisches Institut, ETH-Zentrum, CH-8092, Zürich, Switzerland; phone 256 36 80; fax 252-70-08. (Abstracts deadline: June 1, 1991.)

International Symposium on Fossil Cnidaria Including Archaeocytha

and Porifera, September 9–14, 1991, Münster, Federal Republic of Germany. Information: Fossil VI. Cnidaria, Pferdegasse 3, D-4400 Münster, Federal Republic of Germany.

Gold and Platinum in Central Africa, September 11–13, 1991, Bujumbura, Burundi. Information: W. Pohl, Institute of Geosciences, Technical University, P.O. Box 3329, D-33 Braunschweig, Germany

■ **Wyoming Geological Association 42nd Annual Fall Field Conference: Mineral Resources of Wyoming**, September 14–18, 1991, Laramie, Wyoming. Information: Gary A. Winter, General Chairman, P.O. Box 2957, Casper, WY 82602; (307) 261-5463, fax 307-261-5136.

■ **Integrating Geographic Information Systems and Environmental Modeling International Conference**, September 15–18, 1991, Boulder, Colorado. Information: GIS/Modeling Conference Secretariat, NCGIA, University of California, Santa Barbara, CA 93106; (805) 893-8224; fax 805-893-8617; E-mail ncgia@ncgia.ucsb.edu or ncgia@voodoo.bitnet.

Second International Conference on the Abatement of Acidic Drainage, September 16–18, 1991, Montreal, Québec. Information: Pamela Friedrich, Centre des Recherches Minérales, 1665, boulevard Hamel, Édifice 2, 1er étage, Québec, Québec G1N 3Y7, Canada.

2nd International Symposium on Environmental Geochemistry, September 16–19, 1991, Uppsala, Sweden. Information: Mats Olsson, Dept. of Forest Soils, Swedish University of Agricultural Sciences, Box 7001, S-750 07 Uppsala, Sweden; phone 46-18-672212; fax 46-18-300831.

■ **22nd Annual Geomorphology Symposium: Periglacial Geomorphology**, September 21–22, 1991, Buffalo, New York. Information: John C. Dixon, Department of Geography, University of Arkansas, Fayetteville, AR 72701; (501) 575-5808.

Second Hutton Symposium on Granites and Related Rocks, September 23–28, 1991, Canberra, Australia. Information: ACTS, GPO Box 2200, Canberra City, ACT 2601, Australia.

15th International Cartographic Conference—9th General Assembly of the International Cartographic Association, September 23–October 1, 1991, Bournemouth, England. Information: James R. Carter, Academic Computing, Illinois State University, Normal, IL 61761; (309) 438-3758; fax 309-438-5319.

International Mine Water Association Fourth Congress, September 25–30, 1991, Ljubljana, Yugoslavia. Information: Miron Veselic, S.P. Geoloski Zavod Ljubljana, Dimiceva 14, 61000 Ljubljana, Yugoslavia; fax 38 61 371 557.

New England Intercollegiate Geological Field Conference, September 28–30, 1991, Princeton, Maine. Information: Allan Ludman, Department of Geology, Queens College, 65-30 Kissena Blvd., Flushing, NY 11367-0904.

1991 American Association of Petroleum Geologists International Conference and Exhibition, September 29–October 2, 1991, London, England. Information: 1991 AAPG Inter-

national Conference, P.O. Box 979, Tulsa, OK 74101-0979.

Society of Organic Petrology 8th Annual Meeting, September 30–October 1, 1991, Lexington, Kentucky. Information: Jim Hower, Center for Applied Energy Research, 3572 Iron Works Pike, Lexington, KY 40511; (606) 257-0261; fax 606-257-0220.

October
Fifth International Congress on Pacific Neogene Stratigraphy and IGCP 246, October 6–10, 1991, Shizuoka, Japan. Information: V-CPNS-IGCP246 Organizing Committee, Geoscience Institute, Faculty of Science, Shizuoka University, Shizuoka 422, Japan; fax 81-542-37-9895.

Federation of Analytical Chemistry and Spectroscopy Societies and Pacific Conference on Chemistry and Spectroscopy, October 6–11, 1991, Anaheim, California. Information: FACSS, P.O. Box 278, Manhattan, KS 66502; (301) 846-4797.

Rocky Mountain Friends of the Pleistocene Annual Field Trip, October 11–13, 1991, Lake Bonneville, Utah. Information: Richard Van Horn, U.S. Geological Survey, Box 25046, MS 966, Denver, CO 80225.

International Symposium on Debris Flow and Flood Disaster Protection, October 14–20, 1991, Emeishan City, Sichuan Province, China. Information: Tong Yuling, International Research and Training Centre on Erosion and Sedimentation (IRTCS), P.O. Box 366, Beijing, China 100044; phone 8413372; telex 22786 ITCES CN; fax 8412539.

American Institute of Professional Geologists Annual Meeting, October 16–19, 1991, Gatlinburg, Tennessee. Information: Lawrence I. Benson, ERC/EDGE, P.O. Box 22879, Knoxville, TN 37933-0879; (615) 966-9761; fax 615-966-4155.

New York State Geological Association 63rd Annual Field Conference, October 18–20, 1991, Oneonta, New York. Information: James R. Ebert, Department of Earth Sciences, State University of New York, Oneonta, NY 13820-4015; (607) 431-3065; fax 607-431-2107.

International Symposium on Geological Hazards and Prevention, October 20–25, 1991, Beijing, People's Republic of China. Information: Chu Zhanchang, Secretariat, Organizing Committee, International Symposium on Geological Hazards and Prevention, 64, Funei St., Beijing, People's Republic of China; phone 658561-410.

Geological Society of America Annual Meeting, October 21–24, 1991, San Diego, California. Information: GSA, Meetings Dept., P.O. Box 9140, Boulder, CO 80301; (303) 447-2020; fax 303-447-1133.

Arbuckle Group Core Workshop and Field Trip, October 27–29, 1991, Norman, Oklahoma. Information: Kenneth S. Johnson, Oklahoma Geological Survey, University of Oklahoma, 100 East Boyd, Rm. N-131, Norman, OK 73019; (405) 325-3031.

Brazilian Geophysical Society Second International Congress, October 28–November 1, 1991, Salvador City, Bahia, Brazil. Information: Brazilian Geophysical Society—SBGf, Alberto Brum Novaes, Universidade Federal da Bahia/UFBA-PPPG, Rua Caetano Moura 123,

Federacão 40.210, Salvador BA, Brasil; phone 55-071-2370408. (*Abstracts deadline: May 31, 1991.*)

November
Hydrology and Hydrogeology in the '90s: Issues, Strategies and Technologies, November 3–7, 1991, Orlando, Florida. Information: AIH, 3416 University Ave. S.E., Minneapolis, MN 55414; (612) 379-1030.

5th International Circum-Pacific Terrane Conference, November 11–28, 1991, Santiago, Chile. Information: D. G. Howell, U.S. Geological Survey, MS 902, 345 Middlefield Rd., Menlo Park, CA 94025; (415) 329-5430.

Clean Seas 91, International Conference on Marine Pollution, November 19–22, 1991, Valletta, Malta. Information: Lesley Ann Sandbach, Project Manager, Clean Seas 91, The Spearhead Group, Rowe House, 55-59 Fife Road, Kingston upon Thames, Surrey KT1 1TA, UK; phone 081 549 5831 (intl: + 44-81-549-5831); telex 928042 SPEARS G; fax 081-541-5657 (intl: + 44-81-541-5657).

December
Mining Indonesia '91, December 4–7, 1991, Jakarta, Indonesia. Information: Eileen M. Lavine, Information Services, Inc., 4733 Bethesda Ave., #735, Bethesda, MD 20814; (301) 656-2942; fax 301-656-3179.

1991 Penrose Conference

October
Development and Evolution of Foreland Basins, October 6–11, 1991, Oliana, Spain. Information: James H. Meyers, Dept. of Geology, Winona State University, Winona, MN 55987; (507) 457-5266 (dir.), (507) 457-5000 (dept.), fax 507-457-5586; Douglas W. Burbank, Dept. of Geological Sciences, University of Southern California, Los Angeles, CA 90089-0740; Lee J. Suttner, Dept. of Geology, Indiana University, Bloomington, IN 47405; Cai Puigdefabregas, Dept. de Política Territorial, Servei Geològic de Catalunya, Diputació, 92, Se, 08015 Barcelona, Spain.

1992

February
First South Asia Geological Congress—GEOSAS-I, February 23–27, 1992, Islamabad, Pakistan. Information: Hilal A. Raza, GEOSAS-I Secretary General, Hydrocarbon Development Institute of Pakistan, 230-Nazimuddin Road, F-7/4, P.O. Box 1308, Islamabad, Pakistan; phone 9251-823690 or 821417; telex 5516 HJIP PK; fax 9251-828773.

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

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

June
American Association of Petroleum Geologists Annual Meeting, June 21–24,

1992, Calgary, Alberta, Canada. Information: George Eynon, General Chairman, Bow Valley Industries, Ltd., P.O. Box 6610, Postal Station D, Calgary, Alberta, T2P 3R7, Canada; (403) 261-6100; or AAPG Convention Department, P.O. Box 979, Tulsa, OK 74101; (918) 584-2555.

Interpraevent 1992—Protection of Habitat against Floods, Debris Flows and Avalanches, June 29–July 3, 1992, Berne, Switzerland. Information: Interpraevent 1992, c/o Bundesamt für Wasserwirtschaft, Federal Office for Water Management, Postfach 2743, CH-3001 Berne, Switzerland.

July
7th International Symposium on Water-Rock Interaction, July 13–22, 1992, Park City, Utah. Information: Yousif Kharaka, Secretary-General, U.S. Geological Survey, MS 427, 345 Middlefield Road, Menlo Park, CA 94025; (415) 329-4535; fax 415-329-5110.

August
29th International Geological Congress, August 24–September 3, 1992, Kyoto, Japan. Information: Secretary General, IGC-92 Office, P.O. Box 65, Tsukuba, Ibaraki 305, Japan; phone 81-298-54-3627; fax 81-298-54-3629; telex 3652511 GSJ J.

September
4th International Conference on Paleogeography, September 21–25, 1992, Kiel, Federal Republic of Germany. Information: ICP IV Organizing Committee c/o GEOMAR, Wischhofstrasse 1-3/Bldg. 4, D-2300 Kiel 14, Germany.

American Institute of Professional Geologists Annual Meeting, September 27–October 1, 1992, Lake Tahoe, Nevada. Information: Jon Price, AIPG, P.O. Box 665, Carson City, NV 89702; (702) 784-6691.

October
Geological Society of America Annual Meeting, October 26–29, 1992, Cincinnati, Ohio. Information: GSA, Meetings Dept., P.O. Box 9140, Boulder, CO 80301; (303) 447-2020; fax 303-447-1133.

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The Geological Society of America

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Are You a 1991 Winner?

Six persons have won free professional registration to the GSA Annual Meeting in San Diego—a value of \$130 each. They were selected from a random drawing of those responding to the 1991 San Diego Annual Meeting Local Committee Survey. (It appeared in the November issue of *GSA News & Information*, and focused on travel and lodging plans.) Thanks to the 383 people who responded, the results have already been put to good use by the San Diego group. There will be other opportunities for winning registrations, GSA products, or even round-trip airfares for two. Stay tuned!

Congratulations to:

- David Best, Northern Arizona University
- R. Laurence Davis, New Hampshire Department of Environment Services
- Arthur Mirsky, Indiana University-Purdue University
- Bernard Pipkin, University of Southern California
- Alexander Schriener, Jr., UNOCAL—Geothermal Division
- Holly Stein, USGS, Denver

GSA ANNUAL MEETINGS

■ 1991

**GSA Annual Meeting, San Diego, California
October 21-24**

General Chair:
R. Gordon Gastil, Dept. of Geological Sciences,
San Diego State University, San Diego, CA 92182



■ 1992

**GSA Annual Meeting, Cincinnati, Ohio
October 26-29**

Call for field trip proposals:
Send proposals to Thomas M. Berg, State Geologist and Chief, Division of Geological Survey, Ohio Dept. of Natural Resources, Fountain Square, Columbus, OH 43224; (614) 265-6605

■ FUTURE

- San Diego October 21-24 1991
- Cincinnati October 26-29 1992
- Boston October 25-28 1993
- Seattle October 24-27 1994
- New Orleans November 6-9 1995

For general information on technical program participation (1991 or beyond) contact: Sue Beggs, Meetings Manager, GSA headquarters.

GSA SECTION MEETINGS

■ 1991

**North-Central
University of Toledo, Toledo, Ohio, April 18-19**

Lon Ruedisili or Mark Camp, Dept. of Geology, University of Toledo, Toledo, OH 43606; (419) 537-2009

**Rocky Mountain-South-Central
University of New Mexico, Albuquerque, New Mexico, April 22-24**

G. Randy Keller, Dept. of Geological Sciences, University of Texas at El Paso, El Paso, TX 79968-0555; (915) 747-5501
or John Geissman or Wolfgang Elston, Dept. of Geology, University of New Mexico, Albuquerque, NM 87131; (505) 277-4204

Foundation to Fund Matching Student-Travel Grants

The GSA Foundation will award matching grants up to a total of \$3000 each to the six GSA Sections. The money, when combined with equal funds from the Sections, will be used to assist students traveling to the 1991 Section Meetings and the GSA Annual Meeting in San Diego.

Travel grants will be awarded and administered by the Sections, whose officers should be contacted for further information.

Forum

- 405 Pennsylvanian time scales and cycle periods
Comment: Ralph L. Langenheim, Jr.
Reply: George deV. Klein
Comment: Philip H. Heckel
Reply: George deV. Klein
Comment: Poppe L. de Boer
Reply: George deV. Klein

Comment: Charles A. Sandberg, Raymond C. Gutschick, Morris S. Petersen, Forrest G. Poole, Willi Ziegler
Reply: K. M. Nichols, N. J. Silberling

- 413 Probable influence of early Carboniferous (Tournaisian-early Viséan) geography on the development of Waulsortian and Waulsortian-like mounds
Comment: V. P. Wright
Reply: David T. King, Jr.

- 415 Letter
- 415 Correction

data from the Chapel Island Formation, as the pale-colored rocks were remagnetized during Paleozoic deformation (Kirschvink, 1979).

Of all the areas currently under consideration for the Precambrian/Cambrian boundary stratotype, the sections on the Siberian platform are clearly the best. Tectonically, they are less deformed than either the Chinese or Newfoundland sections, and the carbon and magnetic stratigraphies work reliably for local, regional, and intercontinental correlation. In particular, the $\delta^{13}\text{C}$ pattern is quite distinctive and shows that the sequences are free of major stratigraphic breaks for an interval of at least 300 m (ca. 30 m.y.) around the boundary horizon. However, in comparing the two major sections on the Aldan River, Ulakhan-Sulugur and Dvortsy, it appears that the Dvortsy locality has a better record of the $\delta^{13}\text{C}$ drop at the critical horizon (top of cycle I) than does Ulakhan-Sulugur. Thus, some of the authors of this paper feel that Dvortsy, rather than the official Soviet candidate, Ulakhan-Sulugur, should be considered seriously for the stratotype section.

We take this opportunity to suggest another possible candidate for the Precambrian/Cambrian stratotype which is not actively being considered by the IUGS working group, but perhaps should be. Recent work on the thick sequence of shallow-water carbonates in the Anti-Atlas Mountains of Morocco has located precisely positions for both the Tommotian/Atdabanian and Vendian/Tommotian boundaries (this paper; Latham and Riding, 1990; Ripperdan, 1990). The section near the village of Tiout has deposition rates five times greater than those on the Siberian platform, this section contains at least trace fossils (Latham and Riding, 1990) and perhaps small shelly fossils near the base of the Lie de Vin formation (B. Daily, 1976, personal communication). Both carbon isotope and magnetic stratigraphies have been obtained from the sequence (Tucker, 1986; Ripperdan, 1990; this paper). Finally, the Moroccan sequence contains occasional volcanic tuff horizons, at least one of which has yielded typical magmatic zircons that have been dated by means of U/Pb techniques, thereby yielding the first stratigraphically bound age estimate for the Tommotian/Atdabanian boundary (521 ± 4 Ma, Compston et al., 1990). The sequence seems to have something for everyone, and thus should be studied as intensively as have the other candidate sections for the boundary stratotype.

ACKNOWLEDGMENTS

Supported by National Science Foundation Grants EAR-8721391 and PYI-8351370. We thank Stanley Awramik for additional samples from

the Lie de Vin formation of Morocco; Andrew Latham, Robert Riding, Michael Purucker, A. Faure-Muret, and the late George Choubert for assistance in the field sampling in Morocco; R. Selnikov and Z. Pearl for mass spectrometric measurements; and K. Bijan for X-ray determinations. This work is a contribution to International Geological Correlation Program Projects 216 (Global Bio-events) and 303 (Event Stratigraphy of the Precambrian-Cambrian Boundary). California Institute of Technology Division of Geological and Planetary Sciences Contribution 4880.

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Luo Huilin, Jiang Zhiwen, Wu Xiche, Song Xualiang, Ouyang Lin, Xing Yusheng, Liu Guizhi, Zhang Shishan, and Tao Yonghe, 1984, Sinian-Cambrian boundary stratotype section at Meishucun, Jinning, Yunnan, China: Yunnan, China, People's Publishing House, 265 p. (in Chinese).

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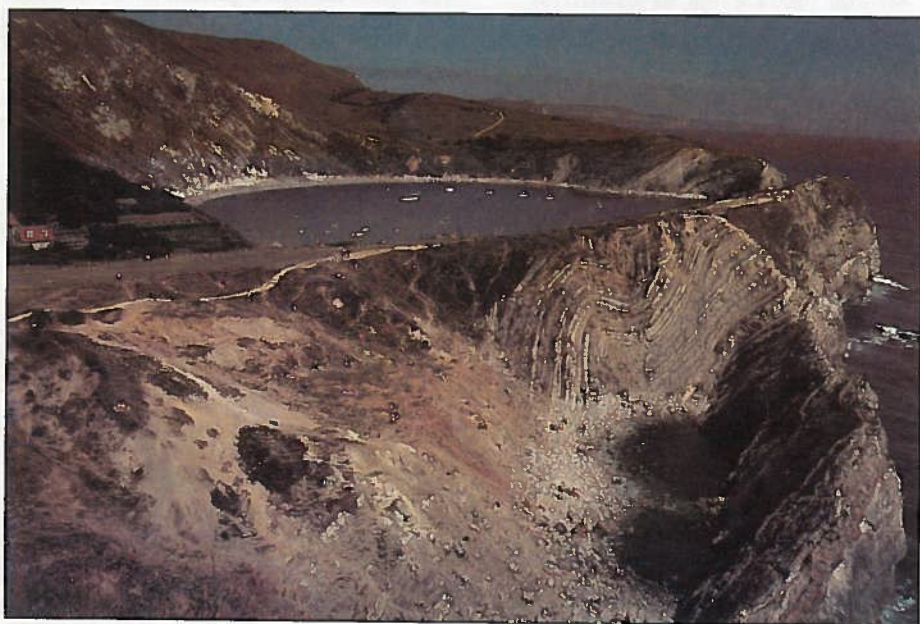
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The Indo-U.S. Subcommittee on Education and Culture is offering twelve long-term (6-10 months) and nine short-term (2-3 months) awards for 1992-1993 research in India. Applicants must be U.S. citizens and hold the Ph.D. or comparable professional qualifications. The fellowship program seeks to open new channels of communication between academic and professional groups in the United States and India and to encourage a wider range of research activity between the two countries than now exists. Scholars and professionals with limited or no prior experience in India are especially

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Application deadline is June 15, 1991. Application forms and further information are available from the Council for International Exchange of Scholars, Attn: Indo-American Fellowship Program, 3007 Tilden Street, N.W., Suite 5M, Washington, DC 20008-3009, telephone (202) 686-4017.



Great Britain GeoTrip: Lulworth Cove in the Hampshire Basin of south-central England. Photo by Dottie Stout

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**Planning to visit the West this year?
Join us in June for GSA's FIRST GeoHostel**

GeoHostel is a learning experience for geologists. It is site-specific with a combination of classroom and field experiences which start from the same location each day. A GeoHostel is held for five to seven days at a destination that is rich in geological interest as well as plentiful in opportunities for side excursions.

GeoHostels offer:

- an enjoyable experience with an educational focus on topics appealing to a wide range of geologists and their guests
- ample free time to enjoy the special environmental and cultural aspects of the location
- leadership by enthusiastic, well-organized geologists who can speak well and who can cover the topics at a level appropriate for the professional non-expert.

Colorado GeoHostel Program

**Colorado School of Mines, Golden, Colorado
Five Days: Sunday, June 23–Thursday, June 27**

Scientific Leaders:
*Kenneth E. Kolm and Gregory S. Holden
Colorado School of Mines*

Colorado School of Mines is set in the foothills of the Colorado Rockies and is conveniently located between Denver and Boulder. June will be a wonderful time to visit Colorado and the spectacular high country of the Rockies.

GH91A Evolution of Geologic Landscapes in the Colorado Rockies, 8:00–9:30 a.m.

GH91B Environmental and Engineering Issues in Colorado, 9:30–11:00 a.m.

These two geology classes will be offered each morning and include local field trips. They are meant for professional geologists who are not experts in this area, but anyone may attend. A person may take one or both classes.

GH2B Old Mining Towns of the Rockies, 9:30–11:00 a.m.

Also offered, primarily for the nongeologist, is a fascinating class on Colorado's mining towns. This class will include at least one full-day trip to visit several mining towns. Persons registering in this class will not be able to take either of the geology classes.

Registration

Minimum age: 21 years. No other limits.

Program

Saturday, June 22: Welcoming Get-together
Sunday, June 23 through Wednesday, June 26: Morning Classes
Thursday, June 27: Full Day Field Excursion and Farewell Party

Fees and Deposit

GeoHostel cost: \$350 (nonmembers and guests)

Special discount rate for GSA members: \$325

Fee includes classroom programs and materials, field excursions, lodging (double occupancy), breakfast, welcoming and farewell events.

Not included are transportation to and from Colorado, transportation during nonclass hours, meals or other expenses not specifically included.

Call today. The full amount is due with your reservation, and is payable by credit card or check. The amount is 50% refundable through May 15, but non-refundable thereafter.

GSA GeoTrips

GT912

Great Britain's Classic Geologic Sites
6 SPACES STILL OPEN AS WE GO TO PRINT. CALL ASAP.

Co-sponsored by NAGT
21 days: Saturday, June 15–Saturday, July 6

Scientific Leaders:
*Donald McIntyre, Pomona College
Ron Roberts, Geological Museum of London
D. H. Tarling, Plymouth Polytechnic Southwest*

This adventure is being coordinated by NAGT President Dorothy (Dottie) Stout, Cypress College, California, who has had abundant experience with geologic trips to our sites in Great Britain, Wales, and Scotland. The itinerary includes visits to the following geologically and historically colorful places: London, Chalk Cliffs, Lyme Regis, Sidmouth, Cornwall, Stonehenge, Bath, Isle of Arran, Parallel Roads of Glenroy, Hadrian's Wall, Great Glen Fault, Torridonians, Moine Thrust, Siccar Point, Edinburgh, and Newcastle-upon-Tyne. Full details available from GSA GeoVentures Coordinator.

Registration

Fee includes double-occupancy lodging, ground transportation, all breakfasts plus 15 dinners and a farewell fête, entry fees, and theater tickets.
Airfare not included.

Open to all geologists and their friends.
GSA and NAGT members will enjoy a \$100 special discount.
Minimum age: 21 years. Trip limit: 30 persons.

Fees and Deposit

(Late registration period began March 1)

Cost: \$3190 (based on 25-person minimum)
Special for GSA and NAGT Members: \$3090

Acknowledging the sensitive travel situation overseas, due to the conflict in the Persian Gulf, our ground suppliers in Great Britain have generously agreed to a lenient cancellation policy. As a result, fees are 50% refundable up to 35 days prior to departure: May 10. (60 days is the usual cut-off time.)

Airlines are also more lenient about cancellation penalties, so please check with our official travel agent for this trip. She will have information about the airlines as well as details about the itinerary.

Jodi Page, CAN-AM TOURS
1560 Superior Ave., Suite A2
Costa Mesa, CA 92627-3653

1-800-367-9917 • (714) 645-7171 • fax (714) 645-7464
8:30 a.m. to 5:30 p.m., Monday–Friday, PST

GT913

Grand Canyon Adventure

FILLED.

An educational adventure: rafting, hiking, and camping
Sunday, July 14–Monday, July 22

Scientific Leaders:
*George H. Billingsley, USGS, Flagstaff
William K. (Ken) Hamblin, Brigham Young University*

GEOVENTURES REGISTRATION

REGISTER TODAY! CALL GSA GEOVENTURES

(Please have your credit card ready)

1-800-472-1988 or (303) 447-2020

Questions welcomed anytime

Non-U.S.-based registrants are encouraged to use
GSA's fax number: 303-447-1133
Give name(s), address, phone, GeoVenture title,
and credit card number