Vol. 4, No. 5 May 1994

GSA TODAY

A Publication of the Geological Society of America

INSIDE

Near–Real-Time Seismology: Rapid Analysis of Earthquake Faulting

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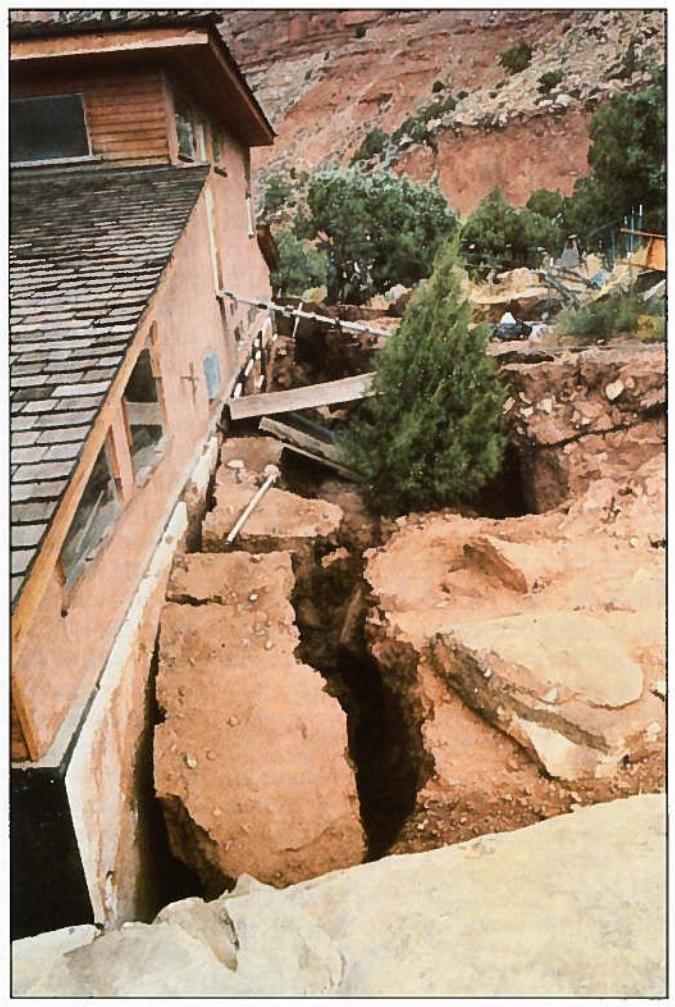

Landslide damage in southern Utah caused by the St. George, Utah, earthquake. Photo courtesy of Gary Christenson, Utah Geological Survey.

ABSTRACT

Recordings of seismic waves generated during an earthquake contain information about the energy release, fault orientation, and slip distribution on the fault. Recent technological advances in seismology enable immediate access to seismograms recorded at globally distributed seismographic stations. The availability of these data allows rapid determination of earthquake source parameters for significant events anywhere in the world from within a few minutes to a few hours after the event—a practice now being widely implemented. Using several methods, we demonstrate the ability to determine an earthquake point-source model in near real time for the St. George, Utah, earthquake of September 2, 1992 (moment magnitude M_w = 5.6). Identification of the actual fault plane and determination of slip distribution in near real time is demonstrated for the M_w = 7.3 Landers, southern California, earthquake of June 28, 1992, using a nearby small event to correct for propagation effects. Availability of quantitative faulting information soon after an event can assist emergency response activities, lend guidance to field deployments following the event, and provide a rapid assessment of the tectonic processes involved and the ensuing hazards posed by future earthquakes.

INTRODUCTION: EMERGENCE OF A NEW SEISMOLOGICAL CAPABILITY

During the past two decades, seismologists have developed a broad suite of methods for analyzing ground-motion recordings produced by earthquake faulting (e.g., Aki and Richards, 1980). Analysis of these seismograms provides fundamental information about the source process, including the location, origin time, fault orientation, style of faulting, and slip distribution on the fault. Those characteristics involving only the overall geometry and temporal history of the rupture are represented in a point-source model of the event, typically as a double-couple or moment tensor representation (equivalent force systems associated with the shear dislocation). Finite-source models include the spatial slip characteristics of the faulting and require specification of the actual fault surface, thus eliminating the ambiguity of the two possible fault orientations intrinsic in point-source earthquake models. Recordings of body waves (P and S waves) and surface waves (Rayleigh and Love waves) at different distances are processed to determine a source model. Variations in wavefield complexity as a function of distance and wave period have led to development of diverse inversion procedures that exploit separate portions of the seismograms in different period ranges. Many earthquake studies are regularly conducted to develop an understanding of faulting, but these studies typically take months to complete.

As earthquake faulting is a transient process, often having serious consequences for society, it is desirable to have quantitative information about the source process as quickly as possible.

Seismology *continued on p. 132*

Donald M. Davidson, Jr., Named New Executive Director of GSA

Keeping in mind that the Executive Director of GSA must be an earth scientist with managerial experience, be familiar with GSA programs, and have a knowledge of the publication business, the Executive Director Search Committee selected Donald M. Davidson, Jr., to replace F. Michael Wahl, who will retire in June after 12 years of service. Davidson will assume his new duties at GSA headquarters in Boulder, Colorado, on July 1, 1994.

For the past four years, Davidson has been Assistant Provost for Resource Planning, Northern Illinois University, De Kalb, where he is responsible for the administration of an $84 million budget, space allocation, new building construction, remodeling, and strategic planning within the Academic Affairs Division. In addition, he oversees the operations of Cooperative Education, Media Services, the Lorado Taft Outdoor Education Campus, and the Northern Illinois University Hoffman Estates Education Center. Immediately prior to his present position, he was chair and professor of the Department of Geology.

He has held positions as chair and professor, Department of Geological Sciences, University of Texas at El Paso, and professor, Department of Geology, University of Minnesota at Duluth. Outside of academe, he supervised a multidisciplinary research group as senior research specialist and group leader, Satellite Imagery Section, Exxon Production Research, Houston, Texas. He also spent several summers as a consultant involved in metallic and nonmetallic deposit exploration and as a staff geologist mapping for the Minnesota Geological Survey.

Davidson became a GSA member in 1964 while working on his Ph.D. at Columbia University. In 1980 he was elected to Fellowship. He has served the GSA North-Central Section as treasurer for the 1985 Section Meeting, as chair of the Student Awards Committee, and as a member of the Education Committee at the section level. Most recently he has served as a SAGE liaison volunteer.

For the past eight years, Davidson has been treasurer of the Society of Economic Geologists, the SEG Foundation, and the Economic Geology Publishing Company. He previously held the position of Business Manager for the Economic Geology Publishing Company, which publishes the journal *Economic Geology*. In his spare time he has served as a reviewer of grant proposals for the National Science Foundation and National Research Council of Canada, as well as reviewing several geology and mining geology programs.

Davidson received his undergraduate degree from Carleton College, Northfield, Minnesota, and earned his graduate degrees at Columbia University, New York. His areas of professional interest are in resource geology, structural geology, Precambrian geology, and remote sensing. His recent work has focused primarily on strategic planning, space allocation analysis, and financial projections.

Davidson, who is 54, and his wife Mary have two sons. The older son, Rob, will pursue a graduate degree in creative writing following a two-year Peace Corps assignment with his wife. Mark, a third-generation geologist, is studying for a master's degree in geophysics at Purdue University, Indiana.

The five-member Executive Director Search Committee, chaired by GSA Vice-President Dave Stephenson, screened applications and interviewed finalists in January. ■

IN THIS ISSUE

GSA TODAY
Vol. 4, No. 5 *May 1994*

GSA TODAY (ISSN 1052-5173) is published monthly by The Geological Society of America, Inc., with offices at 3300 Penrose Place, Boulder, Colorado. Mailing address: P.O. Box 9140, Boulder, CO 80301-9140, U.S.A. Second-class postage paid at Boulder, Colorado, and at additional mailing offices. **Postmaster**: Send address changes to *GSA Today*, Membership Services, P.O. Box 9140, Boulder, CO 80301-9140.

SUBSCRIPTIONS for 1994 calendar year: **Society Members**: *GSA Today* is provided as part of membership dues. Contact Membership Services at (800) 472-1988 or (303) 447-2020 for membership information. **Nonmembers & Institutions**: Free with paid subscription to both *GSA Bulletin* and *Geology*, otherwise $40 for U.S., Canada, and Mexico; $50 elsewhere. Contact Subscription Services (same phones). **Single copies** may be requested from Publication Sales. Also available on an annual CD-ROM, with *GSA Bulletin*, *Geology*, and *GSA Data Repository*, and in an annual, hardbound, library edition; call Membership Services for prices. **Claims**: For nonreceipt or for damaged copies, members contact Membership Services; all others contact Subscription Services. Claims are honored for one year; please allow sufficient delivery time for overseas copies.

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Printed with pure soy inks in the U.S.A.

WASHINGTON REPORT

Bruce F. Molnia

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

Science and Technology in the President's Fiscal Year 1995 Budget

Although Fiscal Year 1995 (FY95) does not start for five months, the budget process is well under way. In February, the Office of Management and Budget released the President's proposed FY95 budget. In all, two volumes and more than 1300 pages are needed to present the budget's details. Formally titled "Budget of the United States Government, Fiscal Year 1995," the volumes detail proposed outlays of $1.5183 trillion and receipts of $1.3422 trillion. As proposed, the President's budget will have a deficit of $176.1 billion, the smallest deficit in a number of years. One key element in the proposed budget is a decline in discretionary outlays from $550.1 billion in FY94 to $542.4 billion, resulting in cuts in 379 of 636 budget accounts detailed in the formal documents.

Between now and September or October, when the final version of the FY95 budget is passed by Congress and signed by the President, there may be significant changes in the final composition of the FY95 budget. (See the Washington Report in October 1993 *GSA Today* for a discussion of the complex budget process.) Yet, it is not too early to examine the composition of the President's FY95 budget and to ask: (1) Where does all the money go? and (2) Where does science and technology, especially earth science, fit into the result?

The first question is relatively easy to answer. Ninety-five percent of the proposed budget would go to: direct benefit payments for individuals (48%), national defense (18%), grants to states and localities (15%), and net interest payments (14%). The answer to the second question is locked up in the details of the other 5% and requires a thorough analysis of the President's budget.

Pages 116–122 of the President's budget are a section titled "Investing in Know How—Science and Technology." Under the heading "S&T Highlights" three key areas provide specific information.

First, in "Research and Development (R&D) Investments," a description is provided of the Administration's proposed FY95 R&D funding totaling $71.03 billion, excluding facilities. This represents a $2.54 billion (4%) increase over FY94. (Proposed facilities total $2.02 billion.) Civilian R&D is proposed to increase more than $1.15 billion (4%) to $31.5 billion. Defense R&D would total $39.53 billion. By 1998 civilian R&D is projected to exceed 50% of the total federal R&D budget. Much of the anticipated increase would be focused on "cost-shared and competitively selected projects that are industry-defined and industry-led." University-based research would increase $437 million (4%) to $12 billion in FY95.

Second, with respect to "Research Grant Overhead Payments," the Federal Government proposes a one year moratorium, instructing grantee institutions not to request any increases in overhead above the amounts claimed in FY94. Of the more than $17 billion awarded to universities and other nonprofit institutions, more than $3 billion (17.6%) is overhead. The moratorium will permit the federal government "to conduct a comprehensive review with the goal of improving the incentives that govern overhead reimbursement for a wide range of federal research grantees and contractors."

Third is a discussion of the National Science and Technology Council (described in detail in the Washington Report in March 1994 *GSA Today*). Although no FY95 budget requests are presented for the council, the statement is made that the council "will ensure that taxpayers receive the maximum benefit for their investment." The council "will spend the next year examining how to improve the integration of S&T activities in a broad range of areas, including information technology, manufacturing, health, environment, fundamental science, and education. This more comprehensive review process should be ready for the 1996 budget."

Under the heading "Putting S&T to Work for America's Future," two areas receive special attention: First, a special effort is being made to expand cost-shared R&D partnerships and technology transfer through the use and development of formal cooperative research and development agreements (CREDAs). There will be more than 3200 CREDAs operational in FY95, a 453 (16%) increase over FY94. CREDAs will include public and private cash and services investments exceeding $1.5 billion. In FY95, it is proposed that the federal agencies would invest $865 million in technology transfer activities. This would represent a $314 million (57%) increase over FY94. Second, R&D activities of the Department of Commerce's National Institute for Standards and Technology (NIST) would be substantially expanded. The budget of NIST's Advanced Technology Program (ATP) would more than double, to $451 million in FY95. About 200 ATP projects are scheduled to operate in FY95. Examples of areas receiving support are biotechnology, environmental technology, and math and science postdoctoral education.

Elsewhere in the proposed budget, the following S&T information can be found.

The budget for the U.S. Global Change Research Program (USGCRP) would increase $348 million (24%), from $1.446 billion in FY94 to $1.794 billion. The largest beneficiary of this increase would be the National Aeronautics and Space Administration's (NASA) Mission to Planet Earth. NASA would receive $214 million (61.5%) of the new funding. NASA's FY95 USGCRP budget would be $1.236 billion or 68.9% of the total program. Significant increases proposed in the global change budgets of other agencies include: National Science Foundation (NSF)—$66 million (46% increase over existing budget), Department of Energy (DOE)—$33 million (35%), Department of Commerce—$21 million (34%), Department of Agriculture—$8 million (19%), and Environmental Protection Agency (EPA)—$4 million (14%). The proposed FY95 global change budget for the Department of Interior would be reduced by 1%.

The proposed FY95 budget for the NSF is $3.2 billion, a $182 million (6%) increase over FY94. The Directorate for Geosciences budget would increase to $443.09 million from its FY94 level of $403.90 million. Similarly, the U.S. Polar Research Program would increase to $162.83 million from $158.50 million, while the proposed budget for U.S. Antarctic Logistics Support Activities would remain constant at $62.60 million.

NASA's proposed FY95 budget is $14.3 billion, down about 2% from FY94's appropriation of $14.5 billion. The proposed FY95 budget includes $2.12 billion for the redesigned international space station and for Russian participation. This represents only a $17 million increase in the program. The proposed budget for the second year of NASA's New Technology Investments program is $67 million, a $25 million (60%) increase from the first year.

The proposed EPA budget is $7.2 billion, up 8% from the FY94 budget of $6.624 billion. DOE's proposed FY95 budget is $18.5 billion, down about 3% from the FY94 budget of $19.0 billion. The National Oceanic and Atmospheric Administration's proposed FY95 budget is $1.96 billion, down about 3% from the FY94 budget of $2.0 billion.

The proposed budget for the U.S. Geological Survey (USGS) includes a modest decrease of $974,000 from the FY94 level of $584.731 million to $583.757 million. The line item showing the greatest proposed increase is the new Critical Ecosystem Research and Assessment activity, with a budget of $11.83 million for FY95. Eight million dollars of this proposed activity is slated for "ecosystem restoration in South Florida." A future Washington Report will examine the details of the FY95 appropriated USGS budget. ■

About People

GSA Fellow **Gordon Eaton** has been sworn in as the head of the U.S. Geological Survey and will serve, in Washington, D.C., as the twelfth director.

Member **Margaret Goud Collins,** former GSA Congressional Science Fellow, has been appointed special assistant to NOAA Chief Scientist (and GSA member) **Kathryn Sullivan.**

Newly elected SEPM officers include GSA Member **Noel James,** Queen's University, Kingston, Ontario, president; Fellow **Léo Laporte,** University of California, Santa Cruz, president-elect; Member **Steven Driese,** University of Tennessee, Knoxville, secretary/treasurer; and Fellow **Michael Arthur,** Pennsylvania State University, University Park, research councilor.

Fellow **Eldridge M. Moores,** University of California, Davis, is the first recipient of the Geological Association of Canada Medal.

Robert L. Fuchs

Challenge Grant from Boettcher Foundation

The Boettcher Foundation of Denver, Colorado, has given the GSA Foundation a challenge grant in the amount of $132,000, to be used to meet certain capital equipment needs of SAGE and the Publications Department. Also, the funds will be used to purchase components of the expanded GSA network system being installed as part of the Boulder headquarters building addition.

The Boettcher Foundation is in its 57th year, having been created in December 1937 as a corporation for charitable and benevolent purposes in Colorado. The initial capital was contributed by the descendants of Charles Boettcher, a German immigrant to Colorado in the mid-19th century who from a single hardware store created a large financial empire in the Rocky Mountain region. The assets of the Boettcher Foundation are now in excess of $150 million, and in 1993 grants totalling $7.1 million were made to Colorado organizations in education (43%), hospital and health services (9%), civic and cultural programs (28%), and community and social services (20%). The majority of Boettcher Foundation grants are for capital projects and are generally made in the form of challenges.

Under the terms of the award, GSA is required to raise the matching amount of $132,000 to complete the planned purchase of capital items. These include equipment for the SAGE technology training facility, a state-of-the-art center for classroom training of K–16 teachers, earth science educators, scientists, and consultants. Publications Department equipment will provide urgently needed upgrades in the prepress production of the three monthly periodicals plus *Abstracts with Programs*, GSA memorials, and dozens of ancillary print items. In addition, the equipment and software will be obtained to handle electronic acceptance of abstract submissions. Finally, the completion of the headquarters addition has added 39 office spaces, requiring a major increase in computer equipment to network fully and most efficiently the entire headquarters staff. Needed are printers, servers, control for uninterrupted power supply, tape backup systems, and the necessary software to connect users to scheduling and mail systems.

The Boettcher grant is part of GSA's Second Century Fund for Earth-Education-Environment. Fund Chair and former GSA President R. W. Bromery expressed appreciation for this gift, and said, "The recognition by the Boettcher Foundation through this challenge grant of GSA's leadership role in earth science provides an important stimulus to the Second Century Fund. I anticipate a prompt response to this challenge from supporters of GSA, both members and other organizations who have indicated their interest in the Society."

What On Earth Is Going On?

WHEN an earthquake cracks the early morning stillness of a remote island in the Pacific or a densely populated area of western North America, the first scientist commenting on the event on television screens across the United States often is Waverly Person. A geophysicist at the Golden, Colorado, National Earthquake Information Center, Person exemplifies the vital role played by earth scientists in public awareness. Often, his voice is the first voice of reason that begins to clear away the confusion and calm the panic that attends these natural catastrophes.

WHERE will the money come from to keep insurance companies solvent and coastal homeowners safely housed if predictions of rising sea levels, as in the mid-March issue of a national news weekly, are borne out? The rate of rise is reported to be accelerating on the Atlantic coast of North America, from one foot in the past 100 years to six inches predicted in the next 20. Insured property along the coastline from the North Atlantic to Mexico carries a value of $2 trillion; catastrophic reserves of the insurance industry total only $160 billion. On the other hand, is this projection of rising sea levels based on sound reasoning and good geology? Our science can provide the voice of reason, based on the study of paleoclimates and global change, a message that we hope will be heeded before the insurance industry commits actuarial suicide while builders squeeze the last homesite out of the last offshore bar.

WHAT is the long-term outlook for our raw-material supply, as the population of Earth increases exponentially? Rising standards of living plus more people mean increasing demands for food, lumber, metals, industrial minerals, and energy. These substances originate in the earth; some are renewable, some not. Even renewable commodities may deplete soils through nutrient loss and erosion. Geology's leading role in finding and developing many of these commodities has been recast. Earth science today must be more efficient in its discovery of minerals and energy, as more is needed but there is less to be found. Production of raw materials must also be accompanied by a reasonable concern for the surroundings—land, ground water, surface water, vegetation, and animal habitat. The importance of the geologist to our standard of living increases with population growth.

HOW can we be assured that there will be sufficient and adequate geological talent to deal with this expanding list of natural and human-made problems facing Earth's inhabitants? By developing the interest of young people in science and encouraging them to choose careers in science. Curiosity about Earth begins early in life and, with proper motivation in the schools, can broaden into a lifelong interest in and respect for our planet. Motivated and well-trained geologists can most effectively deal with problems related to earth science and bring reason and an understanding of these problems to the entire community.

WHICH organization can most effectively support and enhance geological science? The Geological Society of America has done just this, for 106 years. As new scientific directions have arisen, GSA has moved in those directions. Public awareness, education, and environmental studies through SAGE and IEE have an expanding role in the Society's activities. The 62-year-old program of student research grants has reached new levels of participation and funding. Publications and meetings continue to be the fundamental building blocks of GSA's service to the science. The Congressional Science Fellow program has been highly successful, bringing good science and a voice of reason into the halls of government, where they are desperately needed.

WHO does GSA rely on for funding? Foundations, companies, and government all make significant contributions to the Society. Most important, however, are the funds received from GSA members like you. Thousands of member gifts make GSA programs possible. Please send yours today along with the accompanying coupon.

Dreiss Memorial Fund Supports Lecturers

A Hydrogeology Division distinguished lecturer has been honored by the creation of a new Foundation fund to support the lecture series. The Management Board of the Hydrogeology Division recently approved the Dreiss Memorial Fund, named for Shirley J. Dreiss, the University of California, Santa Cruz, professor and former USGS geologist who was killed in an automobile accident in December 1993.

Income from the fund will be used to pay part of the expenses of the Division's Birdsall lecture series, and in recognition of that funding the series will henceforth be called the Birdsall–Dreiss Distinguished Lecturer Series. Surplus income in any year will be used for scholarships and research grants under the auspices of the Division.

Shirley's reflections following her 1992 lecture tour provide appropriate commentary on her feelings about hydrogeology: "As the Birdsall Lecturer ... I was struck by the variety and vitality of the programs that I visited. Much of the variety stems from the fact that most hydrogeology groups are relatively small, so programs very much reflect the interests and expertise of individuals. Undoubtedly a good bit of the variety also results from the fact that hydrogeology is still a young field with diverse, wide-open research areas. We as hydrogeologists are in the enviable situation of 'over choice' with respect to research directions. In what other single field can researchers work on such diverse topics as microbial transport and bioremediation in porous media, ore genesis, or wetland ecology? I find myself thinking of these programs as a suite of good restaurants with specialties reflecting the flair of individual chefs and regional influences. So, for example, the menu featuring interaction of surface and ground waters has excellent programs in unsaturated-zone hydrogeology in the Southwest and in interaction of lake and ground waters in the northern Midwest....Water is an essential, economically important natural resource that certainly does not deserve less prestige within the geologic profession than mineral and petroleum resources."

Friends and colleagues of Shirley Dreiss are invited to honor her work and life by contributing to the Dreiss Memorial Fund. The attached coupon may be used to send gifts to the GSA Foundation. ■

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Seismology *continued from p. 129*

For more than a decade, regional and global earthquake monitoring systems have been developing automation capabilities for rapid determination of source locations and magnitudes of earthquakes worldwide. Primarily, these capabilities exploit telemetry of seismic recordings to central facilities where automatic event detection and location algorithms are running continuously (Lee, 1981). Most of the monitoring instrumentation in such systems has usually recorded a narrow range of high-frequency ground motions that provide good time resolution for accurate event location but are not well suited to characterizing other source parameters.

Globally distributed networks of seismic stations with more complete ground-motion recordings have existed for several decades, but the data were not generally available for significant lengths of time—up to months—after an event. An ongoing upgrade of global international seismic systems, exploiting technological developments for both extremely broad band ground-motion sensitivity and high-dynamic-range recording systems, has been accompanied by improvements in rapid access to the globally distributed data (Romanowicz et al., 1991; Boschi et al., 1991; Incorporated Research Institutions for Seismology [IRIS], 1992). This has involved primarily telephone dial-up access, where specific time windows of ground-motion recordings can be remotely retrieved from the site (IRIS, 1992) Additional broad-band stations, such as those in the Berkeley Digital Seismic Network, have continuous telemetry to regional monitoring centers. By linking global monitoring operations, which determine initial earthquake locations and approximate magnitudes, to automated dial-up data-retrieval systems, both regional and global seismic recordings can be obtained soon after an earthquake occurs, typically within the few minutes to few hours that it takes for all primary body waves and surface waves to travel to regional and global stations, respectively.

Using these new capabilities, high-quality broad-band seismic data are assembled in near real time and made generally available on-line via Internet computer connections at major seismic data centers such as the Incorporated Research Institutions Data Management Center (IRIS-DMC); the Caltech TERRAscope Data Center, the Berkeley Digital Seismic Network (BDSN) Data Center, and the University of Tokyo pre-POSEIDON Data Center. This immediate access to global and regional data sets suitable for waveform inversion enables rapid quantification of important earthquake source parameters as well as prompt investigation of unusual sources, such as volcanic eruptions.

Inversion of rapidly retrieved global seismic data can also be automated, but this requires careful assessment of the resolution and reliability of various procedures, particularly given the limited numbers of signals available in real time. Each of the seismic wave analysis procedures has limitations and advantages for resolving distinct source attributes. Since earthquakes of all sizes and locations, with various data availability, are of interest, a wide variety of seismic analysis techniques is warranted. Some methods exploit signals from a single station, others require at least several regional observations, and yet others utilize global coverage (e.g., Ekström et al., 1986; Ekström, 1993; Fukushima et al., 1989; Dreger and Helmberger, 1991; Ritsema and Lay, 1993; Thio and Kanamori, 1992; Giardini et al., 1993).

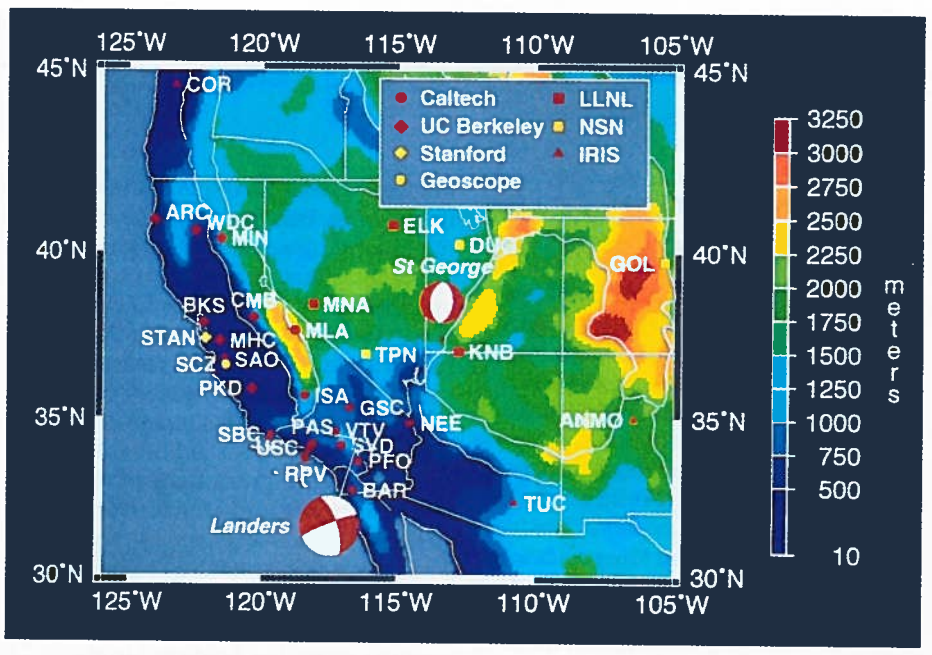

Figure 1. Map of the western United States showing the location of the two earthquakes discussed in this article, along with the location of broad-band seismographic stations with real-time data accessibility now operating in the region. The background color indicates the surface topography. Graphics software was provided courtesy of Paul Wessel and Walter Smith.

ST. GEORGE, UTAH, EVENT OF SEPTEMBER 2, 1992: RAPID DETERMINATION OF A POINT-SOURCE MODEL

An important recent earthquake for which a variety of different near–real-time procedures were applied and compared is the September 2, 1992, St. George, Utah, earthquake (M_w = 5.6) (Pearthree and Wallace, 1992). Located within the transition zone between the Basin and Range and Colorado Plateau in southwest Utah (Fig. 1), this is the largest seismic event in Utah and its border regions since 1975. This moderate-sized earthquake produced signals recorded at broad-band stations in the western United States (locations of those with real-time access are shown in Fig. 1) as well as globally, making it well suited for comparing results from different procedures. We applied a variety of seismic analysis procedures to quickly estimate double-couple or moment tensor point-source models for this event and compare the resulting source mechanisms (Fig. 2). The solutions are quite consistent, and all indicate normal faulting at a depth of 10–15 km.

A conventional P-wave first-motion solution (Fig. 2A) was obtained (Pechmann et al., 1992) from regional short-period stations of the University of Utah seismographic network and other arrays in adjacent states, and these data also provided an accurate source location. In this case, the station coverage is sufficient to provide a well-constrained solution, as the event is surrounded by stations from various networks. Researchers at Harvard University produced the solution in Figure 2B by the "quick" centroid-moment tensor (CMT) inversion (Ekström, 1993), which used teleseismic body wavetrains from six stations with periods longer than 45 s. For recent large events of interest, near–real-time data are used to automatically obtain preliminary CMT inversions, and the solutions are broadcast to seismological research groups (Ekström, 1993). These solutions are usually very similar to the final CMT solution obtained months later after more extensive data become available. The CMT procedure uses seismic waves that take several hours to reach stations around the world. More rapid source analyses (yielding a source solution within 20 min or so) can be performed using regional distance recordings 50–1500 km from the source.

We employ four regional distance techniques that vary in the wave types and period range of ground motions used. A modified CMT procedure, using regional distance body and surface-wave ground motions (Ritsema and Lay, 1993), was applied to signals from six regional broad-band stations with good azimuthal distribution around the St. George epicenter (Fig. 2C). This procedure requires very little preprocessing, as it involves inversion of the complete waveform, usually about 10–15 min long, filtered to retain periods longer than 50 s. At these periods, a laterally uniform Earth model is sufficient to account for propagation effects. Only the latest generation of high-dynamic-range, broad-band seismometers provides on-scale, long-period signal recordings at regional distances for earthquakes larger than magnitude 5.5.

Intermediate period (10–50 s) regional distance surface waves can be analyzed for a source model when a suitable, heterogeneous velocity model is available. Results of one procedure for the Utah earthquake are shown in Figure 2D. In this procedure, fundamental mode Rayleigh and Love waves are isolated by windowing; the spectra are computed and corrected for path-specific propagation effects due to variable crustal structure and then inverted for the source mechanism (Patton and Zandt, 1991; Thio and Kanamori, 1992; Pasayanos and Romanowicz, 1992). The correction procedure requires a modest amount of time and can be automated in the future. The source model in Figure 2D was obtained within a few hours of the event.

Regional body waves also can be used to estimate first-order properties of the seismic source (Wallace and Helmberger, 1982; Dreger and Helmberger, 1991). P waves in the period range 5–30 s are relatively insensitive to variations in crustal structure and

continued on p. 133

Grants Available for Collaborative Work

The Office for Central Europe and Eurasia of the National Academy of Sciences is offering travel and host grants to U.S. scientists who would like to engage in collaborative research with colleagues from Central and Eastern Europe and the former Soviet Union. Grants will fund two programs: the Collaboration in Basic Science and Engineering (COBASE) and the Radioactive Waste Management Program. COBASE offers short-term development grants to $2200 for hosting a European or Asian colleague for two weeks to prepare a collaborative research proposal for submission to the National Science Foundation or other funding organization. Long-term grants of $3600–$12,100 would support hosting or visiting a foreign researcher for one to six months to become familiar with research and prepare results for publication.

Deadlines for short-term grant applications are June 24 or December 9. Applications for long-term grants are due by June 24. The Radioactive Waste Management Program, funded by the U.S. Department of Energy, would support researchers who wish to host colleagues from the former Soviet Union for 6–12 months for research on managing radioactive waste. Grant levels range from $16,000 to $30,000. Deadlines for applications are March 30 or September 30. Applicants must be U.S. citizens with a Ph.D. or research equivalent. Foreign colleagues, who must also have a Ph.D. or equivalent, must be citizens of participating countries in Eurasia. For an application or additional information, please contact: Office for Central Europe and Eurasia, National Academy of Sciences, 2101 Constitution Ave., N.W., Washington, DC 20418, (202) 334-3680, fax 202-334-2614, E-mail ocee@nas.edu.

In Memoriam

George Biemesderfer
Bethlehem, Pennsylvania
May 29, 1993

Phillip Guild
Bethel, Arkansas

John M. Kellberg
Knoxville, Tennessee
July 14, 1993

Harold Kirkemo
Sun City, Florida

Louis Heyman
Amarillo, Texas
February 10, 1994

Robert F. Legget
Ottawa, Ontario, Canada
April 17, 1994

Heine Lowenstam
Pasadena, California
June 7, 1993

Gordon B. Oakeshott
Walnut Creek, California
December 27, 1993

Fred B. Phleger
Solona Beach, California
December 14, 1993

William G. Pierce
Cupertino, California
January 31, 1994

Carl B. Richardson
Tucson, Arizona

Austin A. Sartin
Shreveport, Louisiana
November 21, 1993

James R. Townsend
Los Angeles, California
November 27, 1990

John W. Wells
Washington, D.C.
January 12, 1994

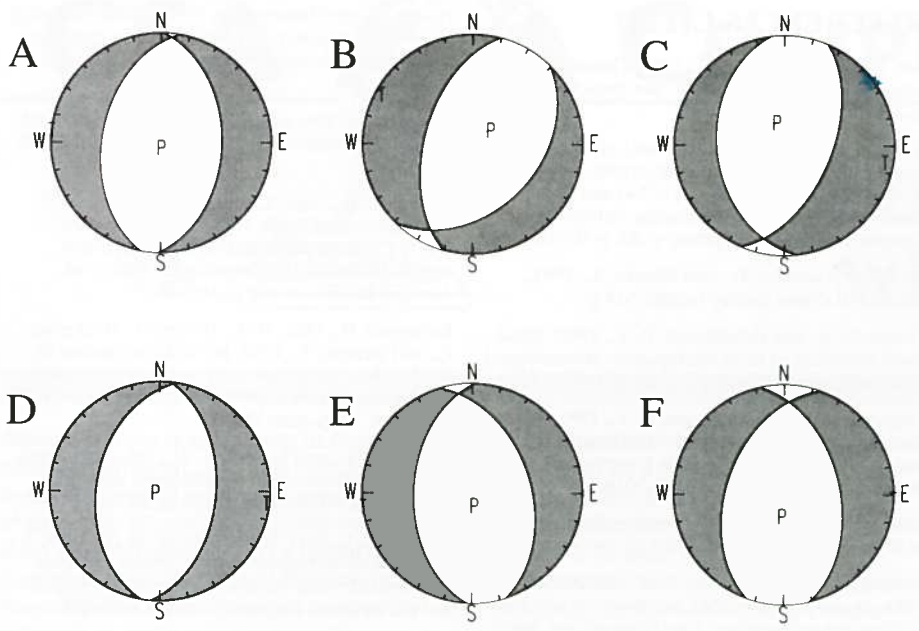

Figure 2. Source focal mechanisms determined using different near–real-time procedures for the 1992 St. George, Utah, earthquake. Each plot is a lower-hemisphere, equal-area projection of the best double-couple solution from the various methods. Compressional (P) and tensional (T) strain axes are plotted; shaded regions correspond to P wave first-motions away from the source. The two curves in each projection represent the fault plane and the auxiliary plane, with independent (aftershock) data indicating that the westward-dipping plane is the actual fault plane. All solutions involve almost pure normal faulting; differences between solutions arise from the limitations of each technique. A: P wave first-motion mechanism. B: Quick CMT solution. C: Regional-CMT solution. D: Regional short-period surface wave solution. E: Regional P wave inversion from multiple stations. F: Regional P and S wave inversion from a single station.

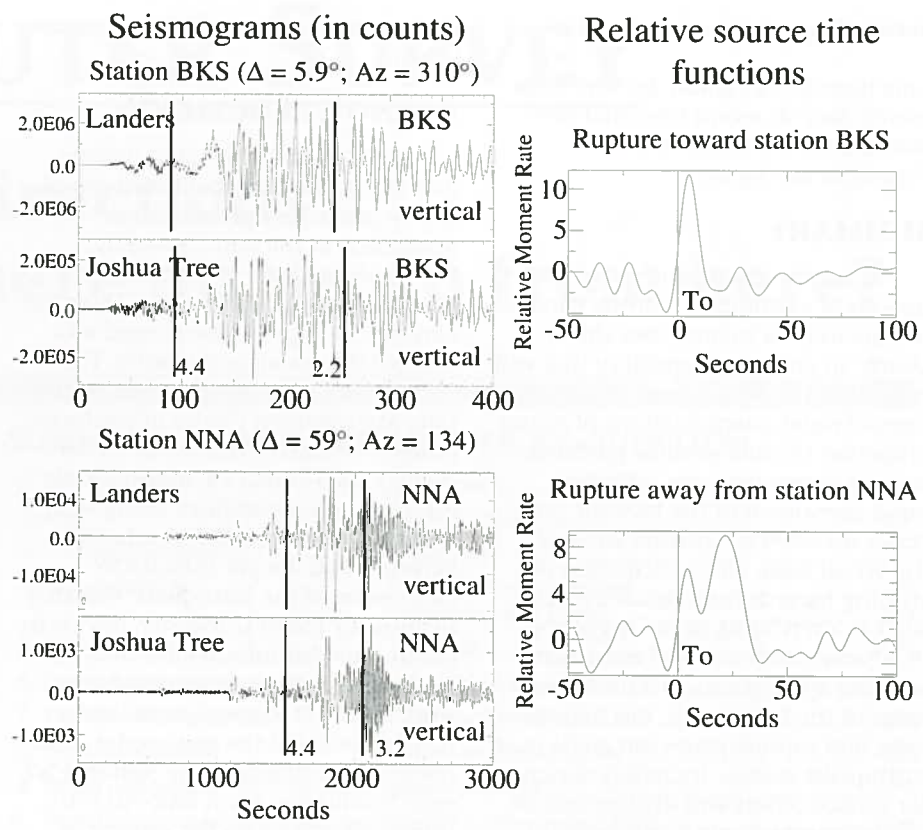

Figure 3. Examples of propagation correction by deconvolving signals from a small event from the corresponding signals from a large event. The data on the left are Rayleigh wave recordings at two broad-band stations of the magnitude 7.3, June 28, 1992, Landers, California, earthquake and the magnitude 6.1, April 23, 1992, Joshua Tree event. The signals share common propagation complexity but differ due to the greater rupture complexity of the Landers event. Deconvolution of the Landers records by the Joshua Tree records yields the relative source time functions shown on the right, which contain information about the spatial-temporal rupture history for the Landers event. Note the great reduction in complexity of the signals achieved by removing the propagation effects. Stations BKS (Berkeley, California) and NNA (Naña, Peru) are at opposite azimuths along the rupture plane, and the differences in the relative source functions reflect the finite rupture of the Landers event as it ruptured northwestward toward BKS. The Landers event involved two subevents, apparent as the double peak at southern station NNA, in which northward rupture resulted in a Doppler shift causing the pulses to overlap, making a single pulse at northern station BKS.

Seismology *continued*

can be modeled simply and quickly. Inversion of 12 regional P waveforms from six western U.S. stations gave the source model in Figure 2E. The P and S wave information in a single, three-component regional seismogram is sometimes adequate to resolve the source as well (Fan and Wallace, 1991; Dreger and Helmberger, 1990); the result of inversion of a single set of recordings from a broad-band station in Berkeley, California, is shown in Figure 2F. Use of broad-band data in the body wave and short-period surface wave frequency band improves resolution of the source depth relative to standard location capabilities.

Each of the methods used in Figure 2 has associated error estimates, but the average parameters for the event are strike, 188° ±10°; dip, 46° ±4°; rake, –89° ±14°; depth, 15 ±5 km; and seismic moment, 2.2 ±0.6 x 10^{24} dyne-cm. The general consistency of the point-source characteristics of this event, all obtained within a few hours of the rupture, indicate that near–real-time quantification of earthquake processes is viable and robust using a variety of methods. Additional methods exist for rapid analysis of teleseismic body waves (Kanamori et al., 1992) as well as very close-in strong motion recordings (Kanamori et al., 1990; Uhrhammer, 1992), and these can be implemented depending on data availability. Some procedures will be more successful for smaller events, while others will be useful for larger events, and the distance range of the available data will also influence the procedures that can be used. A point-source characterization is sufficient to assess the overall nature of faulting and energy release.

Although the point-source inversions discussed above can routinely recover the seismic moment and overall faulting geometry, none of them provides a unique choice of the fault plane or variations in the slip function on the fault. For the St. George earthquake, the only basis for identifying the fault plane (believed to correspond to the west-dipping Hurricane fault in this case) is the distribution of small aftershocks (Pechmann et al., 1992). Point-source parameters are retrieved using seismic wavelengths longer than the source dimensions, and the period range limits the temporal resolution of the source energy release. Resolving greater details of the finite spatial-temporal rupture history requires use of shorter period wave energy, but this in turn requires an increasingly accurate Earth model to account for wave propagation effects.

In regions of dense instrumentation and seismic activity, there are ongoing efforts to "calibrate" the propagation paths, developing catalogs of models or propagation transfer functions that can be used for rapid or routine source model investigations (e.g., Ho-Liu and Helmberger, 1989; Dreger and Helmberger, 1991). Similarly, steady improvements in global aspherical Earth models provide better propagation models for long-period body and surface waves, but these have been used primarily to improve point-source inversions (Velasco et al., 1992).

1993 LANDERS, CALIFORNIA EARTHQUAKE: RAPID DETERMINATION OF A FINITE FAULT MODEL

For near–real-time analysis of finite source characteristics of earthquake ruptures applicable on a global scale, we have adapted a procedure called "empirical Green's function analysis," historically applied mainly to small, locally recorded events. The essence of this technique is to use the seismic wavefield produced by a small earthquake located near a larger event of interest to empirically account for propagation effects on each path (Ammon et al., 1993; Nakanishi, 1991). This technique works best for colocated events with identical fault mechanisms that have a large difference in rupture duration (involving at least a magnitude unit difference in size). The signals from the smaller event are treated as the Earth's impulse response and are deconvolved from the signals of the larger event to remove common propagation effects. The deconvolved signals are relative source functions containing the isolated spatial-temporal energy release information of the larger event (Fig. 3). Since an empirical path correction usually has much greater accuracy than that provided by existing aspherical Earth models, this procedure greatly extends the period range of seismic signals that can be used to study the source, particularly for surface waves.

Earthquakes that rupture over a significant spatial (>20 km) and temporal (>10 s) extent often produce readily observable variations in the source time functions, which are azimuthally dependent functions of the spatial-temporal rupture history. Thus, analysis of the azimuthal variation of relative source time functions can reveal the spatial-temporal faulting complexity. This works best if the rupture progresses unilaterally down a fault in one direction, as this maximizes the azimuthal pattern. For a bilateral rupture it may not be possible to determine the actual fault plane.

A near–real-time determination of a finite fault model was performed for the M_w = 7.3, June 28, 1992, Landers, southern California, earthquake, the largest event to occur in the contiguous United States in 40 yr (Kanamori et al., 1992; Henyey, 1992; Harris and Simpson, 1992; Stein et al., 1992). As soon as a preliminary point-source solution was obtained for this event by the CMT procedure (Fig. 1), we searched for nearby smaller events with the same mechanism with high-quality signals at the same stations. The small event used for empirical path corrections in this case was the April 23, 1992, Joshua Tree earthquake, which had a magnitude of 6.1. Both events involve right-lateral strike-slip faulting. In general, we exploit the large CMT catalog for all significant earthquakes since 1977 (more than 10,000 CMT solutions are included) to find a suitable small event close to a large event of interest. Then, on-line databases at various data centers are searched for common path seismograms for use in the deconvolutions. Very broad band data are available on-line only for events in 1989 and later, whereas digital data are available from the Harvard data center back to 1977. All of this data collection and deconvolution can be performed in a few minutes.

Upon deconvolving the surface wave recordings for the Landers event using the Joshua Tree signals, we immediately detected strong azimuthal patterns in the deconvolved source functions that revealed north-northwestward rupture of the fault (Ammon et al., 1993). The Landers rupture involved two main pulses of energy release, each lasting about 10 s, with a 10 s separation between the subevents. These pulses arrive closer together at stations in the direction of rupture due to the Doppler shift effect of rupture directivity, so the relative source functions are single pulses toward the north, while clear double pulses are observed toward the south (see Fig. 3). Having determined the fault plane, we assume unilateral rupture to arrive at the slip model shown in Figure 4, which is compared with actual surface-break slip measurements (Sieh et al., 1994). By detecting systematic azimuthal patterns in the relative amplitude of the two pulses for seismic waves with different radiation patterns, we were also able to invert for a change in strike between the subevents, involving a 12° counterclockwise rotation (Fig. 4). This corresponds well to the transfer of slip from north–striking to north-northwest–striking faults observed in the surface breaks (Sieh et al., 1994).

Most events around the world with magnitudes >7.0 can be analyzed for details of the source rupture process as long as suitable data for a small event are available. This generally proves to be the case, and we have analyzed several other large events in or offshore of California in 1991 and 1992, uniquely identifying the rupture plane in each case. Deconvolution has also proved advantageous for determining overall

Seismology *continued on p. 134*

Seismology *continued from p. 133*

time histories of rupture for very large events, such as recent ones that produced destructive tsunamis in Nicaragua and Japan.

SUMMARY

Procedures for real-time determinations of earthquake faulting parameters are in their infancy, but this is clearly an emerging capability that will expand in the near future. The advantages of rapid quantifications of source properties include possible guidance for emergency response activities, rapid assessment of the tectonic processes involved by identification of the actual fault, and anticipation of ensuing hazards from future events such as aftershocks or the triggering of adjacent faults, as well as tsunami warning applications. Detailed knowledge of the fault depth, mechanism type, and rupture plane can guide post earthquake studies, including searches for surface offsets and deployment of geodetic and seismic instruments in the source vicinity. In addition, there is great value in rapid analysis, because unusual events will not be overlooked or forgotten as readily, a common occurrence in the past given the transient nature of earthquake activity and the formerly slow rate of data accumulation.

ACKNOWLEDGMENTS

We appreciate the rapid distribution of information about earthquake source parameters provided by researchers at Harvard University, California Institute of Technology (Caltech), and University of California, Berkeley, along with the general seismological research community. The on-line data resources provided by the Data Management Center of the Incorporated Research Institutions for Seismology (IRIS-DMC) are indispensable for these new capabilities, along with on-line data centers at Caltech, UC Berkeley, and the pre-POSEIDON data center of the Earthquake Research Institute of Tokyo University. Jim Pechmann provided information from the University of Utah seismographic network for the St. George event, and a helpful review of the manuscript. This research was supported by National Science Foundation grant EAR-9017767. Patton acknowledges the support of the U.S. Department of Energy at the Lawrence Livermore National Laboratory under contract W-7405-Eng-48. Contribution number 203 of the Institute of Tectonics and C. F. Richter Seismological Laboratory.

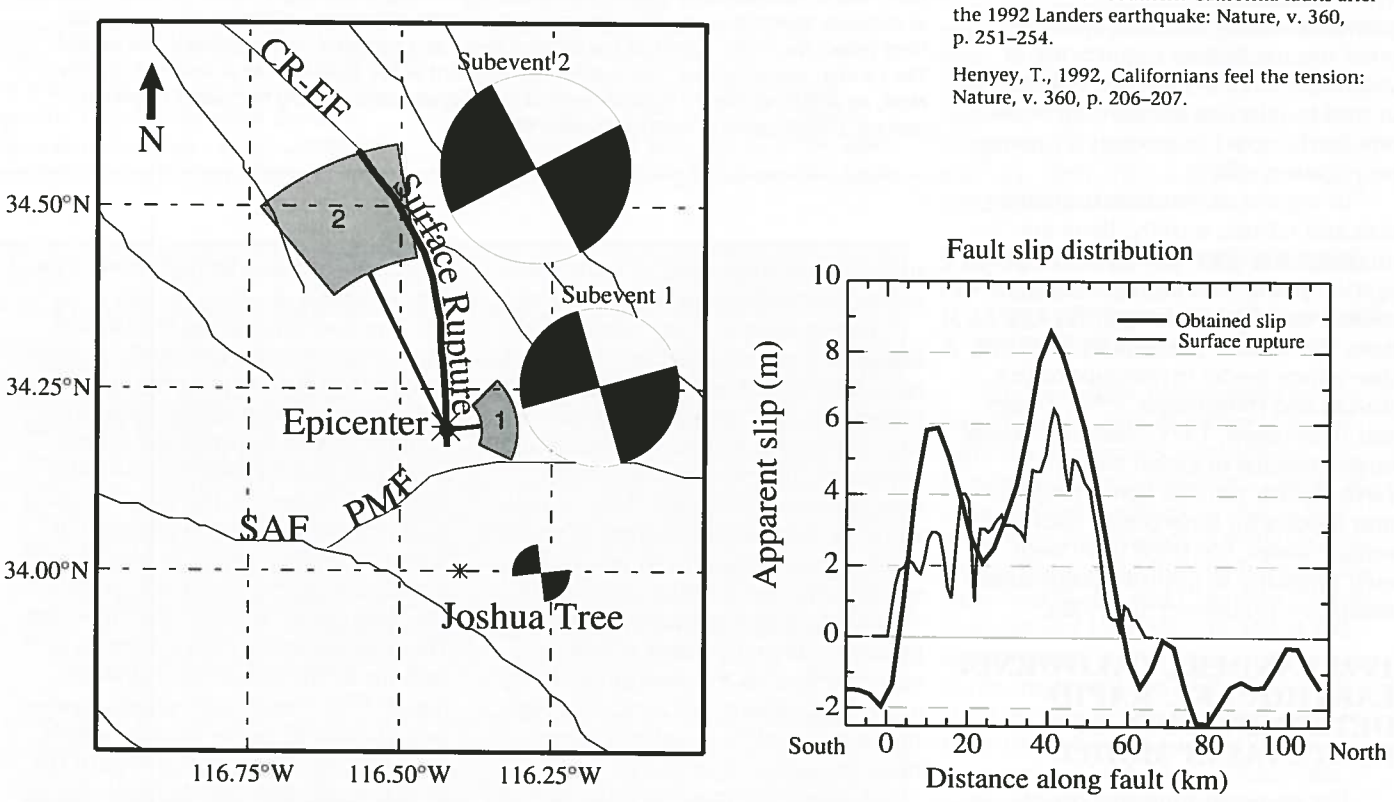

Figure 4. Near–real-time finite source model obtained for the June 28, 1992, Landers earthquake, involving two subevents with slightly different right-lateral strike-slip mechanisms, along a north-northwestward trend with northward rupture propagation (left). The shaded areas indicate the relative positions of the center of energy release in the two subevents relative to the Joshua Tree event to the south (asterisk). The distribution of slip along the fault found for this model (right) is compared to the observed pattern of surface rupture. CR-EF is Camp Rock–Emerson faults; SAF is San Andreas fault; PMF is Pinto Mountain fault.

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Manuscript received, May 3, 1993; revision received August 19, 1993; accepted October 18, 1994 ■

GSA Section Officers—1994–1995

GSA has six regional North American sections, generally including GSA members who live within the geographical limits of each section. (Members who live in one section but have professional interest in another section can declare membership in the section of interest rather than their geographical section.) Each section holds annual technical and business meetings. The number of voting members shown for each section is as of December 31, 1993.

CORDILLERAN Voting members: 3716
Geographic area: Alaska, Arizona south of lat 35°N, California, Hawaii, Nevada, Oregon, Washington, British Columbia, Yukon, Northwest Territories.
Officers: Eldridge M. Moores, chair; Catherine J. Hickson, vice-chair; Bruce A. Blackerby, secretary; Darrel S. Cowan, past chair.

ROCKY MOUNTAIN Voting members: 1813
Geographic area: Arizona north of lat 35°N, Colorado, Idaho, Montana, New Mexico, North Dakota, South Dakota, Utah, Wyoming, Alberta, Saskatchewan.
Officers: Stephan G. Custer, chair; David R. Lageson, vice-chair; James Schmitt, vice-chair; Kenneth E. Kolm, secretary; Douglas C. Brew, past chair; Robert W. Blair, Jr., past vice-chair.

NORTH-CENTRAL Voting members: 1307
Geographic area: Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Nebraska, Ohio, Wisconsin, Manitoba, Ontario west of 89th meridian.
Officers: Robert F. Diffendal, Jr., chair; James B. Swinehart, vice-chair; George R. Hallberg, secretary; Alan E. Kehew, past chair; Ronald B. Chase, past vice-chair.

SOUTH-CENTRAL Voting members: 1288
Geographic area: Arkansas, Kansas, Oklahoma, Texas.
Officers: Philip L. Kehler, chair; Page C. Twiss, vice-chair; Rena M. Bonem, secretary-treasurer; John A. Breyer, past chair.

NORTHEASTERN Voting members: 2178
Geographic area: Connecticut, Delaware, District of Columbia, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, New Brunswick, Newfoundland, Nova Scotia, Prince Edward Island, Quebec, Ontario east of the 89th meridian.
Officers: Stephen G. Pollock, chair; Barry Doolan, vice-chair; Kenneth N. Weaver, secretary-treasurer; Sandra M. Barr, past chair.

SOUTHEASTERN Voting members: 1568
Geographic area: Alabama, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, Virginia, West Virginia.
Officers: Donald C. Haney, chair; Harry Y. McSween, vice-chair; Michael J. Neilson, secretary-treasurer; Molly Fritz Miller, past chair; Lynn Glover, III, past vice-chair. ■

GSA COMPUTER SURVEY

New Directions ... Where do we go from here?

Along with their dues mailing in August 1993, all GSA members received a questionnaire on computer use. The computer survey was initiated as a way to gauge interest in several issues, especially ways of dealing with manuscripts and publications. Also of particular interest is the ability to receive abstracts via electronic mail and to archive GSA meeting abstracts on a digital medium that is easier to search. The scenario for arranging the GSA Annual Meeting technical program could change substantially if this were in place. Other possible uses of E-mail in relation to the Annual Meeting include registration and lodging reservations, more geological software exhibitors, and computerized display of research in technical sessions.

Response

We received a total of 2777 responses (16.3% response) by our final deadline of December 31, 1993. The demographics of survey respondents closely resemble what we know about GSA members (see pie charts). This, along with a 95% confidence interval in the range of 0.95 to 1.86, indicate the validity of the sample. Backup for each report, which shows the number of responses as well as percentages, is also available upon request.

Sample Bias

Sample bias might be an issue because the response comes from a general group (all persons listed as GSA members) rather than a statistically selected sample. Considering the size of the response and the mirrored demographics of the membership, however, we have been advised that the response group is a very likely representation of the total membership. Perhaps the responses are skewed toward those who respond to a possibility of reward (all who responded were entered in a gift drawing). It is our impression that non–U.S. residents may be somewhat overrepresented in the sample, but this cannot be tested until addresses are input and sorted. We are unaware of any other sample bias.

Tabulation

The results are reported on the basis of the nature of the question. Questions for which more than one response was possible have been calculated as a percentage of the total number queried. For example, the percentage of professionals aged 25–35 years was 427/1770 or 24%. The "yes" or "no" questions have been calculated on the basis of the number of responses for that question. This is an accepted and standard reporting method.

Answers to question 10 do not appear in this report because we found that the wording of this question caused some confusion. Question 10 was to be answered only by those who answered "no" to question 9. Instead, everyone answered question 10, thus making the results of that question invalid.

Comments on *Comments*

Comments were input as text separately from the database, and were identified with the survey number. We are able to do a word search by subject. We have done this for "publications," "CD-ROM," "Bulletin," and "Geology." A few of the many thoughtful and significant comments are included in this article in a balance consistent with the overall survey responses.

Avoiding Temptation

It is tempting to generalize that if 64% of our sample have a certain attitude, varying an average of ±1.5%, the entire membership has the same attitude. Before drawing such conclusions, it is important to understand what each response means by reading the full question, know what the basis for the percentages is, and look for major trends rather than small variances. Decisions based on this information should be developed through further queries or sample testing.

If you have questions or would like a copy of the full report, please call Matt Ball at 1-800-472-1988 or fax 303-447-0648.

SUMMARY: DOMINANT ANSWER BY QUESTION

1. Member status:	Member	64%
2. Age:	36–45 years	30%
3. Primary responsibility:	Professor	32%
4. Have access to:	Computer with a modem	57%
	Computer with E-mail	59%
5. E-Mail service:	Internet	42%
6. Computer for word processing:	IBM PC or equivalent	64%
7. Word processing software:	Microsoft Word	52%
8. Graphics software:	Don't produce graphics	33%
9. Would participate in electronic submission of abstracts:		67%
11. Have not submitted an abstract electronically to other organizations:		90%
12. Of those that have, most were satisfied with the process:		90%
13. Primary purpose of computer usage:	Research	72%
14. Computer used for other activities:	IBM PC	62%
15. Do not utilize GIS databases:		72%
16. Do have access or plan to in near future to CD-ROM drive:		68%
17. Would not be interested in GSA abstracts on CD-ROM:		53%
18. Of those that would want abstracts on CD-ROM, most want access prior to meeting:		49%
19. Would not want to augment presentation with computer display:		58%
20. Would not be interested in demonstrating own software product:		93%
21. Would want to access GSA membership and other databases via a computer network:		79%
22. Most popular on-line material:	Abstracts	72%
23. Interested in GSA computer education at section and national meetings:		84%
24. Want more information on software for teaching:		59%
25. Want more information on software for research:		83%
26. Want to see more software and hardware vendors in exhibits hall:		87%
27. Want technical sessions devoted to useful geological software:		85%
28. Would include sessions with presentations by vendors:		53%
29. Would like "hands on" facilities for access to products:		90%

"I would like to see GSA move more rapidly to embrace new electronic technologies for publishing, communications, and research. The financial and scientific success of the Society may depend on its ability to stay on the leading edge of technology." Craig M. Schiffries

"GSA should ... be on Internet. The Publications Department should ... be on line to receive, review, and edit manuscripts by computer. The Membership Department should be accessible by E-mail. All years of the* Bulletin *and* Geology *should be available on CD-ROM." Bob Hatcher

"No question, GSA must move energetically and effectively sooner rather than later to make information having to do with the geological sciences available to its membership and to the wider interested public as well. Not only will those able to use electronic access benefit, but the absence of such an electronic pipeline to and from the earth sciences will tend to diminish their impact on world affairs." Paul Dickert

"As I have moved on into career work, I have found that my preparation for using computers was lacking severely. Any programs the Society could provide to emphasize the need for computer education would be a big plus to future and present geologists. I wish I knew as an undergraduate how important computer technology was going to be to earth science studies." Ronald J. Clendening

"The computer has brought me into the last half of the 20th century. My resistance has changed to an embrace. I am 64 and I look at the computer as a means to extend my useful and productive life." Harold Sugden

"You are supposing here that most geologists are going to have the funds privately or from organizations they work for to buy high speed computers and software. Funds are very limited in these hard economic times for such expenditures. For some of us geologists, working on the computer is such a struggle—we have a hard enough time keeping abreast of our own science without having to learn a whole new technology. I find that almost all manuals are not user friendly." Sharon Diehl

COMPUTER SURVEY REPORT TOTALS

1. Membership status:

A. Member	1770	64%
B. Student Associate	342	12%
C. Teacher Associate	31	1%
D. Fellow	430	16%
E. Honorary Fellow	8	.3%
F. Senior Fellow	124	4%
G. Senior Member	65	2%
H. No response	7	.3%

2. Age bracket:

A. Under 25 years	68	3%
B. 25 - 35 years	672	24%
C. 36 - 45 years	832	30%
D. 46 - 55 years	579	21%
E. 56 - 60 years	202	7%
F. Over 60 years	419	15%

3. Primary daily responsibilities:

A. Professor (at any level)	889	32%
B. Department Chair	107	4%
C. Dean, Vice-President, Provost	23	.8%
D. Student	351	13%
E. Owner/Partner/Officer	211	8%
F. Manager	211	8%
G. Chief/Sr. Geologist	376	14%
H. Geologist	842	30%
I. Geophysicist	115	4%
J. Other	577	21%
Significant Other		
Consultant	*44*	*2%*
Hydro	*55*	*2%*
Research	*58*	*2%*
Retired	*113*	*4%*
Teacher	*28*	*1%*

4. Personal access to the following:

A. Computer with a modem	1578	57%
B. Computer connected to E-mail	1644	59%
C. Neither A nor B	492	18%

5. E-mail service:

A. Bitnet	361	13%
B. Internet	1206	43%
C. Telenet	327	12%
Related services		
D. CompuServ	139	5%
E. Prodigy	75	3%

6. Computer hardware commonly used for word processing:

A. Macintosh	1114	40%
B. IBM PC or equivalent	1768	64%
C. NEXT	5	0.2%
D. UNIX or equivalent workstation	175	6%
E. Mainframe	64	2%
F. Other	63	2%

7. Word processing software:

A. Microsoft Word (Mac) or Word for Windows	1432	52%
B. WordPerfect	1293	47%
C. TEX/LATEX	28	1%
D. Other	428	15%
Significant Other		
Macwrite	*36*	*1%*
Wordstar	*72*	*3%*
Writenow	*27*	*1%*

8. Software used for the production of publication-quality graphics:

A. I don't produce publication-quality graphics	926	33%
B. MacDraw	344	12%
C. Adobe Illustrator	331	12%
D. Canvas	484	17%
E. Aldus Freehand	139	5%
F. Surfer	225	8%
G. Other	908	33%
Significant Other		
Autocad	*92*	*3%*
Corel Draw	*143*	*5%*
Cricket Graph	*31*	*1%*
Excel	*34*	*1%*
Freelance	*56*	*2%*
Harvard Graphics	*57*	*2%*
Kaleidograph	*30*	*1%*
Quattro Pro	*30*	*1%*
Superpaint	*29*	*1%*

9. Would you participate in the electronic submission of abstracts?

A. Yes	1816	67%
B. No	883	33%

11. Have you submitted an abstract electronically to AGU, AAS, or other organizations?

A. Yes	266	10%
B. No	2483	90%

12. If you answered yes to the above question, were you satisfied with the process?

A. Yes	247	90%
B. No	26	10%

13. Computer use in other aspects of your professional activities:

A. Research	2010	72%
B. Database access	1593	57%
C. Library access	1399	50%
D. Keyword searching	793	29%
E. Communication with colleagues	1570	57%
F. Other	404	15%

14. Computer hardware used for these other activities:

A. Macintosh	1032	37%
B. IBM PC or equivalent	1722	62%
C. NEXT	6	.2%
D. UNIX or equivalent Workstation	505	18%
E. Mainframe	281	10%
F. Other	74	3%

15. Do you utilize GIS databases?

A. Yes	731	28%
B. No	1923	72%

16. Do you currently have access, or do you plan access in the near future, to a CD-ROM drive?

A. Yes	1832	68%
B. No	878	32%

17. Would you be interested in the availability of GSA abstracts on CD-ROM?

A. Yes	1254	47%
B. No.	1433	53%

18. When would you want access to the abstracts on CD-ROM?

A. Prior to the Annual Meeting	822	49%
B. During the Annual Meeting (for on-line keyword searching)	159	10%
C. After the Annual Meeting for library and/or archival purposes	682	41%

19. Would you have interest in augmenting your technical presentation at a GSA meeting with a large-screen computer display or computer-driven overhead projection tablet?

A. Yes	1092	42%
B. No	1492	58%

20. At the 1994 GSA Annual Meeting in Seattle would you be interested in demonstrating a software product you have written ?

A. Yes	175	7%
B. No	2442	93%

21. Would you be interested in accessing a GSA database of membership information, abstracts, or other material of interest to geoscience professionals via a computer network?

A. Yes	2143	79%
B. No	553	21%

22. What sorts of materials would you like to access on-line?

A. Abstracts	2006	72%
B. Bulletin boards	1425	51%
C. Meetings information and registration	1433	52%
D. Membership information	1083	39%
E. Other	297	11%

23. Would you be interested in GSA-sponsored activities at the annual or section meetings to encourage and educate the membership in the use of computers in the geological sciences?

A. Yes	2219	84%
B. No	434	16%

24. Would you like more information about the availability of software for teaching?

A. Yes	1560	59%
B. No	1090	41%

25. Would you like more information about availability of software for research?

A. Yes	2221	83%
B. No	461	17%

26. Would you like to see more software and hardware vendors display their products in the exhibits hall?

A. Yes	2192	87%
B. No	319	13%

27. Would you like to see one or more technical session(s) devoted to the demonstration and recommendation of useful geologic software?

A. Yes	2227	85%
B. No	399	15%

28. Should we include sessions with presentations by vendors?

A. Yes	1337	53%
B. No	1180	47%

29. Should we provide facilities for "hands-on" access of products?

A. Yes	2285	90%
B. No	247	10%

"Many of us are not well versed in computers and the option to remain so should be given."
Virginia T. McLemore

"I would like to see GSA and its members on the leading edge of computer technology. An on-line membership option with access to databases for search and retrieval of data and documents and a members' bulletin board with access to shareware, demos, helpful hints for users, etc. Setting up the infrastructure for this type of GSA will be expensive, but once in place, it could yield great savings over the cost (in dollars and trees) of paper-based communication. It is also more efficient and accessible. Let's do it!"
Brad Burton

"It seems like there will have to be a revolution in the field of publications. It also seems like GSA is positioning itself to be at the leading edge of this revolution. Asking questions like these is one of the small rays of hope that a successful revolution will occur."
E. William Behrens

"Software advances are so rapid that it is impossible to keep up with it without regular exposure to new products. Meetings are a good place for this exposure."
Gerald B. Langille

DRAWING WINNERS

Complimentary Airfare (within the continental U.S.)
Kevin Kincare

Microsoft Word
Keith Moore

Microsoft Excel
Carl Wellstead

Seattle Annual Meeting Registration
Russell A. Brant
David R. Lageson

Section Meeting Registration ('94 only)
Richard Dart
Ronald Greeley
Steve A. Hallem

GSA Journals on Compact Disc
Andrew B. Judd

$25 GSA Bookstore gift certificate
Lu Chia-Yu
Gerd Kirchner
Francesco Pirajno
Isabella Premoli-Silva

Vista Pro Software
John Thomas Dutro, Jr.
Peter Herzberg
Luiz Jose Homen Del-Rey Silva
Brian J. Skinner

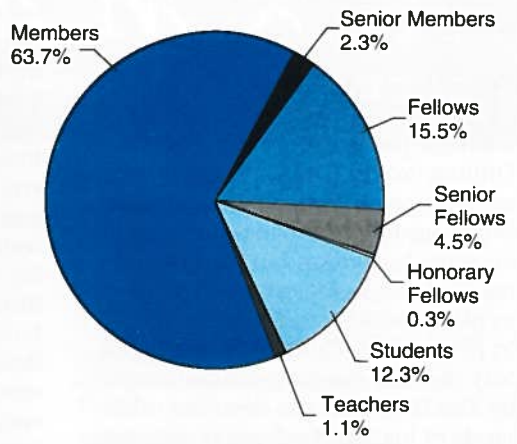
RESPONSE BY MEMBER STATUS

(Highest response shown in bold.)

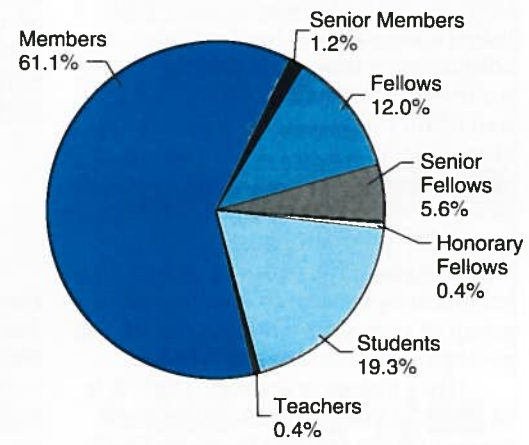
	Member	Student Associate	Teacher Associate	Fellow	Honorary Fellow	Senior Fellow	Senior Member
Number of respondents	**1770**	**342**	**31**	**430**	**8**	**124**	**65**
Reponses to questions 1 and 2 are shown in charts at right.							
3. Daily responsibilities							
Professor	34%	4%	42%	**51%**	38%	23%	14%
Department Chair	4%	0	**19%**	8%	0	0	2%
Dean, Vice-President, Provost	1%	0	0	**2%**	0	0	0
Student	1%	**94%**	10%	0	0	0	0
Owner/Partner/Officer	8%	1%	0	**10%**	0	6%	8%
Manager	10%	0	0	6%	**13%**	1%	9%
Chief/Sr. Geologist	2%	0	0	**13%**	0	8%	8%
Geologist	**36%**	18%	6%	22%	13%	23%	32%
Geophysicist	4%	3%	3%	5%	**13%**	2%	5%
Other	20%	16%	42%	17%	25%	60%	**66%**
4. Personal access to the following							
Computer with a modem	**61%**	49%	58%	53%	38%	44%	45%
Computer connected to E-mail	60%	**77%**	55%	63%	50%	25%	28%
Neither	16%	12%	29%	18%	**50%**	44%	37%
5. E-mail service							
Bitnet	16%	17%	13%	17%	**25%**	7%	5%
Internet	**57%**	55%	35%	48%	25%	14%	15%
Telenet	10%	**28%**	6%	8%	13%	2%	8%
CompuServ	7%	4%	10%	5%	**13%**	3%	2%
Prodigy	4%	3%	**6%**	2%	0	2%	**6%**
6. Computer used for word processing							
Macintosh	37%	57%	**68%**	41%	50%	25%	32%
IBM PC or equivalent	**67%**	54%	45%	61%	50%	55%	58%
UNIX or equivalent workstation	7%	6%	6%	8%	**13%**	0	2%
Mainframe	**3%**	2%	**3%**	1%	0	1%	2%
7. Word processing software:							
Microsoft Word or Word for Windows	50%	**68%**	55%	50%	50%	32%	43%
WordPerfect	**50%**	39%	32%	45%	25%	31%	43%
TEX/LATEX	**1%**	.8%	0	**1%**	0	**1%**	0
Other	18%	11%	32%	18%	13%	**34%**	12%
8. Graphics software:							
Don't produce publication-quality graphics	32%	18%	55%	40%	38%	**56%**	43%
MacDraw	12%	15%	19%	13%	**25%**	6%	11%
Adobe Illustrator	11%	**15%**	3%	**15%**	0	6%	6%
Canvas	17%	**35%**	6%	14%	13%	3%	5%
Aldus Freehand	4%	**8%**	6%	7%	0	0	2%
Surfer	**10%**	**10%**	0	3%	0	1%	8%
Other	38%	**40%**	16%	27%	25%	21%	23%
9. Would submit an abstract electronically:	**95%**	85%	42%	66%	50%	29%	53%
11. Have submitted an abstract electronically to another organization:	9%	7%	**13%**	**13%**	12%	8%	9%
12. Of those that submitted electronically, were satisfied with the process:	89%	81%	**100%**	97%	**100%**	**100%**	**100%**
13. Computer use							
Research	73%	**85%**	32%	74%	63%	46%	42%
Database access	62%	51%	**65%**	53%	25%	32%	34%
Library access	49%	**73%**	48%	48%	25%	32%	28%
Keyword searching	28%	**42%**	19%	24%	25%	17%	15%
Communication with colleagues	57%	**63%**	55%	60%	**63%**	27%	34%
Other	18%	8%	10%	15%	0	**19%**	17%
14. Computer — Other							
Macintosh	35%	51%	**61%**	40%	50%	22%	31%
IBM PC or equivalent	**66%**	56%	42%	58%	38%	48%	49%
UNIX or equivalent workstation	19%	**29%**	6%	16%	13%	3%	3%
Mainframe	11%	**15%**	6%	6%	0	4%	5%
15. Utilize GIS databases:	**30%**	24%	23%	26%	12%	14%	7%
16. Have access to CD-ROM drive:	70%	73%	**77%**	64%	43%	39%	46%
17. Are interested in GSA abstracts on CD-ROM:	47%	**57%**	43%	45%	25%	25%	33%
18. Of those interested, would want access to GSA abstracts on CD-ROM:							
Prior to Annual Meeting	49%	47%	59%	51%	0	**65%**	42%
During Annual Meeting	9%	**15%**	12%	7%	0	3%	11%
After Annual Meeting	42%	39%	29%	42%	**100%**	32%	47%
19. Interested in augmenting presentation at meetings with computer display or projection tablet:	43%	**59%**	52%	34%	13%	12%	23%
20. Interested in demonstrating a self-written software product at 1994 GSA Annual Meeting:	7%	7%	7%	**8%**	0	2%	2%
21. Interested in accessing GSA via a computer network:	82%	**90%**	70%	74%	50%	47%	65%
22. Materials of interest on-line:							
Abstracts	73%	**86%**	68%	69%	38%	41%	52%
Bulletin Boards	54%	63%	58%	**68%**	25%	18%	35%
Meeting Info. and Registration	53%	**66%**	58%	48%	13%	21%	17%
Membership Info.	40%	**46%**	19%	45%	25%	15%	23%
Other	13%	**17%**	13%	10%	0	10%	14%
23. Interested in GSA computer education at meetings:	85%	88%	**100%**	77%	88%	70%	87%
24. Would like more info. about software for teaching:	58%	73%	**100%**	59%	57%	27%	46%
25. Would like more info. about software for research:	82%	**94%**	74%	80%	71%	65%	76%
26. Would like to see more software and hardware vendors in the exhibit hall:	89%	88%	**100%**	84%	**100%**	75%	83%
27. Would like to see technical sessions devoted to the demonstration of software:	85%	89%	93%	79%	**100%**	76%	91%
28. Would like sessions with presentations by vendors:	54%	51%	**86%**	49%	33%	53%	63%
29. Would like facilities for "hands-on" access of products:	91%	94%	97%	86%	**100%**	81%	92%

PROFILE OF RESPONDENTS

MEMBERSHIP CATEGORY

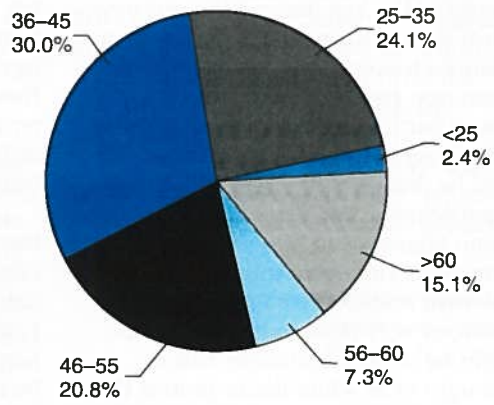


Survey Response

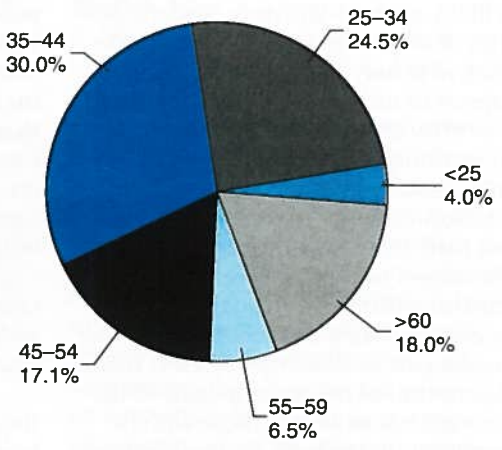


GSA Membership Statistics

YEARS OF AGE



Survey Response



GSA Membership Statistics

I am grateful to all who helped in this project, especially those who took the time to respond to the questions. I also appreciate the help of those who advised me on sampling and reporting methodologies. This has been primarily a GSA Meetings Department activity, supported by GSA's Program Committee. The 1994 Technical Program Chair, Mark Ghiorso, University of Washington, was responsible for designing and pre-testing the questions; GSA Data Systems Manager Mark Duvall designed the Access database; and Meetings Assistant Matt Ball was responsible for entering data and tabulating the results.

Sue Beggs
GSA Meetings Manager

BOOK REVIEWS

Challenger at Sea. *Kenneth J. Hsü. Princeton University Press, Princeton, New Jersey, 1992, 417 p.*

This book tells parts of three stories. Principally it is a history of the rich scientific products from the Deep Sea Drilling Project (DSDP) through the work on board its vessel *Glomar Challenger.* Second, it provides for lay readers some background in the development of the geological sciences so as to place the aims and results of DSDP in perspective. Third, because the history of DSDP is a personal one as seen by Ken Hsü, who also describes other facets of his life, this book is very nearly his autobiography. The three parts and their success or failure in this English-language book result from two editions of much of the same story published a decade ago. The German edition was a popular science book for the general reader, and so a thumbnail history of geology was introduced along with many of the living or dead participants. The Chinese edition gave an opportunity to this Chinese-American-Swiss-internationalist to explain the changes in his personal and geological philosophy, and to update a large group of geologists who had missed the geological revolution of the 1960s.

Hsü's history is through 1983; it is of DSDP including IPOD, without the present Ocean Drilling Program. *Challenger at Sea* is not a leg-by-leg summary in the order of drilling. Rather, it is the presentation of a set of scientific themes, such as salt domes or subduction or paleoceanography. Each theme has by way of background a summary of the development and state of knowledge in geology before drilling, along with vignettes of the legs designed to test new ideas within the evolving concepts of plate tectonics or geochemistry or paleontology. Hsü weaves in anecdotes about participants, in particular those chief scientists who were his friends, and he describes his own activities as a participant. The perpendicular pronoun reigns. As in *Rashomon,* everyone remembers an event differently, but in my own opinion Hsü's stories are the truth, or very close to it. Some omissions or small inaccuracies can be thought of as white lies to protect the guilty. This history is of scientific and technical failures and successes; Hsü hints about project management, the JOIDES advisory structure, and the politics of international science, but a definitive history of those interesting aspects of drilling has yet to be written.

Why should a reader be interested in learning how Ken Hsü, steeped in his Confucian virtues, changed from a tectonic "fixist" to someone embracing plate tectonics? Interest stems from the almost evangelistic description of the conversion of a well-known figure of contemporary science. The least successful part of *Challenger at Sea* is Hsü's description of the development of the geological sciences for those with no background. We learn again of Hutton and Hess, Agassiz and Argand, and such concepts as stratigraphy, geologic time, and magnetic reversals. The explanations are succinct and reasonable, but these sections are a hopeless mess of small inaccuracies that will detract from the long-term usefulness of this edition. After the book was translated into English, Hsü or the publisher should have asked someone to read through the text to correct the dozens of annoying errors of fact. As examples, Jagger in 1943 was with the University of Hawaii, not the USGS; Kinnordy Manor was in Scotland, not England; the *Glossopteris* flora was one of four (or according to some experts, three, but not two) principal floras of its time; in the early 1940s and early 1950s, Simpson was a professor at Columbia, not Harvard; the part of the Carlsberg Ridge studied by Vine lies in the Northern, not Southern, Hemisphere. Hsü's concept of the paradigm that plate tectonics replaced is novel and probably not held by many earth scientists. Readers may become infected by what I used to call the "*Time* magazine syndrome": content seems plausible, until one encounters something about science or education or another familiar field, an item riddled with errors and therefore generating doubts about the other articles.

The book is dedicated to the late Sy Schlanger, a careful worker in many fields of geology, and a close friend of Ken Hsü and of others in the ocean drilling community.

Ralph Moberly
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Geology of Western Himalaya. *Vikram C. Thakur, Pergamon Press, Oxford and New York, 1992 (Volume 19 of Physics and Chemistry of the Earth series), 363 p., $589.*

Thirty years have passed since the publication of Augusto Gansser's remarkable book *Geology of the Himalayas,* which summed up the available geologic knowledge of the Himalayas produced between 1851 and 1961. The enormous amount of information on Himalayan geology accumulated during the past three decades has necessitated the publication of regional geology books such as *Geology of Western Himalaya* by Vikram C. Thakur, currently Director of the Wadia Institute of Himalayan Geology in Dehra Dun, India.

The Himalayan segments lying to the west of Nepal—Kumaun, Garhwal, Himachal, Kashmir, Zanskar, and Ladakh regions in India and Kohistan of Pakistan—were the first parts of the Himalayas to be explored and mapped by natural historians of the 19th century. In his attempt to synthesize the geological data on the Western Himalaya, Thakur has drawn from papers published in both international and Himalayan countries' journals. Therefore, this book will, one hopes, fill in (to some extent) the significant gap that now exists in the geoliterature of foreign and native Himalayan researchers, and which at times results in questionable claims of first discoveries on both sides.

The up-to-date geological maps, cross sections, and descriptive tables as well as a bibliography of 818 references provide a rich source of information.

I especially enjoyed reading, at the beginning, the last chapter of the book—a thoughtful plate-tectonic interpretation of the western Himalaya. An important, novel idea presented here is Thakur's "alternative" structural explanation for crystalline rocks in the Lesser Himalaya as imbricate upthrust wedges of the basement rocks rather than the often-considered klippen of Higher Himalayan crystalline rocks. Overall, Thakur has tried to avoid controversy and argument on crucial issues of Himalayan geology; such controversy, however, would have made the book a lot more exciting to read.

The high price of this useful book may keep it out of the personal libraries of many Himalayan geologists.

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Stable Isotope Geochemistry: A tribute to Samuel Epstein. *Hugh P. Taylor, James R. O'Neil, and Isaac R. Kaplan, editors. Geochemical Society, San Antonio, Texas, 1991, $65.*

Authors of this diverse collection of isotope geochemistry papers comprise many of Sam Epstein's past students, post-docs, and collaborators, who convened for a symposium in December 1989 in honor of his retirement from a long and productive career. Sam Epstein has been the focal point of many fundamental discoveries in stable isotope geochemistry, and his research has profoundly affected the earth sciences during the latter half of this century. The book's 516 pages and its modest price make it a valuable addition to any earth scientist's reference library.

The book begins with an enlightening history of Sam Epstein's life and research career, followed by over 500 pages of research articles organized into various sections that reflect Epstein's diverse research activities and interests. Illuminating photos of Sam Epstein at different times in his career appear throughout the text. The careful organization of this book arranges the research papers into blocks of easily digestible material.

The first section, Experimental and Theoretical Isotope Fractionation Studies, is the most interesting and informative. The first article, by R. N. Clayton and S. W. Kieffer, combines theoretical and experimental results to derive oxygen isotope thermometers, characterizing the coexisting mineral fractionations as polynomial expressions. The next, by R. E. Criss, gives a derivation of the polynomial expressions in a report that clarifies the early theoretical isotope fractionation papers of Urey and Bigeleisen. A well-written paper by K. Muehlenbachs and C. Connolly elucidates experimentally determined ^{18}O self-diffusion coefficients for leucite under anhydrous exchange. E. M. Stolper and S. Epstein's extensive report on ^{18}O fractionation between CO_2 and silica glass follows. The section ends with an exciting article by E. DeLoule and others on D/H analysis of hydrous minerals by ion microprobe, in which they report a ±10‰ precision.

With the exception of the last section, the remainder of the book focuses on stable isotope applications to the earth sciences. The second section, Hydrosphere and Ancient Oceans, has a pair of interesting discussions on the stable isotope history of the ocean. The section is highlighted by Y. Kolodny and B. Luz's article on oxygen isotopes of phosphates in fossil fish from the Devonian to the present.

The third section, Climatology and Glaciology, is dominated by isotope hydrology topics, exemplified by R. A. Sommerfield et al. and I. Friedman et al.'s work on stable isotope shifts during hoar formation at depth in snow packs. The paleoclimatology presentation, though, left me unsatisfied.

The fourth section, Paleoenvironment and Archeology, has five very interesting articles, beginning with H. O. Ajie and I. R. Kaplan's carbon and nitrogen isotope results demonstrating better preservation of osteocalcin over collagen in fossil bone. L. W. Cooper et al. show the similarities of stable isotope data of leaf water in plants to surface water evaporation processes. C. J. Yapp and H. Poths present results of ^{13}C measurements of natural goethites, and X. Feng and S. M. Savin present results of oxygen isotope studies of zeolites. Z. Pearl and M. Magaritz apply stable isotopes to Roman marble source determination.

About one-third of this book is dedicated to high-temperature processes. Hugh Taylor's valuable contributions are in four of the 11 articles that make up the Igneous and Metamorphic Geochemistry and Ore Deposits and Hydrothermal Alteration sections, and include ^{18}O studies of crystalline rocks in southern Italy, the Schwarzwald massif of Germany, the Ruby Range of Nevada, and the southern Sierra Nevada. Other valuable articles are T. K. Kyser and R. Kerrich's review and discussion of hydrogen isotope effects from retrograde reactions of hydrous minerals, and R. E. Criss and D. E. Champion's impressive ^{18}O cross section of the fossil hydrothermal system in the Comstock Lode, Nevada.

This book is a collection of many outstanding works by some of the most noteworthy stable isotope investigators in the world. The broad range of topics and technical nature of the papers may not make this book suitable for an introductory or an advanced level class in isotope geochemistry, but it does provide many important reference papers and is a prominent example of important advances in the field of isotope geochemistry.

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Soils in Archaeology—Landscape Evolution and Human Occupation. *Edited by Vance T. Holliday. Smithsonian Institution Press, Washington and London, 1992, $39.95.*

Soils in Archaeology is an outgrowth of a 1988 symposium in Phoenix, Arizona, sponsored by the Society for American Archaeology. The editor, Vance T. Holliday, and the other seven volume contributors are mainly geologists and physical geographers who apply the terminology and techniques of the soil scientist to archaeological investigations. A glossary of soil science terms is also provided.

The main beneficiaries of the book are likely to be archaeologists who will now find, probably for the first time in the American literature, a compilation of case studies devoted exclusively to use of soils for interpreting archaeological environments. Simple as it may sound, this is not an easy task, for the four-letter word "soil" is used quite differently in various earth science disciplines: to the geotechnical engineer, soil has certain physical properties that can be measured and thus distinguished from rock; to the pedologist, soil is a medium for plant growth; to the sedimentologist, soil is usually depositional particulate matter; to the Quaternary geologist, soil is often a weathering horizon that may be laterally traceable and hence useful for stratigraphic correlation and interpretation of paleoenvironments; and to

continued on p. 139

the traditional archaeologist, soil frequently refers to sediments that enclose or otherwise support artifacts and other indicators of human activities.

Earth scientists wanting to know more about geoarchaeology and archaeological geology (arguments about terminology still rage, characteristic of newly evolving disciplines), will find particularly useful the summaries by Ferring, by Mandel, and by Bettis dealing with alluvial sediments, buried paleosols, terrace formation, and related geoarchaeological contexts, especially in the midwestern United States; by Holliday summarizing the principles of soil morphology and genesis; by Goldberg and Gladfelter emphasizing micromorphological and soil-stratigraphic investigations in the Levantine; and by Sandor measuring the long-term effects of prehistoric agriculture on soils in New Mexico and Peru.

A particularly useful contribution is that by Stein, who succinctly describes the multiple origins of organic matter in archaeological contexts. Commonly, for example, a single radiocarbon date becomes "biblical" with respect to interpretation of site and sediment antiquity. Archaeologists, and especially engineering geologists, often get caught up in the "pseudo-quantification" of sedimentation rates and soil age based on just one laboratory number. Stein carefully distinguishes sediment and soil age, defining each of the terms, and she further points out sources of organic-matter contamination that frequently render radiocarbon dates practically useless from a paleoenvironmental standpoint. These and other lessons described in *Soils in Archaeology* are valuable to the earth scientist in general and to the archaeologist in particular.

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Satellites of the Outer Planets: Worlds in Their Own Right. *David A. Rothery. Clarendon Press, Oxford, UK, 1992, 208 p., $75 (clothbound) $35 (paperbound).*

David Rothery's *Satellites of the Outer Planets* is a terrestrial geologist's introductory perspective on the geology of the major satellites of the outer planets. Although this book is almost completely qualitative, it is not simply another grand picture tour through the outer Solar System. Many outstanding controversies regarding icy satellites and Io are covered in fair detail. Rothery opens with four chapters that (1) introduce the satellites, (2) offer background information on models of the compositions and thermal evolution of icy satellites, (3) give an overview of the *Voyager* missions to the outer Solar System, and (4) discuss the essential concepts of mechanical and chemical layering in icy satellites. He then delves into the geology of the major satellites in the outer Solar System. In three chapters, Rothery presents the geology of the outer planets' satellites in approximate order of increasing geologic dynamism, rather than adopting the more usual organization based on the astronomical organization of satellites in the Solar System. Dead Worlds deals with satellites that show few signs of former geologic activity. Recently Active Worlds covers satellites that show abundant evidence for past geologic activity, but which do not now seem to be active. Logically, the book then covers "active worlds," which probably or demonstrably are still geologically dynamic. Rothery goes on to summarize major deficiencies in our knowledge of the geology of the outer planets' satellites, including the unknown geology of the "unseen worlds," Titan, Pluto, and Charon. He completes the book by highlighting two upcoming space missions to Jupiter's and Saturn's satellites (Galileo and Cassini).

Rothery excels at synthesizing and balancing complex arguments gleaned from a vast literature, without getting into analytical and experimental details. He presents particularly well-rounded discussions on the chemical nature of volcanism on Io, the origin of Ganymede's grooved terrain, the nature of extrusive deposits on Ariel and Miranda, the formation of Miranda's coronae, and the physical nature and origin of plumes and dark streaks on Triton. The book also groups together, probably for the first time, geologic interpretations that up to tens of kilometers of strike-slip fault motion (transform motions in some cases) may have occurred on Europa, Ganymede, Enceladus, and Ariel.

Rothery's treatment will be unsatisfying to most scientists and advanced graduate students in earth and planetary sciences, because of the lack of quantitative analysis and the lack of references within the text. However, an abbreviated bibliography at the end of the book can allow the interested reader to access some of the pertinent literature. This book certainly is not recommended as a graduate-level text. There are several factual errors, although these are minor in comparison to the great number of facts and technical arguments that Rothery presents correctly. This book should be especially well received by a select group of lay readers and lower level undergraduate geology students. Certain advanced students and professionals in earth and planetary sciences also may benefit by the book's broad overview. David Rothery has helped bridge the chasm between planetary science and terrestrial geology, especially in bringing home the striking similarities and stark differences among the many bizarre worlds in the distant realms of our Solar System and between those worlds and Earth.

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Life in Amber. *George O. Poinar, Stanford University Press, Stanford, California, 1992, xii + 350 p., 8 colored pls., $55.*

Amber has long engaged human imagination. It is an attractive "gem." The beautifully preserved insects and other organisms embedded in amber are widely appreciated, both for scientific importance and cultural allusions. Amber artifacts are a fascinating part of archaeology. Amber's unusual electrical properties are intriguing. The botanical origin of amber, its behavior as a sedimentary material, its diagenesis—all are geological problems not fully solved. Amber literature includes classic writings, poetry, and fictional references as well as scientific accounts ranging from the studies of amateurs to those of professional scientists of the highest calibre. Poinar's book draws from a very wide range of published information. His own extensive work is a continuation of studies by the Berkeley group of entomologists and paleontologists. The book is a wide-ranging, authoritative compilation bringing order to an enormous mass of widely dispersed information. It should be consulted by anybody confronted with an amber-related geological or biological problem.

Amber studies have explosively expanded in volume and scope during the past few decades. Prior to the 1960s, Baltic amber and that from Cedar Lake in Canada supplied the overwhelming bulk of amber and inclusions available for study. Since then, very large collections of Chiapanecan amber and Dominican amber have been gathered and studied. Also, many lesser localities have been uncovered, rediscovered, or merely critically studied and evaluated. Poinar's book is an organized comprehensive introduction to the geology of amber occurrences.

Until recently, ideas about the botanical origin of amber were almost entirely based on association with fossil plants. Widespread use of infrared and nuclear magnetic resonance spectroscopy has permitted direct comparison of ambers with plant resins of known origin. This has drastically altered conceptions of botanical origin so that most pre-1960 interpretations are no longer tenable. Poinar's book will bring you up to speed in this department. Analysis of amber resinoids, however, is still a very active field, and ideas may be expected to continue to change.

Poinar, an entomologist, emphasizes the biology of amber inclusions. The largest section of the book is a critical catalogue of inclusions, genus by genus. This is not easy reading, but it is a really valuable reference for students of specific organic groups. The relatively short discussion of paleoecology of amber and its inclusions and Poinar's comments on the paleogeographic implications of the inclusions, should interest any student of Earth history.

Poinar also summarizes the processes of resin accumulation and diagenesis. Much has been accomplished in these fields during the past three decades, but they remain imperfectly understood.

Finally, geologists will appreciate the comprehensive account of the geology and stratigraphy of inclusion-bearing amber deposits.

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The BIRPS Atlas: Deep Seismic Reflection Profiles Around the British Isles. *S. Klemperer and R. Hobbs. Cambridge University Press, Cambridge, UK, 1991, 128 p., $150.*

Over the past 18 years, deep seismic reflection profiling has grown from a few interesting experiments performed by academics to emerge as an essential tool in mapping subsurface structural variations within and around the continents. The BIRPS (**B**ritish **I**nstitutions **R**eflection **P**rofiling **S**yndicate) group has been collecting such data around the UK since 1981 and established itself early on as the premier organization for data gathering and interpretation of deep reflection profiles in Atlantic-type continental margins. Although the results from these studies are presented in a variety of published articles, Simon Klemperer and Richard Hobbs have compiled the basic information (in the form of stacked seismic data with some limited interpretation) into an atlas for distribution. The result is an excellent product for anyone interested in examining, evaluating, and, undoubtedly, reinter-

Book Reviews *continued on p. 140*

preting the more than 12,000 km of profiles that have been recorded over the past 12 years in this area. The atlas also includes nearly 2000 km of industry profile that have been released to BIRPS.

The atlas is separated into two parts: (1) a book that describes the program objectives, individual profile and area objectives, data acquisition, processing, and some interpretation, and (2) six packets containing the stacked, and in some cases migrated, profiles for six geographic areas—northwest Scotland, the Caledonides west of Britain and Ireland, the Variscides southwest of Britain and Ireland and the Atlantic margin, the northern North Sea, central North Sea, and the southern North Sea and the London platform. The data are plotted at a sufficiently large scale to be useful (typically 1:200,000 with no vertical or horizontal exaggeration for a velocity of 6.0 km/s), and a map of all of the line locations is provided at a scale of 1:2,000,000.

Sufficient information is provided on the acquisition and processing parameters such that most seismic specialists will be able to evaluate the effectiveness of the data gathering and reduction. For those who wish to examine the data with different processing parameters, the digital tapes are available from the British Geological Survey in Edinburgh. However, the real value of an atlas such as this one, and of others that have become available in recent years for similar projects (e.g., the COCORP atlas and the DEKORP atlas), is that they make the data accessible to a large group of nonspecialists who may not be capable, or willing, to rework the digital information on their own, but who may be most interested in what is visible on them. Klemperer and Hobbs provide sufficient geological background and basic data interpretation for most regions that nearly all interested earth scientists will find the atlas useful.

I have been using BIRPS data in classes for ten years; this atlas will now make it possible for many other earth scientists to do the same. In this regard, and because the data are a valuable research tool, this volume is essential for all libraries; however, the price may limit its distribution to individuals. This is a pity when one considers that the costs of acquiring these profiles were enormous, and that much of the information could be obtained in no other way. In this context, as well as in the scientific value of the information, this atlas is a bargain. I highly recommend it.

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The Mesozoic Pacific: Geology, Tectonics, and Volcanism.

Malcom S. Pringle, William W. Sager, William V. Sliter, and Seth Stein, editors. American Geophysical Union,Geophysical Monograph 77, Washington, 1993, 435 p., cloth, $54.

This monograph commences with a graceful and cogent appreciation of the contributions to Pacific geology by the late Sy Schlanger. It continues with 19 scientific articles that report a selection of recent studies of the western and central part of the Pacific Ocean basin from the Late Jurassic through the Cretaceous. Sets of papers indicate a number of the foci of current Pacific research. One of these is the igneous and oceanographic events of Aptian and Albian time, at the beginning of the Cretaceous magnetic superchron. New data and new or updated interpretations of the biostratigraphy and various manifestations of igneous activity are given, including the geochemistry of the Ontong Java Plateau, the general bathymetry of the mid-Pacific, and volcanic sequences. The tectonic evolution of the Cretaceous plates, guyots of the western Pacific, and the petrology and ages of chains of seamounts and islands are other foci. Most of these, too, provide information about mid-Cretaceous igneous activity, when Earth was losing heat at a rate about one-third greater than normal.

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Permo-Triassic Events in the Eastern Tethys.

Edited by W. C. Sweet, Yang Zunyi, J. M. Dickins, and Yin Hongfu. Cambridge University Press, Cambridge and New York, 1992, 181 p.

For students of the Permo-Triassic or for those wishing to delve into some of the most relevant issues in that critical interval of time during which Earth's lithosphere, biosphere, and atmosphere were in upheaval, here is a multi-author book that should not be missed. It focuses on the eastern Tethys and offers comparisons with the central and western Tethys. In my opinion, the value of this book rests upon its wide range of topics and broad-based subject matter. Topics address sea level and geochemical changes, brachiopods, ammonites, conodonts, plants, correlation of nonmarine boundaries, paleomagnetism, volcanic activity, and the remarkable biotic turnover that marks the Permo-Triassic boundary. This work is an international synthesis from IGCP Project 203 which encompasses five years of investigations on stratigraphy, stratigraphic classification, and regional correlations between the eastern and western Tethys. It offers 16 papers by 40 specialists from China, Russia, the United States, France, Spain, Italy, Denmark, India, New Zealand, and Australia. Numerous Chinese authors concentrate on south China, where complete sequences through the Permo-Triassic boundary are believed to exist. Yang and Li treat the boundary problems. Ding provides conodont control in numerous measured sections, Yin et al. discuss mass extinctions and clay rocks at the boundary to bolster support for the effects of volcanism, and Chai et al. discuss the elemental geochemistry of clays, microspherules, and clastic rock debris at the Permian-Triassic (P-T) boundary to compare volcanic eruptive vs. bolide impact ideas. These authors believe that either a bolide triggered the voluminous volcanic output at the P-T boundary or such a cosmic event was merely coincident with volcanic processes already underway near the end of the Permian. Xu and Grant treat the Permian succession of brachiopods in south China and mass extinction of

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reef-dwelling taxa. All these issues, of course, hinge on the reliability of correlations and the scale of biostratigraphic resolution. Toward this goal, a contribution by Walter Sweet is particularly relevant. It provides a conodont-based, high-resolution biostratigraphic analysis of the P-T boundary at Kashmir, Pakistan, Iran, and Dzhulfa and south China.

Other regions discussed include India (Kapoor; Tiwari and Vijaya), the Mediterranean (Cassinis et al.), the former USSR (Zakarov), Israel (Eshet), and Australia and New Zealand (Dickins and Campbell). Broglio Loriga and Cassinis present fossiliferous sections from the Bellerophon and Werfen formations in the southern Italian Alps which appear to be completely transitional, and they argue against the traditional view that these Permo-Triassic rocks record a significant time gap.

Judicious editing has created uniformity and easy reading in this well-illustrated and well-indexed book, making it a valuable contribution toward our knowledge of Permo-Triassic events.

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The Geology of the Carolinas. *Edited by J.W. Horton, Jr., and V. A. Zullo. University of Tennessee Press, Knoxville, 1991, 406 p., $49.95.*

This useful reference volume was begun in 1987 to commemorate the 50th anniversary of the founding of the Carolina Geological Society. Forty-one active and two recently deceased investigators from state and federal agencies and state and private colleges and universities contributed to make this volume a state-of-the-art summary of the geology of North and South Carolina. The 19 chapters include an Introduction by the editors, seven chapters devoted to the crystalline rocks of the Blue Ridge and Piedmont (five are geographically focused, one is devoted to plutonism, and one to metamorphism); two chapters cover early Mesozoic history (one on extensional basins and one on igneous rocks); six chapters cover the stratigraphy and biostratigraphy of the Cretaceous and Cenozoic sediments of the Atlantic Coastal Plain; and the final three chapters deal with surficial geology and geomorphology, evidence for Cenozoic tectonism, and an excellent summary of mineral resources.

Chapter 1 by Horton and Zullo contains a useful review and discussion of the pros and cons of the belt terminology, particularly as applied to the crystalline rocks of the Carolinas. For anyone interested in recent work on and differing interpretations of the complex Piedmont province, the four chapters on the Piedmont are invaluable. Particularly noteworthy is the discussion by Butler and Secor of the tectonic model of M. W. Higgins for the southern Appalachians. In chapter 6, by Maher, Sacks, and Secor, we are led through the complexities of the tectonothermal history of the eastern Piedmont of South Carolina. It is in this geographic area, by these and other referenced researchers, that we have the first recognition of the importance of post-Devonian ductile extension in the southern and central crystalline Appalachians.

The chapters on early Mesozoic history are excellent. Both contain a wealth of data and interpretation. Chapter 9 by Olsen and others covers in considerable detail the lithostratigraphy and paleontology of the strata in the exposed and buried early Mesozoic basins. Ragland's review of the early Mesozoic igneous rocks includes new compilations and plots of chemical data from many sources.

The six chapters on the Atlantic Coastal Plain differ in approach, amount of detail, and stratigraphic nomenclature, but they all focus on marine transgression and regression. The overview of coastal plain geology in the introductory chapter by Horton and Zullo is a useful guide for the uninitiated. Chapter 15 on sequence stratigraphy of Miocene deposits of the North Carolina continental margin provides the only substantive discussion of offshore geology in the volume. The section on soft-sediment deformation, including liquefaction, in Chapter 18 on Cenozoic tectonics, by Prowell and Obermeier, is particularly informative and well written.

I found relatively few things to criticize. The only typographical error that caught my eye was the 1000-km-long spodumene pegmatite (p. 336). Several of the coastal plain chapters were difficult to follow because not all geographic names were on the maps. Geologic units appear in reverse order of age in the explanation of Figs. 9-3, 9-12, and 11-7. Not everyone will agree with the conclusions of the authors, but that's true of any substantive publication. I have difficulty in reconciling the new map (Fig. 3-2) and interpretation of the Sauratown Mountains anticlinorium in Horton and McConnell's chapter on the western Piedmont with my field observations. That problem can be argued elsewhere or resolved by others.

Of topics treated only superficially in the volume, the most obvious ones are geophysics and the third dimension, modern seismicity, and ties to offshore geology (other than in Chapter 15). None of these interferes significantly with the intent of the volume: to provide an up-to-date summary of the geology of the Carolinas. It will remain an important reference for a long time.

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Heavy Minerals in Colour. *Maria A. Mange and Heinz F.W. Maurer. Chapman and Hall, London, 1992, 147 p., $68.*

"This book is intended primarily as a manual that describes and illustrates the transparent heavy minerals most commonly found in sediments" (from the Preface). It succeeds admirably in this. The book is divided into two parts: Principles and Practice, and Descriptions of Heavy Minerals. The color plates are the essence of the book; all common and some uncommon accessory minerals are represented in beautifully reproduced color photographs. In fact, this book could even be left on your coffee table, and guests would find the photographs beautiful as well as informative.

The best use for this volume, however, is as a laboratory manual next to your microscope. All of the photographs are of grain mounts; the minerals look quite different in thin section. If this is the type of work you do, then this book is essential.

My only criticism of the book is the title and terminology of "heavy minerals." It reminds me of the old riddle, "Which is heavier, a kilogram of zircon or a kilogram of quartz?" As any secondary-school student who has been introduced to the concept of density knows, the answer is "neither." These are not "heavy" minerals; they are "dense" minerals or "accessory" minerals. The silliness of terminology is illustrated on page 5, where the authors discuss "more dense heavy mineral grains." I realize that I am bucking tradition, but accurate terminology encourages clear thinking.

Other than this quibble, I highly recommend this book to anyone working with accessory minerals in sediments, especially if studied in grain mounts. I found almost no typos, the photographs are beautiful, the text is accurate, and the price is very reasonable. It's a good buy.

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Structural Geology of Fold and Thrust Belts. *Edited by Shankar Mitra and George W. Fischer. Johns Hopkins University Press, Baltimore, 1992.*

This is an excellent set of thematic papers that explore the structural evolution of middle to upper crustal levels of compressional orogens. The book is dedicated to David Elliot, one of the pioneers in the study of thrust belt structure and evolution, who published several seminal works in the middle 1970s and died early in his career, in 1982. The contributions in this book reflect the present emphasis in thrust belt research on the timing of structural development, which is approached from three angles: geometry and kinematics, mechanics and mechanisms, and regional structural styles. The volume should be of interest to earth scientists who work in orogenic belts, particularly structural geologists, sedimentologists, and geophysicists. In addition, the text serves as a useful methodological reference for structural geologists who work not only in fold and thrust belts but also in extensional and strike-slip regimes.

Geometric and kinematic studies of fold and thrust belts are fundamental to our understanding of the evolution of compressional orogens. Although simple geometric models of thrust belt formation proposed in the early 1980s have advanced our understanding considerably, contributions in this volume show conclusively that such models are largely inadequate. In the future a much more integrated approach will be required, utilizing extensive kinematic analysis, three-dimensional reconstructions, and geophysical and GPS studies, as well as detailed field studies. In addition, as is pointed out by several of the authors, continued dating of synkinematic minerals will help us place absolute age constraints on complex relative structural chronologies.

The mechanics and mechanisms of deformation within thrust sheets and fault zones is a continued area of emphasis in thrust belt research. As several of the authors suggest, deformation in both middle and upper crustal thrust sheets and fault zones is ductile or macroscopically ductile. Some contributors address the time evolution of such flow through field-based studies of paleostress, finite strain, and the kinematics of faulting. Others show that the study of deformation mechanisms in fault zones can provide critical constraints on the timing and conditions *(P, T)* of thrust sheet movement. Concerning this line of research, some of the authors note that the growing body of experimental deformation studies should be more closely integrated with field studies of fault zones and shear zones in order to better constrain both extrapolations of experimental data to geologic strain rates and the relative contributions of different deformation mechanisms.

In the last section of the book a limited number of regional structural styles are examined. Despite their broad geometric and kinematic similarities, thrust belts contain widely varying structural styles, many demanding unique methods to study the evolution of the structures. In these cases, the authors evaluate large systems of structures in terms of the deformation processes, strength contrasts, and kinematics controlling their formation.

Structural Geology of Fold and Thrust Belts serves as a useful reference that should help to guide future studies of fold and thrust belts, especially field studies. We have a great deal more to learn about the evolution of orogenic belts through integrating geometric models with kinematic and absolute age data and through studies of deformation history.

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Granitoid Rocks. *D. B. Clarke. Chapman and Hall, New York, 1992, 283 p., $45.*

This book, designed "as a bridge between the specialist and the generalist," attempts to summarize the knowledge required to make a careful and complete study of a granitoid pluton. The sections on field technique and granitoid classification are a good introduction for anyone wishing to work on plutonic rocks. The emphasis on field work and field observation in a book about granitoids is refreshing. Many established petrologists, as well as students embarking on a study of plutons, will find this part of the book very useful. Tables and enumerated lists of useful information given throughout the book are handy references.

Much of the text is devoted to a rather superficial treatment of geochemistry, experimental petrology, and case studies. Clarke's intent is that the reader look up listed references for more information, but a book designed as an introduction should be more self-contained. The discussion of geochemistry is particularly frustrating—always, it seems, stopping short of providing real insight into the logic involved in interpreting and applying geochemical data. A novice reading about the critical issue of whether a granitoid represents a liquid, an accumulation of crystals, or some mixture of the two is looking for specific ideas on how to deal with the problem. Instead, he or she is told "Good luck!" Some important concepts, most notably AFC and other complex processes, are glossed over. The presentation is often flavored (sometimes too strongly) by the author's opinions about the relative importance of various magmatic processes and geological tools. A few of the diagrams, including several at the end of chapter 4, will convey no useful information to the generalist. Despite these weaknesses, *Granitoid Rocks* is a useful addition to my library. I recommend it to any student or professional planning to make a detailed study of a granitoid pluton.

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CALL FOR GSA COMMITTEE SERVICE—1995

The GSA Committee on Committees wants your help in finding potential candidates to serve on committees of the Society or as GSA representatives to other organizations. You can help by volunteering yourself or suggesting the names of others you think should be considered for any of the openings and submitting your nomination on the form below. Younger members are especially encouraged to become involved in Society activities.

Listed here are the number of vacancies along with a brief summary of what each committee does and what qualifications are desirable. If you volunteer or make recommendations, please give serious consideration to the special qualifications for serving on a particular committee. *Please be sure that your candidates are Members or Fellows of the Society and that they meet fully the requested qualifications.*

Volunteering or Making a Recommendation

All nominations received at headquarters by **July 15, 1994,** on the official one-page form will be forwarded to the Committee on Committees. *Council requires that the form be complete.* Information requested on the form will assist the committee members with their recommendations for the 1995 committee vacancies. Please use one form per candidate (additional forms may be copied). The committee will present at least two nominations for each open position to the Council at its October 26 meeting in Seattle, Washington. Appointees will then be contacted and asked to serve, thus completing the process of bringing new expertise into Society affairs.

Committee on Committees

The 1994 committee consists of the following people: Chairman **James F. Tull,** Department of Geology, Florida State University, Tallahassee, FL 32306-3026, (904) 644-1448; **Mary P. Anderson,** Department of Geology and Geophysics, University of Wisconsin, Madison, WI 53706, (608) 262-2396; **Mohamed T. El-Ashry,** World Bank, 1818 "H" Street, Washington, DC 20433, (202) 473-3202; **John W. Hess, Jr.,** Desert Research Institute, Las Vegas, NV 89132-0040, (702) 895-0451; **Jerome F. Machamer,** 6217 Lee Highway, Arlington, VA 22205-2011, (703) 237-6257; **E. R. Ward Neale,** Geological Survey of Canada, 3303 33rd Street NW, Calgary, Alberta T2L 2A7, Canada (403) 292-7000.

NOMINATION FOR GSA COMMITTEES FOR 1995

(One form per candidate, please. Additional forms may be copied.)

(Please print)

Name of candidate _____

Address _____

_____

Phone ( ) _____

COMMITTEE(S) BEING ☐ VOLUNTEERED OR ☐ NOMINATED FOR (please check):

Committee(s):

Comment on special qualifications:

☐ GSA Fellow
☐ GSA Member

Section affiliation:
Division affiliation(s):

Brief summary of eduction:

Brief summary of work experience (include scientific discipline, principal employer—e.g., mining industry, academic, USGS, etc.):

If you are VOLUNTEERING to serve GSA, please give the names of 2 referees/references (please print):

Name: _____

Phone: ( ) _____

Name: _____

Phone: ( ) _____

If you are NOMINATING SOMEONE other than yourself to serve GSA, please give your name, address, and phone number (please print):

Name: _____

Address: _____

_____

Phone: ( ) _____

DEADLINE: Please return this form to headquarters by July 15, 1994. Form must be complete to be considered. Mail to GSA Executive Director, P.O. Box 9140, Boulder, CO 80301.

Call for GSA Committee Service—1995

Day Medal (2 vacancies)
Selects candidates for the Arthur L. Day Medal. Committee members should have knowledge of those who have made "distinct contributions to geologic knowledge through the application of physics and chemistry to the solution of geologic problems."

Education
(3 vacancies—1 member-at-large; 2 secondary teacher vacancies)
Stimulates interest in the importance and acquisition of basic knowledge in the earth sciences at all levels of education.

Committee members work with other interested scientific organizations and science teachers' groups to develop precollege earth-science education objectives and initiatives. The committee also promotes the importance of earth-science education to the general public.

Geology and Public Policy (3 vacancies)
Translates knowledge of the earth sciences into forms most useful for public discussion and decision making.

Committee members should have an awareness of public policy and decisions involving the science of geology. They should also be able to develop, disseminate, and translate information from the geological sciences into useful forms for the general public and for the Society membership; they should be familiar with appropriate techniques for the dissemination of information.

Honorary Fellows (2 vacancies)
Selects candidates for Honorary Fellows, usually non–North Americans.

Committee members should have knowledge of geologists throughout the world who have distinguished themselves through their contributions to the science.

Membership (2 vacancies)
Screens Member and Fellow applications; evaluates membership benefits and makes recommendations to the Council about them.

Committee members must be GSA Fellows and must be able to attend one meeting a year. Previous experience in recruitment programs and in the evaluation of professional qualifications is desired.

Minorities and Women in the Geosciences (3 vacancies)
Stimulates recruitment and promotes positive career development of minorities and women in the geoscience professions.

Committee members should be familiar with minority and female education and employment issues and have expertise and leadership in such areas as human resources and education. Membership shall include representation of minorities and women and representatives from government, industry, and academia.

Nominations (5 vacancies; one position for a member from Canada or Mexico)
Recommends to the Council nominees for the positions of GSA officers and councilors.

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Committee *continued from p. 142*

Committee members should be familiar with a broad range of well-known and highly respected geological scientists.

Penrose Conferences (2 vacancies)
Reviews and approves Penrose Conference proposals; recommends and implements guidelines for the success of the conferences.

Committee members must either be past conveners or have attended two or more Penrose Conferences.

Penrose Medal (3 vacancies)
Selects candidates for the Penrose Medal.

Committee members should be familiar with outstanding achievements in the geological community that are worthy of consideration for the honor. Emphasis is placed on "eminent research in pure geology which marks a major advance in the science of geology."

Research Grants (3 vacancies)
Evaluates research grant applications and selects grant recipients.

Committee members must be able to attend the spring meeting and should have experience in directing research projects and in evaluating research grant applications.

***Treatise on Invertebrate Paleontology* (1 vacancy)**
Advises the *Treatise* editor in all phases of *Treatise* policy including planning of new volumes as well as revisions; also gives advice on special editorial matters such as acceptance or rejection of contributed manuscripts.

Committee members should be familiar with and have a broad understanding of paleontology.

Young Scientist Award (Donath Medal) (1 vacancy)
Selects candidates for the Donath Medal.

Committee to have members covering a broad range of disciplines, i.e., geophysics, economic geology, stratigraphy, etc.

Committee members should have knowledge of young scientists with "outstanding achievement(s) in contributing to geologic knowledge through original research which marks a major advance in the earth sciences."

GSA Representative to the North American Commission on Stratigraphic Nomenclature (1 vacancy)
Must be familiar with and have expertise in stratigraphic nomenclature. ■

ACKNOWLEDGMENT

The GSA Council acknowledges with thanks the many member-volunteers who, over the years, have stimulated growth and change through their involvement in the affairs of the Society.

Each year GSA asks for volunteers to serve on committees, and many highly qualified candidates express their willingness to serve. Not everyone can be appointed to the limited number of vacancies; however, members are reminded that there are also opportunities to serve in the activities and initiatives of the sections and divisions. Annually, Council asks sections and divisions to convey the names of potential candidates for committee service to the Committee on Committees. The Southeastern and South-Central Sections have diligently responded to this call.

MEETINGS

■ Indicates new or changed information

GSA Penrose Conferences

June 1994

Fractured Unlithified Aquitards: Origins and Transport Processes, June 15–20, 1994, Racine, Wisconsin. Information: John A. Cherry, Waterloo Centre for Groundwater Research, University of Waterloo, Waterloo, Ontario N2L 3G1, Canada, (519) 885-1211, ext. 2892, fax 519-746-5644; David M. Mickelson, Dept. of Geology and Geophysics, University of Wisconsin, 1215 W. Dayton St., Madison, WI 53706, (608) 262-7863, fax 608-262-0693; William W. Simpkins, Dept. of Geological and Atmospheric Sciences, 253 Science I, Iowa State University of Science and Technology, Ames, IA 50011, (515) 294-7814, fax 515-294-6049.

1994 Meetings

May

GSA Rocky Mountain Section Meeting, May 4–6, 1994, Durango, Colorado. Information: Douglas Brew, Geology Dept., Ft. Lewis College, Durango, CO 81301, (303) 247-7254, fax 303-247-7310.

Geologic Remote Sensing Tenth Thematic Conference, May 9–12, 1994, San Antonio, Texas. Information: ERIM/Thematic Conferences, P.O. Box 134001, Ann Arbor, MI 48113-4001, (313) 994-1200, ext. 3234, fax 313-994-5123, Internet: wallman@vaxb.erim.org.

Midwest Friends of the Pleistocene Annual Meeting, May 13–15, 1994, Cincinnati, Ohio. Information: Tom Lowell, Dept. of Geology, University of Cincinnati, Cincinnati, OH 45226, (513) 556-4165, E-mail: Lowelltv@ucbeh.san.uc.edu; or Scott Brockman, Division of Geological Survey, Ohio Department of Natural Resources, Columbus, OH 43224, (614) 265-6604.

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

Pan-American Current Research on Fluid Inclusions (PACROFI V), May 19–21, 1994, Cuernavaca, Morelos, Mexico. Information: David A. Vanko, Dept. of Geology, Georgia State University, Atlanta, GA 30303, fax 404-651-1376, E-mail: geodav@gsusgi1.gsu.edu.

National Association of Geology Teachers, Eastern Section Annual Meeting, May 20–22, 1994, Nyack, New York. Information: Michael J. Passow, 296 Central Ave., Englewood, NJ 07631, (201) 871-0846.

Northeast Friends of the Pleistocene Annual Meeting, May 20–22, 1994, Hazelton, Pennsylvania. Information: Duane Braun, Geography and Earth Science Dept., Bloomsburg University, Bloomsburg, PA 17815, (717) 389-4139.

High-Level Radioactive Waste Management International Conference, May 22–26, 1994, Las Vegas, Nevada. Information: Tom Sanders, Attn: Transactions Office, American Nuclear Society, 555 N. Kensington Avenue, La Grange Park, IL 60525.

Glacial Cycles at High Latitudes, May 29–June 1, 1994, Fjærland, Norway. Information: Berit H. Barkley, Dept. of Geology, P.O. Box 1047 Blindern, 0316 Oslo, Norway, 47-22-856691, fax 47-22-854215.

June

1st North American Rock Mechanics Symposium, June 1–3, 1994, Austin, Texas. Information: NARM Symposium, Continuing Engineering Studies, Cockrell Hall 10.324, University of Texas, Austin, TX 78712; or Priscilla Nelson, (512) 471-5664; or Stephen Laubach, fax 512-471-0140.

Geochronology, Cosmochronology, and Isotope Geology Eighth International Conference (ICOG-8), June 5–11, 1994, Berkeley, California. Information: Garniss H. Curtis, Institute of Human Origins–Geochronology Center, 2453 Ridge Road, Berkeley, CA 94709, (510) 845-4003, fax 510-845-9453.

Fifth International Conference on Ground Penetrating Radar, June 12–16, 1994, Kitchener, Ontario, Canada. Information: GPR '94, Waterloo Centre for Groundwater Research, University of Waterloo, Waterloo, Ontario N2L 3G1, Canada, (519) 885-1211, ext. 2892, fax 519-725-8720.

Seventh Symposium on the Geology of the Bahamas, June 16–20, 1994, Bahamian Field Station, San Salvador, Bahamas. Information: Mark R. Boardman, Dept. of Geology, Miami University, Oxford, OH 45056; (513) 529-3230, fax 513-529-1542, E-mail: boardman@miamiu; or Daniel R. Suchy, Bahamian Field Station, Ltd., 270 SW 34th St., Ft. Lauderdale, FL 33315, (305) 331-2520.

First International Symposium on Protection and Development of Mountain Environment, June 20–24, 1994, Ponte di Legno, Italy. Information: Man & Mountain '94, c/o Valdepur Service s.r.l., via Seradello 225, 25068 Serezzo (BS), Italy.

Western Society of Malacologists 27th Annual Meeting, June 26–30, 1994, Santa Barbara, California. Information: Henry W. Chaney, Santa Barbara Museum of Natural History, 2559 Puesta del Sol Rd., Santa Barbara, CA 93105, (805) 682-4711, ext. 334, fax 805-569-3170.

July

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

■ **Third Annual Meeting, History of the Earth Sciences Society,** July 7–9, 1994, Troy, New York. Information: Northeastern Science Foundation, Inc., Rensselaer Center of Applied Geology, 15 Third Street, P.O. Box 746, Troy, NY 12180, (518) 273-3247

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

Geological Indicators of Rapid Change, International Workshop, July 11–18, 1994, Corner Brook, Newfoundland. Information: A. R. Berger, Chairman, Geo-Indicators Working Group, 528 Paradise St., Victoria, BC V9A 5E2, Canada, (604) 480-0840, fax 604-480-0840.

Basement Tectonics 11th International Conference, July 25–29, 1994, Potsdam, Germany. Information: Onno Oncken, Conference Chairman, GeoForschungs Zentrum, Telegrafenberg, D-0-1561 Potsdam, Germany, phone 49-331-310601, fax 49-331-310306.

Society for Industrial and Applied Mathematics Annual Meeting, July 25–29, 1994, San Diego, California. Information: SIAM Conference Coordinator, 3600 University City Science Center, Philadelphia, PA 19104-2688, (215) 382-9800, fax 215-386-7999, E-mail: meetings@siam.org.

August

New Perspectives in the Appalachian-Caledonian Orogen: A Symposium in Honour of Hank Williams, August 12–13, 1994, (field trip August 14–19), Corner Brook, Newfoundland, Canada. Information: J. Hibbard, MEAS, Box 8208, NCSU, Raleigh, NC 27695, (919) 515-7242, fax 919-515-7802, E-mail: hibbard@meavax.nrrc.ncsu.edu; or C. van Staal, Geological Survey of Canada, 601 Booth St., Ottawa, Ontario K1A 0E8, Canada, (613) 995-4333, fax 613-995-7997, E-mail: vanstaal@cc2sutp.emr.ca.

Meetings *continued on p. 144*

Clay Minerals Society 31st Annual Meeting, August 13–18, 1994, Saskatoon, Saskatchewan, Canada. Information: Ahmet R. Mermut, Dept. of Soil Science, Saskatchewan Institute of Pedology, University of Saskatchewan, Saskatoon S7N 0W0, Canada, (306) 966-6839, fax 306-966-6881, E-mail: mermut@sask.usask.ca.

West Australian Basins Symposium, August 14–17, 1994, Perth, Australia. Information: Petroleum Exploration Society Australia, Attn.: J. B. O'Reilly/N. K. Guppy, P.O. Box 1102, West Perth, W.A. 6872, Australia, phone 61-9-481-6666, fax 61-9-481-1952.

The South Atlantic: Present and Past Circulation, August 15–18, 1994, Bremen, Germany. Information: South Atlantic Symposium, Barbara Donner, Fachbereich Geowissenschaften der Universität, Postfach 33 04 40, D-28334 Bremen, Germany.

45th Highway Geology Symposium, August 17–19, 1994, Portland, Oregon. Information: Scott Burns, Dept. of Geology, Portland State University, Portland, OR 97207-0751, (503) 725-3389, fax 503-725-3025.

14th International Sedimentological Congress, Equatorial Gateway in Atlantic Symposium, August 21–26, 1994, Recife, Brazil. Information: Luba Jansa, Bedford Institute of Oceanography, Dartmouth, N.S., Canada B2Y 4A2, (902) 426-2734, fax 902-426-4465, E-mail: jansa@agcrr.bio.ns.ca.

International Geographical Union Regional Conference, Environment and Quality of Life in Central Europe: Problems of Transition, August 22–26, 1994, Prague, Czech Republic. Information: Conference Secretariat, IGU RC 1994, Albertov 6, 128 43 Praha 2, Czech Republic, phone 42-2-24912060, or 42-2-296025, fax 42-2-24915817 or 42-2-296025, E-mail: kucera@prfdec.natur.cuni.cz

■ **Mapping & Remote Sensing Tools for the 21st Century,** August 26–29, 1994, Washington, D.C. Information: ASPRS, Dept. DP, 5410 Grosvenor Lane, Suite 210, Bethesda, MD 20814-2160, (301) 493-0290, fax 301-493-0208, E-mail: e7g4hem@toe.townson.edu

International Symposium on Paleoenvironmental History of East and South Asia and Cretaceous Correlation (IGCP 350), Taegu, Korea. Information: Ki-Hong Chang, Dept. of Geology, Kyungpook National University, Taegu, Korea 702-701, phone 82-53-950-5355, fax 82-53-957-0431, E-mail: khchang@bh.kyungpook.ac.kr.

Proterozoic Crustal and Metallogenic Evolution, August 29–September 1, 1994, Windhoek, Namibia. Information: G.I.C. Schneider, Geological Society of Namibia, P.O. Box 699, Windhoek, Namibia, phone 264-61-37240, fax 264-61-228324.

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

September

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

■ **Arctic Ocean Grand Challenge, Scientific Rationale–Strategy–Science Plan,** Helsinki, Finland, September 2–7, 1994. Deadline for applications: May 6, 1994. Information: Josip Hendekovic, European Science Foundation, 1 quai Lezay-Marnésia, 67080 Strasbourg Cedex, France, phone 33-88-76-71-35, fax 33-88-36-69-87.

Prospecting in Areas of Glaciated Terrain—Tenth Conference, September 5–7, 1994, St. Petersburg, Russia. Information: The Conference Office, The Institution of Mining and Metallurgy, 44 Portland Place, London W1N 4BR, England, phone 44-71-580-3802, fax 44-71-436-5388.

Biotic Recoveries from Mass Extinctions, IGCP Project 335, September 5–8, 1994, Plymouth, United Kingdom. Information: Malcom B. Hart, Dept. of Geological Sciences, University of Plymouth, Drake Circus, Plymouth, Devon P1A 8AA, UK, fax 44-745-233-117; or Douglas H. Erwin, Dept. of Paleobiology, NHB-121, Smithsonian Institution, Washington, DC 20560, (202) 357-2053.

International Conference on Arctic Margins, (ICAM '94), September 5–9, 1994, Magadan, Russia. Information: Kirill V. Simakov, North East Science Center, Russian Academy of Sciences, 16 Portovaya St., Magadan, Russia 685000, (907) 474-7219 (USA) or 7-41-3-223-0953 (Russia); or Dennis K. Thurston, Minerals Management Service, 949 E. 36th Ave., Anchorage, AK 99508-4302, (907) 271-6545, fax 907-271-6565.

■ **Alluvial Basins: Past and Present Environments,** Lunteren, The Netherlands. September 10–15, 1994. Information: Josip Hendekovic, European Science Foundation, 1 quai Lezay Marnésia, 67080 Strasbourg Cedex, France, phone 33-88-76-71-35, fax 33-88-36-69-87.

First International Airborne Remote Sensing Conference and Exhibition: Applications, Technology, and Science, September 11–15, 1994, Strasbourg, France. Information: Robert Rogers, ERIM, Box 13001, Ann Arbor, MI 48113-4001, (313) 994-1200, ext. 3234; fax 313-994-5123.

Illinois Basin Energy and Mineral Resources Workshop, September 12–13, 1994, Evansville, Indiana. Infomation: Theola Evans, Kentucky Geological Survey, 228 MMRB, University of Kentucky, Lexington, KY 40506, (606) 257-5500, E-mail: theola@kgs.uky.edu.

Salt Tectonics, September 14–15, 1994, London, England. Information: Ian Alsop, Derek Blundell, and Ian Davison, Dept. of Geology, Royal Holloway, University of London, Egham, Surrey, UK, phone 44-784-443615, fax 44-784-471780.

Underground Technology Research Council, September 16–18, 1994, Chicago, Illinois. Information: John MacDonald, Meeting Chairman, Guy F. Atkinson Construction Company, P.O. Box 428, Enumclaw, WA 98022, (206) 825-1410, fax 206-825-2514; or Frank Kendorski, UTRC Chairman, Morgan Mining & Environmental Consultants, Ltd., 4921 Chase Avenue, Downers Grove, IL 60515, (708) 305-7900, fax 708-305-9841.

Fifth International Mine Water Congress, September 18–23, 1994, Nottingham, UK. Information: Conference Secretary, IMWA Conference, c/o Department of Mineral Resouces Engineering, University of Nottingham, University Park, Nottingham NG7 2RD, UK.

Geomorphology and Natural Hazards, (25th Annual Binghamton Geomorphology Symposium), September 24–25, 1994, Binghamton, New York. Information: Marie Morisawa, Dept. of Geol. Sciences and Environmental Studies, State University of New York, Binghamton, NY 13902-6000, (607) 777-2837, fax 607-777-2288, E-mail: marieem@bingvmb.cc.binghamton.edu.

Society for Organic Petrology 11th Annual Meeting, September 25–30, 1994, Jackson, Wyoming. Information: Ron Stanton, U.S. Geological Survey, 956 National Center, Reston, VA 22092, (703) 648-6462, fax 703-648-6419, E-mail: rstanton@ncrds.usgs.er.gov.

Geochemical Event Markers in the Phanerozoic, final meeting of IGCP Project 293, September 26–28, 1994, Erlangen, Germany. Information: Michael M. Joachimski, Institute of Geology and Mineralogy, University of Erlangen/Nürnberg, Schlossgarten 5, 91054 Erlangen, Germany, 49-9131-852615, fax 49-9131-859295; or Helmut H. J. Geldsetzer, Geological Survey of Canada, 3303-33rd St., N.W., Calgary, Alberta T2L 2A7, Canada, (403) 292-7155, fax 403-292-5377.

■ **Littoral 94,** European Coastal Zone Association for Science and Technology Second International Symposium, September 26–29, 1994, Lisbon, Portugal. Information: Associação EUROCOAST-Portugal, a/c Instituto de Hidráuclica e Recursos Hídricos, Faculdade de Engenharia-Universidade do Porto, Rua dos Bragas, 4099 Porto Codex Portugal, fax 351-2-310870, 351-2-318787, 351-2-319280.

12th Australian Geological Convention, September 26–30, 1994, Perth, Australia. Information: Secretary, 12AGC, P.O. Box 119, Cannington, WA 6107, Australia, 61-9-351-7968, fax 61-9-351-3153.

Eco Rio '94, International Symposium on Resource and Environmental Monitoring, September 26–30, 1994, Rio de Janeiro. Information: National Institute of Space Research—INPE c/o Mônica Oliveira, CRI, P.O. Box 515, Av. dos Astronautas, 1758-CEP 12227-010, San José dos Campos, SP-Brazil, phone 55-123-22-9816 or 41-8977, ext. 250, fax 55-123-21-8543 or 22-9325.

October

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

Meetings *continued on p. 147*

1994 GeoVentures

GEOTRIP

Rim to River: Moab, Canyonlands, and Cataract Canyon

Great value for an exceptional trip!

7 days, 8 nights: May 28–June 4, 1994

Scientific Leaders: **Kenneth Kolm and John Emerick,** *Colorado School of Mines*
John A. Campbell, *Ft. Lewis College*

Itinerary

May 28, Saturday—Travel day to Moab. Orientation at 7:30 p.m.
May 29, Sunday—La Sal Mountains. Paradox Valley overview. Lodging in Moab.
May 30, Monday—Arches National Park and vicinity. Lodging in Moab.
May 31–June 3, Tuesday–Friday—Hike to the River on Upheaval Trail. Hiking in Canyonlands including Powell's Overlook and the Maze District. Tent camping.
June 4, Saturday—Rafting Cataract Canyon. Hike in Dark Canyon. Sunset overflight of Canyonlands and return to Moab for farewell dinner at Mi Vida.
June 5, Sunday—Travel day.

Fee and Deposit

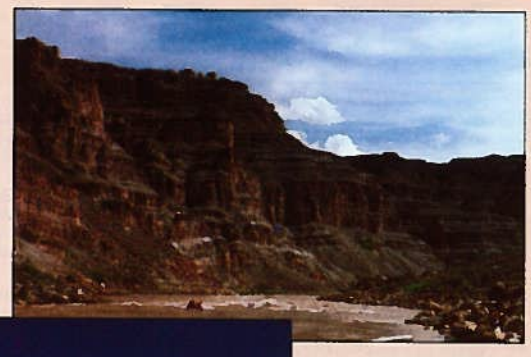
Estimated Cost: GSA Member: $1220. Nonmember: $1370.
Based on 24 people. May be more if there are fewer registrants. If you have previously traveled on a GSA GeoTrip, the nonmember surcharge will be waived.
Total balance due: April 1. Minimum age: 21. Limit: 24 persons.

Fee includes all meals except dinner on the arrival day and breakfast on the departure day; comfortable van transportation; double-occupancy lodging in Moab; five days of rafting; tents, sleeping bags, and pads when camping; geological reading material and guidebook; sunset overflight of Canyonlands; and, of course, the final dinner at Mi Vida.

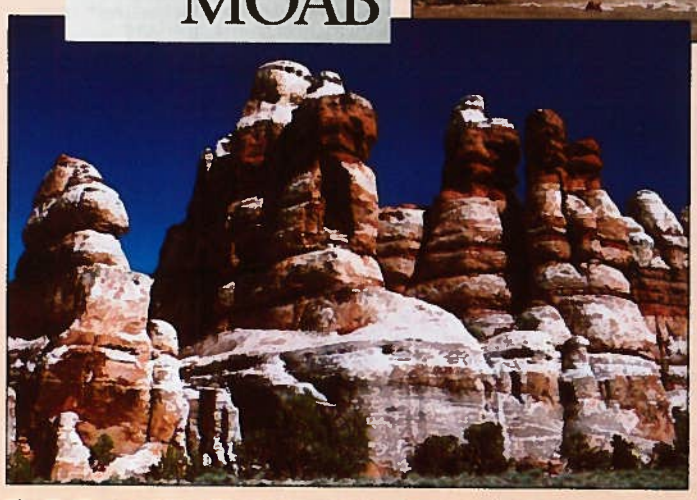
Not included is airfare to and from Grand Junction, Colorado, or transfer to Moab, Utah. We will arrange for an optional group pick-up and return. The cost is about $20 each way (100 miles).

Air Transportation

Air transportation can be arranged by Cain Travel Agency in Boulder, 1-800-346-4747, Monday through Friday, 8:30 a.m. to 5:30 p.m. MST. Please ask for Robin Langerak.



Cataract Canyon
Ken Kolm



The Dollhouse, Maze District, Canyonlands *Ken Kolm*

GEOHOSTEL

Scenic Geology and Natural History of the Central Colorado Rocky Mountains

Western State College, Gunnison, Colorado

5 days, 6 nights: June 25–30, 1994

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

Chari Mountain, McClure's Pass: Elk Range, Colorado
Ken Kolm

Itinerary—*All trips begin and end in Gunnison.*

Saturday, June 25
7:00 to 9:00 p.m.—Welcoming Reception.
Sunday, June 26
8:00 a.m. to 5:00 p.m.—Geological Sequence of Central Colorado.
Monday, June 27
8:00 a.m. to 1:00 p.m.—Geology of the Gunnison Valley.
Tuesday, June 28
8:00 a.m. to 5:00 p.m.—Geology of the Northern Rio Grande Rift.
Wednesday, June 29
8:00 a.m. to 12 noon—Features of Calderas and Ash Flow Tuffs of the San Juan Volcanic Field.
1:00 p.m. to 7:00 p.m.—Optional afternoon field trip to the Great Sand Dunes.
Thursday, June 30
8:00 a.m. to 5:00 p.m.—Lake City Tour.
The Farewell Party begins at 7:00 p.m.

Fee and Deposit

Cost: GSA Member: $480. Nonmember: $530.
$100 deposit, due with your reservation; refundable until April 30, less $20 processing fee. Total balance due: May 1. Minimum age: 21. **Limit:** 32 persons.

Fee includes classroom programs and materials, field trip transportation, lodging for 6 nights (single-occupancy, or double for couples, dormitory rooms), breakfast and sack lunch daily through Thursday, tram rides, and welcoming and farewell events. **Not included** are transportation to and from Gunnison, Colorado, transportation during hours outside class and field trips, meals, and other expenses not specifically included.

For Registration or for More Information about 1994 GeoVentures, call Matt Ball or Edna Collis: (303) 447-2020 or 1-800-472-1988

AGU CHAPMAN CONFERENCE

Scrutiny of Undergraduate Geoscience Education: Is the Viability of Undergraduate Geoscience Education in Jeopardy as We Approach the 21st Century?

September 7–11, 1994 • Washington, D.C.

Conveners: Dorothy L. Stout, *Cypress College*
Eugene W. Bierly, *American Geophysical Union*
John T. Snow, *University of Oklahoma*

CALL FOR PAPERS

The purpose of the conference is to bring together geoscientists from diverse backgrounds and expertise to discuss and develop long-term plans to improve the quality of undergraduate geoscience instruction in a world in which content, data, and technology are expanding exponentially.

ABSTRACT DEADLINE: July 15, 1994

REGISTRATION DEADLINE: August 15, 1994

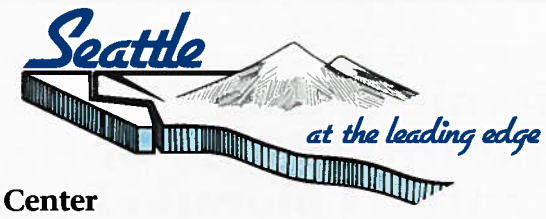
Topics to be discussed:

- What constitutes relevant training for geoscience majors for their future job market?
- What is the collaborative role between geoscience educators and others in the field of geoscience?
- Do we need to improve the teaching of geoscience? If so, how do we do it?
- What are our educational goals for teaching nonmajors in geoscience education?
- What are the demands of a changing world on undergraduate teaching and curriculum?

For further information:
AGU—Meeting Department, 2000 Florida Ave., N.W., Washington, DC 20009,
(202) 462-6900, fax 202-328-0566, E-mail: sbell@kosmos.agu.org.

GSA ANNUAL MEETINGS

1994



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

General Chairman: ***Darrel S. Cowan, University of Washington***
Abstract Deadline: July 6—Call for Papers in April *GSA Today*
Preregistration Deadline: September 16
For information call the GSA Meetings Department, 1-800-472-1988 or (303) 447-2020.

Registration Materials will be in JUNE *GSA Today*—Register Early!

1995

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

General Chairman: ***William R. Craig, University of New Orleans***
Technical Program Chairman: ***Laura Serpa, University of New Orleans***
Call for Field Trip Proposals: *Please contact the Field Trip Chairmen listed below.*

Whitney Autin
Louisiana Geological Survey
P.O. Box G, University Station
Baton Rouge, LA 70893-4107
(504) 388-5320

Duncan Goldthwaite
4608 James Drive
Metairie, LA 70003
(504) 887-4377

Call for
CONTINUING EDUCATION COURSE PROPOSALS

PROPOSALS DUE BY DECEMBER 1

The GSA Committee on Continuing Education invites those interested in proposing a GSA-sponsored or cosponsored course or workshop to contact GSA headquarters for proposal guidelines. Continuing Education courses may be conducted in conjunction with all GSA annual or section meetings. We are particularly interested in receiving proposals for the 1995 New Orleans Annual Meeting or the 1996 Denver Annual Meeting.

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

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

For general information call the GSA Meetings Department, 1-800-472-1988 or (303) 447-2020.

FUTURE

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

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

GSA SECTION MEETINGS

1994

Rocky Mountain Section, Fort Lewis College, Durango, Colorado, May 4–6, 1994. Douglas Brew, Department of Geology, Fort Lewis College, Durango, CO 81301, (303) 247-7254, fax 303-247-7310.

1995

Northeastern Section, Radisson Hotel, Hartford, Connecticut, March 20–22.
Southeastern Section, Knoxville Hilton Hotel, Knoxville, Tennessee, April 6–7.
North-Central and South-Central Sections, University of Nebraska, Lincoln, Nebraska, April 27–28.
Rocky Mountain Section, Montana State University, Bozeman, Montana, May 18–19.
Cordilleran Section, University of Alaska, Fairbanks, Alaska, May 24–26.

May *BULLETIN* and *GEOLOGY* Contents

The Geological Society of America
BULLETIN
Volume 106, Number 5, May 1994

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GEOLOGY
VOLUME 22
NO. 5
P. 385–480
MAY 1994

Forum

CLASSIFIED ADVERTISING

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first 25 lines	$0.00	$1.35
additional lines	$1.35	$1.35

Code number: $2.75 extra

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

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Positions Open

OPPORTUNITIES IN GEOCHEMICAL HYDROLOGY, ORGANIC GEOCHEMISTRY, & STABLE ISOTOPE GEOCHEMISTRY

The Earth Sciences Division of the Lawrence Berkeley Laboratory is seeking up to three experienced scientists specializing in geochemical hydrology, organic geochemistry, and stable isotope geochemistry, respectively, to conduct basic and applied research aimed at understanding processes at the Earth's surface and in the shallow subsurface. The successful applicant will be expected to develop a strong research program relevant to the pressing national needs in environmental restoration and waste management, to aid in the development of larger-scale division research initiatives, to interact with government agencies that fund such research, and to disseminate research results through publications and presentations at scientific meetings. There are opportunities for collaborative research with other Division and U.C. Berkeley scientists who specialize in hydrology, geology, geophysics, and isotope geochemistry. A Ph.D. in hydrology, geochemistry, or a related discipline, and a demonstrated ability to secure research funding are desired.

Please submit one resume, publication record, and names of three references to: Lawrence Berkeley Laboratory, Staffing Office, Box #JGSA2311 (for geochemical hydrology & organic geochemistry) or #JGSA2308 (for isotope geochemistry), One Cyclotron Road, Bldg. 938A, Berkeley, CA 94720. An equal opportunity employer.

FACULTY POSITION
SOUTHERN OREGON STATE COLLEGE
GROUNDWATER GEOLOGIST

The Geology Department at Southern Oregon State College invites applications for a tenure-track faculty position (nine-month academic year appointment beginning September 16, 1994) in Groundwater Geology. The position requires the Ph.D. and is at the Assistant or Associate Professor rank. The individual selected should have strengths in hydrogeology, mineralogy-lithology, and chemistry. Teaching assignments include developing professional and popular course sequences in surface and groundwater hydrogeology; general undergraduate lecture and laboratory courses; and a professional mineralogy-lithology sequence. The successful candidate is expected to continue externally funded research and develop cooperative efforts in hydrogeology with local agencies. Applicants should forward curriculum vitae, descriptions of teaching and research interests, and names of three referees to Professor Monty Elliott, Chair, Dept. of Geology, Southern Oregon State College, 1250 Siskiyou Blvd., Ashland, OR 97250. Southern Oregon State College is an Equal Opportunity/Affirmative Action Employer. Women and people of diverse racial, ethnic, and cultural backgrounds are encouraged to apply. Position will remain open until filled, but preference will be given to applications received before May 15, 1994.

GEOLOGIST

Tenure-track position, Assistant Professor, beginning August, 1994. Ph.D. in Geology required. Seek person with one or more of the following specialties: geohydrology, environmental geology, Pleistocene geology, or geomorphology. Department has twelve full-time faculty members (six geologists) and offers B.S. degrees in Atmospheric Sciences, Geography, Geology, and Masters Degree. Closing date May 30, 1994. Send vita and names of three references to: Dr. Mervin Kontrovitz, Head, Department of Geosciences, Northeast Louisiana University, Monroe, LA 71209-0550. FAX 318-342-1755. EOE/AA.

CALIFORNIA STATE UNIVERSITY, BAKERSFIELD

Subject to available funding, the Department of Physics and Geology invites applications for 1 or 2 1-year sabbatical replacement position(s). Ph.D. or ABD required. We seek candidates with expertise in one of two areas: 1) Environmental geochemistry-contaminant hydrogeology as they apply to shallow aquifers, or 2) Structural geology-geomorphology which can be related to neotectonics of southern California; this person must also be able to teach introductory mineralogy and petrology including optical methods. Experience in the San Joaquin Valley or southern California and willingness to interact with local regulatory agencies and oil companies preferred. Successful applicant(s) will also be expected to participate in our introductory geology and/or physical science courses. CSU Bakersfield has an enrollment of approximately 5,000 students. It is conveniently located near popular beach and mountain attractions, and is a two-hour drive from Los Angeles. Candidates should submit a letter of application, a current curriculum vita, and names of at least three references no later than May 30, 1994 to: Dr. Robert Horton, Chair, Department of Physics and Geology, California State University, 9001 Stockdale Highway, Bakersfield, CA 93311-1099. California State University, Bakersfield, fosters and appreciates ethnic and cultural diversity among its faculty and students and is firmly committed to achieving the goals of equal employment opportunity and Affirmative Action. Applications from women, ethnic minorities, veterans, and individuals with disabilities are welcome.

EXECUTIVE DIRECTOR

SEPM (Society for Sedimentary Geology), a not-for-profit, Tulsa-based, scientific society (ca. 5500 members) engaged in publication, education, and technical meeting activities, is seeking a permanent, full-time Executive Director to lead the Society into the 21st century. Proven management and financial experience plus technological skills in electronic communication and computer publishing are necessary. Applicants should be able to direct a staff of seven full-time professionals, coordinate activities with the elected officers of the Society and numerous volunteer committees, effectively handle financial/budgeting/marketing activities, and should have the vision to explore new directions for Society growth. Excellent oral and written communcation skills are prerequisite. Experience with not-for-profit organizations and fund raising, as well as familiarity with the earth sciences, also are desirable skills. Review of applications will begin 1 August 1994, but the search will remain open until the position is filled. To apply, send vita, names of three references, and a 1-page statement of the skills and vision you would bring to this position to: Dr. Janet Combes, Chairman, Search Committee, SEPM, P.O. Box 4756, Tulsa, OK 74159-0756. SEPM is an equal opportunity employer; women and minorities are encouraged to apply.

Opportunities for Students

Visiting Fellows and Students/Institute for Rock Magnetism. Applications are invited for visiting fellowships (regular and student) lasting for up to 3 weeks during the period from September 1, 1994, through February 28, 1995.

Topics for research are open, although fellows are encouraged to take advantage of the chosen focus for cooperative research in a given year. During 1994-5, the focus for research will be the connections between the fundamentals of rock magnetism and paleomagnetic observations.

Short proposals (two pages, single-spaced text plus necessary figures and tables) are due by June 10, 1994, for consideration by the Institute's Review and Advisory Committee (Richard Reynolds, Chair).

Successful applicants will be notified in early August 1994.

A limited number of travel grants of $500 are available to researchers who can demonstrate no existing financial resources. No funds are available for per diem expenses.

The Institute Staff (Bruce Moskowitz, Associate Director, and Christopher Hunt, Facilities Manager) will be happy to provide application forms and information necessary for proposal preparation.

Deadline for submission is June 10, 1994, at the following address: Chris Hunt, Facilities Manager, Institute for Rock Magnetism, University of Minnesota, 293 Shephard Laboratories, 100 Union St. SE, Minneapolis, MN 55455-0128, (612) 624-5274; FAX: 612-625-7502; E-mail: chunt@staff.tc.umn.edu.

Graduate Research Assistant-Environmental Sciences. Graduate research assistantship (Ph.D.) with major in Soil Chemistry or Water Resources available in the Department of Agronomy at Iowa State University. Student will be expected to develop a research topic in the area of soil and/or water chemistry with the emphasis on physical chemistry at mineral surfaces: interaction of pesticides and other anthropogenic organic pollutant chemicals with soils and sediments; abiotic degradation of organics at surfaces of natural, synthetic and modified clay minerals and oxides. Opportunities available for interdisciplinary research. For more information contact Dr. Ljerka Ukrainczyk, tel. (515) 294-5408, e-mail: L_ukrain@iastate.edu, Department of Agronomy, Iowa State University, Ames, IA 50011.

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

Services & Supplies

HIMALAYAN NOTES. A biannual international newsletter on Himalayan geology. $6 for two issues. Editor: Dr. Rasoul Sorkhabi, Department of Geology, Arizona State University, Tempe, AZ 85287-1404, USA.

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ILLINOIS STATE GEOLOGICAL SURVEY

The Illinois State Geological Survey (ISGS) is a division of the Illinois Department of Energy and Natural Resources. We are an affiliated agency of the University of Illinois located on the Urbana-Champaign campus. Survey staff of approximately 200 scientific and technical support personnel conduct basic and applied research.

The Chief provides scientific leadership and administrative direction to the staff of the Survey; implements policies; directs the planning, implementation, and evaluation of research and services programs; and interacts regularly with all levels of government, industry and the general public to maintain and enhance the Survey's reputation for excellence in science and public services.

Candidates for Chief should have a Ph.D. in geosciences with an established research record; demonstrated abilities of leadership and administration of a multi-disciplinary organization involved in research and service; a record of adherence to EEO guidelines; articulate and persuasive oral and written communication skills; and the ability to attract funding for research.

To apply, send letter of application, names and addresses of referees, and résumé by July 1, 1994, to:

Chairman, Chief Search Committee
Illinois State Geological Survey
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Champaign, IL 61820
(217) 244-2776

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Meetings *continued from p. 144*

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

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

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

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

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

9th National Conference on Hydrogeology and Engineering Geology of Karst Terranes, October 16–18, 1994, Nashville, Tennessee. Information: James F. Quinlan, Box 110539, Nashville, TN 37222, (615) 833-4324; or Geary M. Schindel, (615) 255-2288. *(Abstract deadline: May 15, 1994.)*

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

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

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

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

November

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

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

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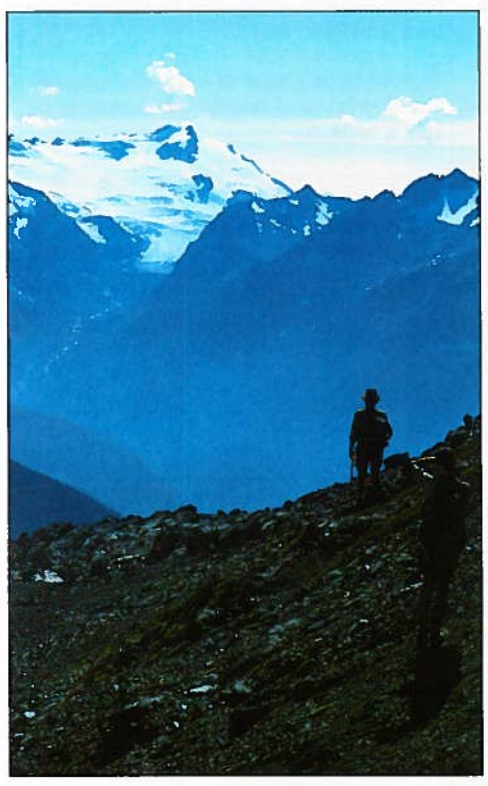

- **Abstract Deadline: July 6**
  See April *GSA Today*
- **Preregistration Deadline: September 16**

Registration and Housing Forms available in June GSA Today

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SPECIAL PAPER
287

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