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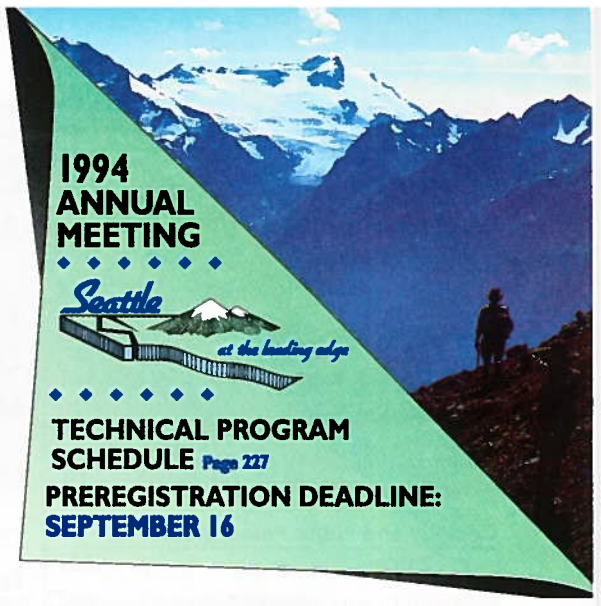

On the Efficacy of Humans as Geomorphic Agents

Roger LeB. Hooke, Department of Geology and Geophysics, University of Minnesota, Minneapolis, MN 55455

Figure 1. A slope in Nepal, terraced for agriculture. The rock tower in the center is inferred to be a volcanic neck. Its height above the rest of the slope (see house for scale) represents differential erosion over a time period that must be long compared with that represented by the terracing.

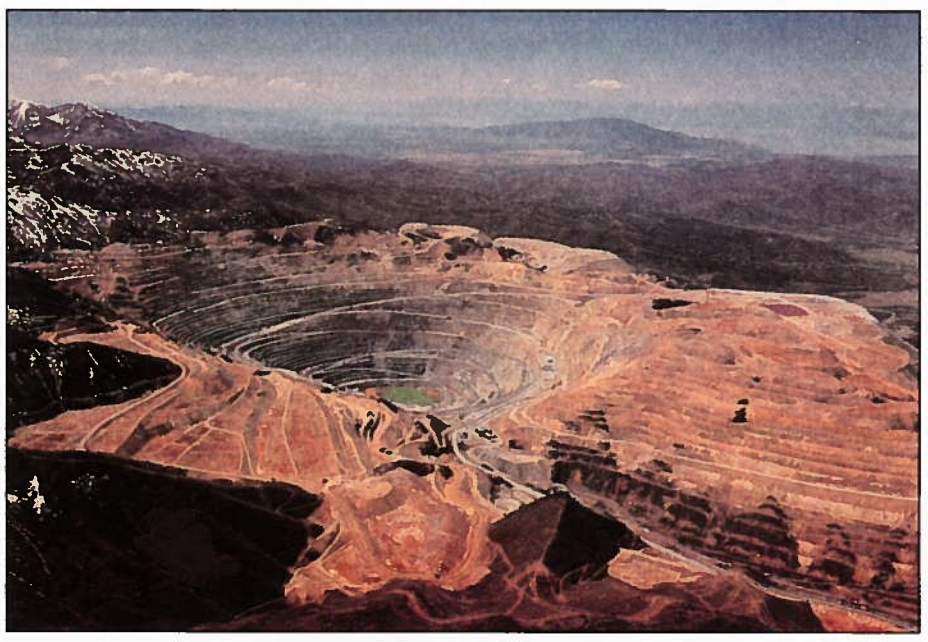

Figure 2. Oblique aerial photograph of Kennecott's Bingham Canyon open pit copper mine, Utah. In the middle distance, where the deepest hole now is, there was a mountain 130 years ago. (Photograph courtesy of Don Green Photography. Reproduced with permission.)

ABSTRACT

Humans are geomorphic agents. They move vast quantities of soil and rock, and have a major visible impact on the landscape. To place this impact in perspective, I have compared humans with more traditional geomorphic agents on the basis of the mass of material moved per year. In most instances we can identify a line, such as the coast, across which this material is moved. For example, the annual sediment load delivered to the oceans and interior basins by rivers is about 24 Gt, and during the Pleistocene, glaciers probably deposited about 10 Gt of till in moraines and outwash fans every year. In the case of humans, movement of material is more random, so it is not possible to identify such a line. However, the total moved by humans, estimated herein to be 40–45 Gt/yr if the effect of agriculture on river sediment loads (10 Gt/yr) is included, is comparable to or significantly greater than that of any other single geomorphic agent. Considering, in addition, the visual impact of their activity, humans are arguably the most important geomorphic agent currently shaping the surface of Earth.

INTRODUCTION

Early geomorphologists focused on descriptions of the landscape and on evolution of landforms on geological time scales. Attempts to understand the *physical* and *chemical* processes that produced different landforms evolved nearly simultaneously, however, and the modern science emphasizes this approach.

Biological processes generally have not been assigned major importance in landscape evolution. However, weathering, soil formation, and the development of karst landscapes are accentuated enormously because microbially produced CO_2 combines with percolating rain water to form carbonic acid. Likewise, soil creep is greatly enhanced by burrowing fauna. But compared with landforms created by more traditional agents such as rivers and glaciers, the effects of these biological agents are limited in both magnitude and extent. Furthermore, as the size of the organism increases, its population usually decreases. Thus although larger organisms are capable of doing more geomorphic work in a short time, they act less frequently, both in space and time, and thus generally have less impact. This rule breaks down, though, when we consider Homo sapiens, both because the population of this species is so out of proportion to that of any other organism of similar size and because this organism has developed an impressive array of tools, from hoes to tractors, for modifying the landscape (Figs. 1, 2).

This role of humans has been long recognized. Over a century ago, Marsh (1869, 1882) called attention to our ever-increasing impact on the landscape, and the modern environmental literature documents many specific examples (e.g., Turner, 1990). However, a quick survey of several textbooks on geomorphology revealed only one that mentioned humans (or man) in the index, and none that devoted a chapter to this agent.

In short, geomorphologists seem reluctant to give humans equal press with more traditional geomorphic agents. Perhaps this is because there is little mystery about either the processes or the products, or perhaps it is because authors prefer to address only "natural" processes. Humans, however, are not unnatural. They are just as much a part of the natural environment as any other organism, and so the products of human activities also must be considered to be natural, be they books, buildings, or sanitary landfills. For the sake of our environment, and thus our future as a species, it is crucial that we recognize and accept that we are not above nature, somehow supernatural.

My objective herein is to compare the efficacy of various geomorphic agents, humans included, on a global scale. How such a comparison should be made is unclear, however. To calculate the work done per unit time—that is, the force exerted to move a mass of soil or rock times the distance it was moved divided by the time required—would be an approach soundly based in physics. This, however, quickly becomes unwieldy; a rock is entrained by a glacier in Hudson Bay, but what force was exerted on that rock to move it to Ohio and how long did it take? Trying to estimate energy expenditure results in similar problems; most geomorphic agents move material to positions of lower gravitational potential, and thus release (potential) energy rather than consume it.

MASS OF MATERIAL MOVED: A MEASURE OF THE EFFICACY OF A GEOMORPHIC PROCESS

An obvious alternative to a comparison of geomorphic agents based on work or energy expenditure is one focusing on the mass of material moved. Here, however, it is necessary to distinguish between processes that simply move sediment back and forth, those that move material away from a location only to replace it with other material, and finally those that move material away without replacing it.

Examples of the first type are waves approaching normal to a beach, wind moving sand back and forth in dunes, and farmers with plows turning up soil on the ~1.7 x 10^7 km^2 of Earth that is under cultivation (Ehrlich, 1988). Such processes move incredible volumes of sediment. Plowing land area under cultivation annually with furrows 0.2 m wide and 0.1 m deep, for example, involves moving 1500 Gt of soil, most of which soon slumps or is washed back into the furrows. Because the lasting effect of such processes on the topography is small, I have ignored them.

Among processes that move sediment away from a location in a single direction, usually downslope in response to gravity, are rivers, glaciers, and slope processes. These "unidirectional" processes are readily quantified because data are available upon which to base estimates of their prowess. For example, the delivery of sediment to the oceans by rivers is well studied.

A common characteristic of such unidirectional processes is that their efficacy can be equated with the rate of movement of sediment across a well-defined line or plane. In the case of rivers, this could be the boundary

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Earth Sciences in the Public Arena: Strengthening Environmental Decisions with the Geological Approach to Critical Inquiry

Summary of a symposium sponsored by the GSA Institute for Environmental Education at the Cordilleran Section meeting, San Bernardino, California, March 22, 1994

Fred A. Donath, IEE Executive Director

Introduction

Geologists routinely use reasoning processes that test data reliability and relevance, probabilities, and causal relationships—skills that can help clear public confusion over verity, risk, and consequences. The development of environmental regulations, a fact of life today, is often difficult and sometimes misguided because of conflicts between facts and values, as perceived by those who will be affected by them and as interpreted by those formulating the regulations. The geologist can help the public and decision makers develop rational perspectives in environmental debates by advocating proper application of relevant geoscience information. Indeed, the geoscientist's grasp of complex geoenvironmental issues carries a responsibility to improve public understanding of the risks of natural hazards, resource availability and consumption, and the impacts of human activities.

In consideration of the above-stated responsibility and capability, IEE has initiated its Geology and Environment Public Outreach Program directed at encouraging greater interaction among geoscientists, the public, and the private sector in matters of the environment. Objectives of the program include heightening public understanding of geoscience and the geological approach to inquiry, increasing the effectiveness of communicating geoscience information, and enhancing environmental decision making with relevant geoscience.

IEE's approach in developing this program includes the sponsorship of symposia, theme sessions, and/or workshops in conjunction with the GSA Section meetings to promote program objectives at the local and regional level. The first of these symposia, entitled *Earth Science in the Public Arena: Strengthening Environmental Decisions with the Geological Approach to Inquiry,* was organized by Pat Abbott, Vic Baker, and Gary Ernst, and held in conjunction with the GSA Cordilleran Section meeting in San Bernardino, California, last March. This summary provides highlights of the presentations taken from the authors' manuscripts and recordings of the proceedings. Unfortunately, one of the presentations does not lend itself well to summary. This was an entertaining and enlightening film that provided an overview of how geology and geologic processes are presented in films by Hollywood directors. Produced by Dorothy L. Stout of Cypress College and her daughter Deborah Steller, this film featured excerpts from popular films, past to present.

IEE thanks the Frank A. Campini Foundation for its generous support of the Geology and Environment Public Outreach Program and this symposium.

A New Organizing Principle for Our National Direction

[*Editorial note: The Honorable George E. Brown, Jr., U.S. House of Representatives, who was scheduled to give 219the keynote address, had to remain in Washington for several important votes. Congressman Brown chairs the House Committee on Science. His address was read by Pat Abbott.*]

Congressman Brown emphasized that the fundamental task of finding a new organizing principle—not just for science but for the nation—is just beginning. For five decades national security has served as the raison d'être for a rapid expansion of our research system, but the Cold War as a national organizing principle is now obsolete. The Cold War riveted our attention to the Soviet threat, while it simultaneously diverted our attention from growing internal threats. In the interim, many domestic problems—economic, social, and political—have become increasingly intractable. These constitute the beginning of a new agenda for the next 50 years, to which science must give its attention as effectively as it has to military defense over the past 50 years.

Over the last half century, we have achieved spectacular scientific and engineering accomplishments in the service of a Vigilant Society. We now need to enlist our science and technology in the service of a Humane Society—where work is meaningful, families are secure, children are well fed and educated, where prevention is the first line of defense in health care, where the environment is respected and protected for future generations, and where sustainable development becomes the conscience of our progress. This new agenda, by its very nature, will upset the status quo in our research system and in many of our institutions. The mechanism for eliciting change or a "turning" in the nation's research system should be comparable to setting a new compass heading for a ship. The creativity and intellectual vigor of the entire science community will be needed to achieve this redirection.

One hopes that in the future we no longer will hear the political term "strategic research," which seems to be a contrived combination of words to achieve politically correct science parlance. Rather, we should have *strategic goals* for the nation, and we should invest in research as part of a strategy to advance those goals. Taxpayer-funded research should have a conscious relationship to those goals. A fundamentally flawed dogma in the science community is that basic research is curiosity-driven research and that applied research is driven only by utilitarian pursuits—and that the two are mutually exclusive. However, a major proportion of basic research is driven simultaneously by the quest for knowledge and by the quest for use. Science's cultural and political distortion of this reality has, in many instances, heightened debate beyond its natural proportions. Let us make a concerted attempt in this changing era for science in the American agenda to focus on the realities.

Earth Science as the Foundation for Effective Natural Resources Management

The Honorable Elizabeth A. Rieke, Assistant Secretary for Water and Science, U.S. Department of the Interior, addressed the changes currently under way in seeking to reinvent government and in making natural resources management policies relevant and responsive to the public good. The changes in natural resources policies being sought need to be based on high-quality, impartial science—science that is developed without a bias in favor of a particular result. In the many critical natural resources tasks before this Administration, commitment is to making science central to the policy debate. Not only must it be ensured that science is available, but its results and implications must be communicated in a way that is useful to policymakers.

Secretary of the Interior Babbitt's commitment to unbiased science as the foundation for effective policy is evident in his establishment of the National Biological Survey. The Secretary is determined to recognize the interrelatedness of the various aspects of life on Earth through an ecosystem management approach. A prerequisite for safeguarding entire ecosystems is a solid base of comprehensive, unbiased science on which to bring everyone together at the policy table. That scientific foundation is what Secretary Babbitt has often termed "better science," by which he means the taking of good science and ensuring that it is used effectively and appropriately in the public arena so that resulting policies benefit from the science. Scientific results should give clear recognition to the underlying assumptions and to the areas where discretion was exercised by the scientists. But the process of science must be allowed to operate and flourish, uncompromised by policy.

Better science is science that is useful and is used. Better science includes the provision of guidance to policymakers when the science does not provide clear results—as it so often does not. Scientists must assist policymakers in evaluating the risks of alternative courses of action. The scientist's preferred counsel is often to wait until more data can be gathered and analyzed. But in many instances, we cannot afford the no-action alternative until the uncertainties in the science are resolved. In those instances, the scientist's evaluation of the nature of the scientific uncertainty and the risks of pursuing the available options is critical to good policymaking.

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Constructive changes in our approaches to natural resources policies must be based on sound, impartial science, for that is the foundation upon which we build effective environmental policy. Policies are needed that are sustainable both ecologically and economically. Earth science must be vigorously present in the policy debate if we are to ensure that we have a healthy economy and a healthy environment.

A Window of Opportunity for the Geosciences

In reflecting on the remarks of Congressman Brown and Secretary Rieke, Craig Schiffries of the American Geological Institute emphasized that a window of opportunity exists for the geosciences. The Administration and the Congress have been consistent in their technology policy statements that we now have a new mission—that we need to direct our research in socially relevant ways and to develop a new rationale for science and technology policy in the post–Cold War era. On many occasions Congress has cried out for information about the societal relevance of research, and nobody from the geoscience community was there to say "Let me give you some recent examples and some future plans," in a way that was readily understandable. The end of the Cold War has placed us at a crossroads, and the shaping of national priorities will have a major effect on the next 40 years much as the end of World War II had a major effect on the Cold War era.

A few examples of recent developments that reflect changing national priorities include: elevating the U.S. Environmental Protection Agency to Cabinet status; establishing a new National Biological Survey; establishing a new White House Office of Environmental Policy; canceling the Super Conducting Super Collider; restructuring and downsizing the Space Station; and establishing a special commission on the future of the National Science Foundation. Also, we are in the process of defining a new mission for federal agencies and national laboratories. The budget in the U.S. Department of Energy for environmental restoration and waste management exceeds $6 billion—more than twice the size of the National Science Foundation budget, and larger than the defense budget of DOE.

Some major legislation currently in Congress has an important geoscience component, and there is a need to provide timely and accurate geoscience information to members of Congress, many of whom do not realize they have a stake in some of these issues. The National Geologic Mapping Act of 1992 is an example. This legislative initiative was led by the Association of American State Geologists, which was able to demonstrate that each member of Congress had a role in this, whether they understood it initially or not. This was largely an educational effort. Other legislation in basic and applied research includes the Landsat Policy Act of 1992 and the Vertebrate Paleontological Resources Protection Act. The latter illustrates the potential problems of writing such legislation without geoscience input. The first draft did not have the word "vertebrate." The bill would have regulated *all* fossils, and a Boy Scout driving a tent peg into diatomaceous earth, thereby destroying microfossils, could be a potential federal felon!

In energy and mineral resources, reform of the Mining Law of 1872 is currently under consideration, major parts of the National Energy Act of 1991 are being implemented, and there will be legislation to amend the Outer Continental Shelf Land Act. In the area of geologic hazards, the National Earthquake Hazards Reduction Act was between passage in the House and consideration by the Senate at the time of the Northridge earthquake in California—quite useful timing! Similarly, the National Flood Insurance Act is timely, and calls on certain geological components.

However, the list of legislation dealing with environmental issues is the longest, and the one that most affects the future for the geoscience community. An incredible number of geoscience issues are coming before Congress right now. The Clean Water Act is particularly important. In addition, there is the Safe Drinking Water Act, reauthorization of Superfund for hazardous waste sites, and the Resource Conservation and Recovery Act, which deals with solid waste issues. There is legislation to elevate EPA, and other legislation to form a new national biological survey. These statutory developments and institutional developments will have long-standing implications for decades to come, so now is the time for the geoscience community to become involved and provide its input.

Hard Times Are Coming

GSA Vice-President Dave Stephenson noted that the focus of the symposium is on the role of earth sciences in the public arena and that, as evidenced by the turnout, a growing number of geoscientists are recognizing the importance of what should be an aggressive public outreach program. Unfortunately, this is developing at the same time that the U.S. Congress is not in a particularly friendly mood toward the sciences. It's quite evident to geoscientists that grantsmanship, research proposals, and basic research, things we've become accustomed to, now must be complemented by outreach, networking, and interface. Earlier, we heard about "better science." The three purposes of science are to satisfy curiosity, to advance technology, and to manage resources. The current mood in Congress is to fund what they consider to be flowers, not roots; their interest no longer is to fund curiosity, satisfaction, and basic research.

A second critical issue is that Congress wants one voice from the entire scientific community. The Council of Scientific Society Presidents (CSSP) was developed, at least in part, to provide a mechanism for the broader scientific community to relate to Congress and to other groups. At a meeting last December of the CSSP, representatives from various Senate and House committees—including Senate Energy, Senate Appropriations, House Committee on Science, House Committee on Budget, House Committee on Education and Labor—took the time to meet with CSSP representatives and, universally, said the same thing. They're saying that, ideally, Congress would like to have one voice from science—not one voice from geoscientists, but one voice from all scientists. Consider the diversity among the behavioral, biological, chemical, earth, health, physics, and other scientific communities. Envision nuclear scientists, on the one hand, and environmental scientists, on the other, coming together with one voice in terms of research priorities. Not likely! So, that presents a challenge in and of itself.

The Council of Scientific Society Presidents was also told that, at best, appropriations in this and the following fiscal year for science, in general, will be flat, with no inflationary adjustments. The scientific community will get a disproportionate share of budget cuts. Support for the national laboratories is being hit hard; certain labs might even be closed. It seems fair to conclude that the image of science in Congress is less than what we would like, perhaps even less than what we think it is. The challenges can perhaps best be met by implementing programs such as those the GSA Institute for Environmental Education is developing. But, geoscientists must keep in mind that we cannot do this as "lone rangers." We cannot promote only geoscientist-type endeavors, but must be doing this as representatives of a broader scientific community. As David Goodstein, Provost of the California Institute of Technology, recently stated, "There is no easy solution of the current problems in front of us. However, one worthwhile step might be to try to transform science education from mining and sorting diamonds in the rough to an attempt to educate all people in a manner suitable to a Jeffersonian democracy. If we don't succeed in doing that, science may not have any future at all."

Roland Schmidt, President of Rensselaer Polytechnic University, who also chairs the American Institute of Physics, has pointed out that there are four motives for government support of research; these are search for understanding, pioneering, utility, and political attractiveness. These motives are listed in the order of increasing appeal to politicians, but they are of decreasing appeal to scientists. So, how can these different priorities be reconciled? One thing scientists can do is to lose some of the arrogance they tend to have. Universally, the Congressional representatives to the CSSP meeting said, "Too frequently, scientists are arrogant when they come to Washington. Scientists lecture; they don't listen." Scientists need to learn more how to listen and less how to lecture. We tend to think the public shares our enthusiasm for things we do of a scientific nature, but the public, by and large, doesn't understand science, and perhaps doesn't even understand scientists. It has been attributed to Congressman George Brown that he believes scientists are merely citizens with special responsibilities. As such, scientists should be especially aware of the values of the society that funds them. Scientific researchers and all other professional scientists must understand the political, social, and economic goals as perceived by the public.

A California Perspective

James F. Davis, State Geologist of California, discussed how our science can relate to the opportunities we have for wise decision making and public policy, which he considers to be the implementation of social objectives through various actions both in the private sector and in the public sector. The public sector essentially sets the framework that stimulates direction for activities in the private sector, through incentives and the like rather than through detailed prescription.

In California, there is great sensitivity to and interest in both environmental and geologic hazards issues. In the past 16 years changes have occurred in the relative importance of these and in the relationship to both the private sector and local government decision making. In establishing the existing hierarchy of government, the nation's founders have given people a proportionately larger role in decision making, in terms of their outcomes and their priorities, through the units of state and local government. So, state government responds to those priorities that exist within the jurisdiction of the state.

A number of environmental issues need to be dealt with at both state and federal levels, such as waste management—redeeming of the Superfund and lesser mistakes of the past, as well as provision for wise policy for waste disposal and management in the future. Consideration of the general quality of the environment is often

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Notice of Council Meeting

Meetings of the GSA Council are open to Fellows, Members, and Student Associates of the Society, who may attend as observers, except during executive sessions. Only councilors, officers, and section representatives may speak to agenda items, except by invitation of the chair. Because of space and seating limitations, notification of attendance must be received by the Executive Director prior to the meeting. The next meeting of the Council will be Tuesday afternoon, October 25, 1994, at the Annual Meeting in Seattle.

NRC Report Addresses Geomagnetism

A new report from the National Research Council provides a broad overview of geomagnetism and its importance to science and society. *The National Geomagnetic Initiative,* prepared by the U.S. Geodynamics Committee of the Board on Earth Sciences and Resources, is an outgrowth of a workshop held in 1992.

The report recommends that the spatial and temporal behavior of Earth's magnetic field be characterized through the cooperative efforts of federal and state agencies, academic institutions, and industry. The plan developed from this initiative would address a variety of short- and long-term objectives.

The report is available for $28 a copy from the National Academy Press, 2101 Constitution Ave., N.W., Washington, DC 20418, (800) 624-6242. Shipping and handling are $4 for the first book and $0.50 for each additional book.

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done at the federal level descriptively by setting standards, and those standards are implemented by the actions of other levels of government.

In considering hazards, loss reduction is obviously the goal, and there are several ways in which that can be achieved. One is through land use management, which includes both regulation and planning. Another is through building design, which is both by practice and by discretion within the regulatory codes. Emergency response is the third, and, finally, there is disaster recovery. Apropos of regulation, this is philosophically based on the belief that setting a standard, or requiring a practice, is socially beneficial to everyone. But that can be frustrated both by the duration and by the process of regulation. Moreover, the altruism of regulation can be defeated by having agendas that really aren't consensus agendas codified in statute.

NIMBYism, "not in my back yard," plays another role. Science gets caught in the middle because everyone wants to use science to advance their own agenda. If you're for something, you'll stress certain elements of scientific understanding; if you're against it, you'll stress others. There is no absolutely right position; it all comes down to judgment. Technology emergence can also influence policy by providing capabilities not previously possible, such as real-time data processing associated with monitoring seismic activity. This creates an immediacy for decision making related to policy and societal protection such that a plan must be in place at the time of an event, or government is considered derelict. The "information highway" offers opportunities for both communication and miscommunication. Extracting the meaningful information is critical to developing good policy.

Thus, it seems that for the earth sciences to be effective in this milieu, we must work at credibility—which does not always come with the credentials. As we look at this credibility situation, we must consider how we advise people of our conclusions. The purpose of scientific dialogue and deliberation, meetings, and literature is to bring forward ideas when they are conceived, to get comment and reaction. Science is characterized in most instances by incremental, not quantum, development. That being so, people exposed to the evolution of scientific ideas, but who don't have a scientific background, often become confused. We geoscientists have a responsibility to provide some kind of context and explanation that promotes understanding by the people who, after all, are the policy setters.

Reinventing Earth Scientists' Contribution to Government

Gordon Gastil of San Diego State University spoke to the need for geoscientists to share their knowledge with the public. His message was straightforward, and simple—the most effective way of incorporating geoscience in the public agenda is to get involved in politics at some level, either as an elected person or as a supporter. Being a good advisor communicating science to those in elected office is not good enough.

In ancient cultures, the carefully kept records of those who monitored the position of light points in the sky were accumulated over multiple generations. Ultimately, this led to the ability to predict such natural events as eclipses. Earth scientists, too, are timekeepers. We interpret records in the sediments and the evolution of organisms, and we date the decay of radioisotopes. Our citizenry sometimes attaches an awe of the miraculous to the journeyman work of science. But whereas astronomers deal with bodies moving through a near vacuum, the nature of geologic events is wrought with complexity. The taxpayers who pay many of our bills perhaps are looking to the day when hazardous events can be divined with the precision of eclipses. Have we been encouraging this expectation?

Once, it was imagined that strain across faults accumulated fairly consistently until it reached a rupture point, causing an earthquake, after which strain again accumulated—thus allowing the calculation of a recurrence interval and a prediction. Now, we contemplate regional stresses straining a network of faults. When one ruptures, additional stresses transfer to some combination of other faults in the network, resulting in a shorter recurrence interval for shaking of an area than for any one of the associated faults. Does the public understand the implications of this, of earthquake magnitude, and of similar questions with which we wrestle? Are we trying hard enough to make them understand? The answer to both questions is a loud "No." Is it that we don't wish to be cast in the role of doom prophets? Or because we are not adequately sure ourselves? If the "Big One" happens in our lifetime, will we be praised

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SAGE REMARKS

Science Is a Way of Knowing and Understanding

Edward Buchwald, Department of Geology, Carleton College, One North College Street, Northfield, Minnesota 55057

Science as a way of knowing involves asking questions of nature, constructing and executing protocols to get answers, evaluating answers, and reporting those answers to other people. College students need better understanding of science. Introductory environmental geology courses have the potential to give them both needed understanding of the processes of science and substantive knowledge of the findings of science.

Few students come to Carleton College, where I teach, with an interest in studying geology. Fewer still have much of a solid understanding of what constitutes geology, but they all seem to know that environmental problems are their problems, too. This gives us an immense opportunity to start with the fundamental concerns of students. We can create environmental geology courses that deal with the issues that current students find so compelling *and* teach them good science.

A good course in environmental geology stresses the interrelationships between science as a way of knowing and the predicaments humans encounter because of economics, ethics, and politics. I like to have students discover that the resolution of environmental problems lies within a square whose corners contain science, economics, politics, and ethics. If we choose to sit in our favorite corner and do not understand the concerns of the other three corners, we will not be part of the resolution of problems. We must venture out of our corner. That applies to geology professors, too; if we do not acknowledge that science operates in a milieu of economics, politics, and ethics, we will not contribute answers, either. We have to develop some comfort in dealing with issues of economics, politics, and ethics. It does not help to pass the blame on to other segments of the college.

A favorite exercise of mine is to take students to an enlarging gully in a nearby county park. Students discover—by field work—that excess runoff from a cornfield outside the park is a likely culprit. I ask the students, in teams, to create protocols to investigate the hypothesis that cornfield runoff is contributing to the gully formation. Each group picks an aspect of the problem, develops further understanding of the situation, and reports its findings. The class, as a whole, evaluates its composite understanding of the runoff-erosion problem and then suggests possible resolutions ranging from doing nothing to structural solutions. Further analysis of the situation results in debates about natural processes, accelerated erosion, human intervention, cost-benefit analysis, valuation, the limits of knowledge, and obligations to future generations. Students learn a lot from this problem because it is real and concrete and illustrates the need for understanding all four corners of the metaphorical square. It is a challenge for me because it stretches my understanding of what works and does not work in environmental problem solving. I often call on what students have learned in other courses to shed light on our problem. This helps to give real meaning to the notion of integrated knowledge, and it most certainly helps students develop attitudes that they need to create answers, not discover them.

We do not "cover" all of environmental geology in a 10-week term, but that is not the goal. What we are attempting is the practice and understanding of science as a way of thinking and knowing as applied to geology and the human predicament. I think it is working for my students and me. Among other benefits, it makes further study of geology an attractive idea for many students.

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.

Reinventing Environmental Management

[We must] stop not only the waste of taxpayers' money but the waste of our natural resources.

—President William J. Clinton
Earth Day Address, 1993

A recently issued Accompanying Report to the National Performance Review presents details of a new federal government approach to managing the environment. Using this new approach, "ecosystem management," the federal government will attempt to organize its environmental activities around ecosystems, rather than around political jurisdictions.

Written by Vice President Al Gore, the 37 page report, titled "Reinventing Environmental Management," points out that in the United States, environmental policy is marked by "duplication and overlap, turf battles, and political jockeying." In the San Francisco Bay region, for instance, a single one-mile stretch of shoreline "may be affected by the decisions of over 400 government agencies."

Using the federal government to highlight this duplication of effort and overlap of tasks and responsibilities, the report lists the following federal bureaus and their roles: the Bureau of Land Management (manages 60% of our federal lands for multiple purposes); the Forest Service (manages our National Forests); the Fish and Wildlife Service (manages our National Wildlife Refuge System); the National Park Service (manages the National Parks and Grasslands for recreation and preservation); the Environmental Protection Agency (EPA) (implements national waste management and air and water quality laws); the National Oceanic and Atmospheric Administration (manages coastal zones and living marine resources); and the Bureau of Reclamation, the Federal Highway Administration, the Department of Energy, the Tennessee Valley Authority, and the Department of Defense (DOD) (run programs with significant environmental impacts).

Vice President Gore points out that federal government management practices related to the day-to-day operation of federally owned and managed land and facilities "raise questions about Washington's commitment to a clean environment." In addition to managing about one-third of all the land in the United States, the federal government is the nation's largest landlord, owning or operating over 500,000 facilities, more than 430,000 of which are residential. Consequently, the "federal government's sheer size makes its impact on the environment apparent."

While operating its facilities on a daily basis, the government has "generated significant amounts of pollution and caused other stresses on our ecological systems." The result of these poor management practices is "higher operating costs, clean-up costs, and the loss of our natural resources and (of) a clean environment." Gore writes that "instead of being a model environmental actor, the government has become part of the problem."

As previously stated, this report is a supplement to the National Performance Review. The Review's primary goals are to make government work better and cost less. With respect to the environment, goals include promoting sustainable economic development, preventing environmental degradation, reducing costs, and maintaining the long-term health of the nation's ecological systems.

Gore states that the "ecosystem management" approach will make government work better "by reducing its negative impacts on the environment and ensuring productive, sustainable natural systems. And it will cost less by incorporating environmental considerations into its decisions and, from a fiscal as well as an environmental standpoint, operating its facilities and programs more efficiently."

The report presents recommendations along two principle themes: (1) improving implementation of environmental management, and (2) improving environmental performance at federal buildings and facilities. Each theme has two subthemes and a number of specific recommendations.

Improving Implementation of Environmental Management

The first subtheme of improving implementation of environmental management concerns improving federal decision making through environmental cost accounting. Traditionally, the federal government has focused on pollution control techniques rather than pollution prevention strategies. Generally these techniques are selected on the basis of accounting and financial management methods that encourage the selection of "alternatives that appear cheaper in the short term—although government and society pay more through expensive clean-up, environmental degradation, and litigation costs over the long term." Environmental cost accounting is described as accounting mechanisms that encourage a prevention-minded approach to procurement and industrial process design decisions. Specific actions of this subtheme are: (1) Develop pilot projects to demonstrate the use of environmental cost accounting by the federal government. (EPA, DOD, and the Office of Management and Budget are to develop projects by September 1994, with a completion date of July 1995.) (2) Report on the demonstration projects and make recommendations on the use of environmental cost accounting in the federal government. (The report is due to the White House Office of Environmental Policy by October 1995. Guidelines for broader government-wide application of environmental cost accounting are due by March 1996.) (3) Issue a directive to implement environmental cost accounting in the federal government. (A presidential directive will be issued in April 1996 to incorporate environmental cost accounting into appropriate decision-making processes.)

The second subtheme of improving implementation of environmental management concerns developing cross-agency ecosystem planning and management. An example of such an integrated effort is President Clinton's "Forest Plan for a Sustainable Economy and a Sustainable Environment." The "Forest Plan," developed as a result of an April 1993 federal Forest Conference, held in Portland, Oregon, "exemplifies a proactive approach to federal environmental policy known as ecosystem management. In ecosystem management, land and resource managers consider both natural processes and human activities in a given geographic region. Managing ecosystems requires defining resource use and conservation goals for specific ecosystems within geographic regions. Monitoring and assessment are also important components of ecosystem management."

Specific actions of this subtheme are: (1) Issue an Ecosystem Management directive by September 1994. (This presidential directive will establish a national policy of sustainable development through ecosystem management, establish collaboration among federal, state, local, tribal, and public entities; establish a cross-agency ecosystem management process; and establish goals and guidelines.) (2) Establish a high-level Interagency Ecosystem Management Task Force to begin development of several cross-agency ecosystem management demonstration projects. (3) Conduct management and budget reviews for the ecosystem management projects as part of the fiscal year 1995 budget process. (4) Establish Regional Ecosystem Management Teams for each of the cross-agency ecosystem management projects. (5) Develop initial ecosystem management plans for the projects, report on progress, and begin implementation. (Initial plans should be completed by August 1995.)

Improving Environmental Performance at Federal Buildings and Facilities

The federal government spends nearly $4 billion a year in energy costs for its buildings. "Without losses in comfort or productivity, the government likely could conserve 25 to 40 percent of the energy used in those buildings through commercially available, cost-effective, efficiency upgrades." Similarly, water conservation measures could also save energy. "By conserving water, the federal government not only will help keep costs down, but will lessen local pressures for new water treatment facilities and power plants."

The Energy Policy Act of 1992 (EPACT) requires that by the year 2000, the federal government will cut its energy consumption by 20%. EPACT also requires agencies to install energy efficiency and water conservation measures with a payback of ten years or less by the year 2005. Additionally, the report requires the President to issue a directive that will require the use of environmentally beneficial landscaping at federal facilities.

If successful,"Reinventing Environmental Management" will be the blueprint for overhauling U.S. environmental policy and will substantially reduce the duplication and overlap, turf battles, and political jockeying that we now take for granted. As so many of the action items have very short fuses, we should know within two years whether the National Program Review is successful in reinventing environmental management, or whether we are engaged in another side-stepping, wheel-spinning exercise. Washington Report will follow this issue very closely. ■

IEE Forum *continued from p. 220*

for having predicted it? No. We will be damned for not having adequately warned people, and perhaps rightly so.

How does one transmit the knowledge one has to where it counts? Have you ever tried to have an impact on a school board, a city council, or any governing body? The results are many times very disappointing, if not downright frustrating. Many earth scientists have been very successful as policy advisors, but the word "elected" carries a special significance. Can those with the responsibility of representing the taxpayers really learn what they need to know through "advice?" We need more qualified scientists in elected positions, at all levels of government, if we are to effectively bring geoscience into the policies and regulations that affect us all. This and following generations must address the fundamental question "Is there a workable balance between humankind and Earth?" Who has seen Earth, been concerned about its climate, measured its resources? The special insights unique to earth scientists must be brought into the debate.

Earth Scientist Involvement in the Community

Drawing upon experience with public involvement in the San Diego area, Pat Abbott of San Diego State University described a different approach to influencing public policy and regulation: education of elected officials in the geological approach to critical inquiry.

Political processes in the United States today seem to be heavily influenced by single-issue people and groups. These narrowly defined interests often become amplified by the media. In many instances, the media would like to simplify issues to "sound bites," rather than try to promote understanding. One way they do this is by presenting two sides even if there is only one person on one side. This opens up opportunities for exploitation where the rules of science

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The 100 Deaths—Passage of S. 978, the National Environmental Technology Act

Murray W. Hitzman, 1993–1994 Congressional Science Fellow

In public policy, as in business or academia, knowing how a system works is a major key to success. The more thoroughly earth scientists understand how Washington works, the more successfully they can bring their expertise to bear in the formulation of public policy. My last article (*GSA Today,* July 1994) described the congressional hearings process and how earth scientists could utilize it to help influence policy. This article uses S. 978, the National Environmental Technology Act, to illustrate how a bill gains passage in the Senate and the many avenues open to scientists for providing expertise in the making of policy.

When I began my fellowship in the office of Senator Joseph Lieberman (D—CT), the legislative director explained to me that every bill "dies 100 deaths" before it can become law. Because I had a background in the earth sciences, I was given the task of helping to gain passage of S. 978, which is designed to foster the development of new technologies for cleanup of contaminated ground water and soil.

In the Beginning

Before my arrival in Washington, Senator Lieberman and his staff had already spent several months researching and crafting legislation to aid development and commercialization of new, more cost-effective technology for the cleanup of contaminated government facilities and Superfund sites. The legislation accomplished this by redirecting 1.25% of funds dedicated to cleanup at all federal agencies with an annual cleanup budget exceeding $50 million to a three-phased program modeled on the highly successful Small Business Innovation Research Act (SBIR) program. The senator's bill, entitled the Environmental Innovative Research Act, was introduced in February 1993.

That same month, Senator Barbara Mikulski (D—MD) introduced a different bill, S. 425, the National Environmental Technologies Agencies Act, to create a new government agency for the development of environmental technology.

The Senate Environment and Public Works (EPW) Committee held a hearing on environmental technology in late February 1993. The hearing focused on the driving forces and barriers in the environmental technology market. Most of the witnesses were from private environmental technology companies. They provided support for the initiatives set out in the Lieberman and Mikulski bills and introduced additional ideas for strengthening the environmental technology industry.

On the basis of this hearing, Senators Lieberman and Mikulski and their staffs joined with Senator Max Baucus (D—MT), chairman of the EPW Committee, to kill the two original bills and write a single, comprehensive piece of legislation. Extensive consultations were conducted with representatives of environmental technology development companies, trade associations, and nongovernmental organizations by staff from the EPW Committee and Senator Lieberman's and Senator Mikulski's offices. Because the president's fiscal year 1994 budget proposed significant expenditures for environmental technology development, primarily within the Departments of Defense and Energy, the administration was also interested in the bill. As a result, negotiations were undertaken between Senate and White House staffs.

From these negotiations a new bill, S. 978, the National Environmental Technology Act, was written and introduced in May 1993. In addition to the provisions of the original Lieberman and Mikulski bills, S.978 authorized a national environmental technology strategy, contained provisions for promotion of environmental technology export, and established a program within the Environmental Protection Agency (EPA) to verify the cost and performance characteristics of environmental technology.

A hearing was held in late May 1993 on S. 978. At the same time, a date was set for markup of the bill by the EPW Committee, where the committee would consider the bill line by line and vote on whether to report out the bill for consideration by the entire Senate. The senators on the committee and their staffs worked together during June and July to thoroughly examine the bill and continued consultations with other parties. Because so many changes were agreed to, the original S. 978 died, and an entirely new bill was written.

The committee markup occurred at the end of July. Only one amendment was offered during the markup, an amendment in the nature of a substitute, which replaced the old bill in its entirety with the new bill (still designated S. 978). The legislation was passed out of committee by a voice vote.

Before a bill can go to the Senate floor, Senate standing rules require the publication of a report on the bill. The report must include the committee's estimate of the regulatory impact of the bill together with a statement of the cost of the bill prepared by the Congressional Budget Office (CBO). The report on S. 978 was completed and printed in late September 1993.

A Naive Arrival

At this point I was assigned to work on the bill. Naively, I thought there was little more to do; I would just wait for Senate Majority Leader George Mitchell (D—ME) to put the bill on the Senate calendar and prepare for the floor debate. I was dead wrong.

To pass the Senate, S. 978 would need broad support. Because this bill would impact a number of government agencies, including EPA and the Departments of Defense, Energy, Interior, and Commerce, it was critical to obtain agency support. Of these agencies, only EPA was within the jurisdiction of the EPW Committee. To ensure passage, the senators on committees having jurisdiction over the other agencies would have to be happy with the bill, and they would be happy only if "their" agencies were happy.

The bill would have direct effects on the White House Office of Science and Technology Policy (OSTP) and would influence the administration's environment, trade, and science policies, so negotiations would need to be undertaken with the White House. Support from the private sector and nongovernmental organizations would also be critical to ensure smooth passage. Though negotiations had already been undertaken with most of these groups, more discussions were needed to ensure support now that the bill was moving toward a vote.

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GSA Congressional Science Fellow Named for 1994–1995

Jill Schneiderman

Jill S. Schneiderman has been selected as the ninth GSA Congressional Science Fellow. She will work as a special legislative assistant on the staff of a committee or member of the U.S. Congress from September 1994 through August 1995.

As a Congressional Science Fellow, Schneiderman will bring to Congress her commitment to make the results of scientific research accessible to policymakers. She hopes to learn about governing and the significance of scientists' work in that process so she can help steer the earth sciences community toward socially responsible scientific agendas. Schneiderman is particularly concerned with issues of earth science literacy such as those expressed in the National Academy of Science's report *Solid Earth Sciences and Society* (1993) and the transformation of geology curricula into an integrated earth systems science approach to teaching and research. Potential congressional work that interests her includes reauthorization of existing environmental statutes such as the Clean Water Act, establishment of a National Institute for the Environment, consideration of the concept of environmental justice, and Antarctic Environmental Protection and Protocol Acts.

Schneiderman received her Ph.D. in geology in 1987 from Harvard University. Her research activities in earth science, supported by the American Chemical Society and the National Science Foundation, have ranged from investigations of the formation of mountain belts to assessments of climate change and have taken her and her students throughout the United States, Finland, Kenya, Italy, Pakistan, the Republic of Georgia, and Vietnam. On leave (1993–1994) from her position as associate professor of geology at Pomona College where she has taught courses in geology, women's studies, and the history of science, Schneiderman recently completed a one-year Smithsonian postdoctoral fellowship at the U.S. National Museum of Natural History. While there, she examined Nile delta sediments for their record of climate change in the Sahara Desert. Committed to the task of diversifying the scientific community, she has developed and taught interdisciplinary science courses that address the concerns of feminists and the national multicultural community. In 1993 she received the Wig Distinguished Teaching Award from Pomona College. Schneiderman received a B.S. in geology from Yale in 1981 and an A.M. in geology in 1985 from Harvard. In July 1994 Schneiderman joined the faculty of Vassar College as associate professor of geology. Following her one-year appointment as GSA's Congressional Science Fellow, Schneiderman will help steer a newly endowed environmental studies program at Vassar and will work with her colleagues in the Department of Geology and Geography to develop and institute an earth systems science curriculum that integrates the concerns of geologists and geographers.

The Fellowship

The Congressional Science Fellowship gives a geoscientist first-hand experience with the legislative process and the opportunity to view science policy issues from the lawmaker's perspective. At the same time, the Fellow assists in the analysis of public policy issues by providing scientific and technical expertise.

Funded by GSA and by a grant from the U.S. Geological Survey, the fellowship demonstrates the value of science-government interaction and relates the need for informed involvement to the earth science community. The program places highly qualified, accomplished scientists with the offices of individual members of Congress or committees for a one-year assignment. Fellows perform in much the same way as regular staff members; they have the opportunity to be involved in varied legislative, oversight, and investigative activities. They offer their special knowledge, skills, and competence for the opportunity to acquire experience and the chance to contribute to the formulation of national policy. The Fellow reports periodically to the GSA membership and to the U.S. Geological Survey during the one-year period.

Requirements for the fellowship include exceptional competence in some area of the earth sciences, cognizance of a broad range of matters outside the Fellow's particular area, and a strong interest in working on a range of public policy problems. Fellows attend a two-week orientation conducted by the American Association for the Advancement of Science.

S. 978 *continued from p. 222*

I was beginning to get the idea that there was still a lot of work to be done.

Meetings were held with the different agencies and with OSTP personnel. Independently, OSTP undertook its own series of consultations with the agencies to craft an administration version of the bill. Late in 1993, meetings to finalize a new version of S. 978 were held between congressional, EPA, and OSTP staff. Without producing their own legislative language, the administration stated that it wanted significant changes, some central to the bill's intent. A tug-of-war was initiated between the congressional and Executive Branch staffs. Numerous drafts of the bill moved up and down Pennsylvania Avenue. It looked as if the bill might die a real death.

Finally, the EPW Committee, having agreed to many of the changes sought by the administration, decided to hold firm and refuse further compromise. Simultaneously, a turf battle erupted between the EPW Committee and the Senate Energy and Natural Resources Committees. Alerted by the negotiations with OSTP, the Energy Committee was becoming concerned that the bill might give some measure of oversight of the Department of Energy to the EPW Committee.

Turf Battles

A new round of discussions began, centering on highly technical details of how the proposed legislation would affect the Department of Energy. Several times it appeared that an impasse had been reached. At one point senators from the Energy Committee put a hold on the bill so that it could not come to the Senate floor for a vote. Again, a true death of the bill seemed imminent.

But discussions continued. Individual meetings lasted hours and dealt with only several sentences of the bill. More detailed research was done by staff members of both committees to determine exact cost implications, effects of the bill on existing programs, and whether one committee was usurping authority from another. It was during this tense phase that my technical earth sciences background came most into play, sorting through various proposals and coming up with compromises, especially on technical issues, that would satisfy both sides.

Negotiations with the private sector and nongovernmental organizations also took place throughout this period. Representatives of individual companies, trade associations, and nongovernmental organizations interested in the legislation contributed several excellent ideas to both the EPW and Energy committee staffs, ideas that were incorporated into the new version of S. 978. Several times suggestions from these groups led to compromises between the government parties.

By late April 1994 the White House was on board. All that remained was a single point of disagreement with the Energy Committee—the definition of what constituted an "environmental technology." Depending on this definition, the bill could broadly influence U.S. technology or could be so narrow as to have little impact. Not surprisingly, the EPW Committee wished to make the definition broad. The Energy Committee wanted it narrower so that energy efficiency, alternate energy technologies, and other areas within their jurisdiction would not come under the purview of the EPA and the EPW Committee.

In the end a definition was agreed on. It did not totally please either side, but both could accept it. To make sure that the legislative language would be interpreted in the way that had been agreed on, a colloquy was drafted that was entered into the *Congressional Record* on the day the bill was brought to the Senate floor. Drafting the colloquy took several weeks of intense negotiations. A colloquy is a conversation between two senators on a particular topic. This colloquy was between Senator Baucus and Senator Bennett Johnston (D—LA), the chairman of the Senate Energy Committee. They utilized examples derived from the private sector to clarify the definition of environmental technology.

To the Floor

Following agreement with the Energy Committee, Senator Baucus asked the majority leader to schedule the bill for the Senate floor. With only days left before the bill would be debated, other Congressional staff and I moved into high gear to try to line up final support for the bill and to draft responses to any conceivable question that might be asked about the legislation. Letters of support for S. 978 were requested from the White House, companies, trade organizations, and nongovernmental organizations. These letters were used to demonstrate broad support for the bill as we sought other senators to sign onto S. 978 as cosponsors.

On May 6, 1994, the original S. 978, the bill as reported from the July 1993 EPW Committee markup, was introduced on the Senate floor by Senator Baucus. It was immediately replaced by the senator with an amendment in the way of a substitute that incorporated all the changes and compromises made since the previous July. The old bill was dead, but the new bill had 16 cosponsors.

Through a unanimous consent agreement, a vote on the bill was scheduled for May 11. Between May 6 and 11, numerous senators drafted amendments to the bill. Frantic meetings were held to discuss these proposed amendments and, if possible, to get agreement that they would not be offered. Several "killer" amendments were threatened that would have prevented passage of the bill. The life of the bill was still in the balance. Eventually, deals were made agreeing to address the senators' concerns during the conference on the bill with the House of Representatives. In the end, only one amendment to the bill was debated on the floor, and it was ultimately withdrawn.

The vote on May 11, 1994, was an anticlimax. There was no final debate, simply a roll call vote. The bill passed 85 to 14, with one senator absent.

What had seemed so simple seven months before had involved hundreds of hours of research, discussion, and compromise. The final bill was different from the bill I had been given to work on the previous September. While some things that Senator Lieberman wanted were now gone—for instance, the environmental innovation research program now dealt only with the EPA and the Superfund and did not include cleanup programs in the Departments of Defense and Energy—other parts were strengthened. The process had worked.

Epilogue

The National Environmental Technology Act has only passed the Senate. Matching legislation is currently (July 1994) moving through the House of Representatives. If the House passes an environmental technology bill, a conference must be scheduled to draft a new bill that resolves the differences between the Senate and House bills. This new bill will then return to the respective houses for passage. All this must take place before the end of the 103rd Congress, probably in October.

Although S. 978 has come a long way, there is still a great distance to go before it arrives on the President's desk—and many more chances for one of those 100 deaths. ■

Murray W. Hitzman, 1993–1994 GSA Congressional Science Fellow, served on the staff of Senator Joseph I. Lieberman (D—CT). The one-year fellowship is supported by GSA and by the U.S. Geological Survey, Department of the Interior, under Assistance Award No. 1434-93-G-2382. The views and conclusions contained in this document are those of the author and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. government.

GSA Committee on Geology and Public Policy—Events at the 1994 Annual Meeting

Monday, October 24—Washington State Convention and Trade Center

Earth Scientists on Capitol Hill (12:00–1:00 p.m.)

GSA's eighth Congressional Science Fellow Murray W. Hitzman has worked in the office of Senator Joseph I. Lieberman for the past year. Hitzman was involved in environmental and science-technology legislation, specifically the Clean Water Act reauthorization, the National Environmental Technology Act, and the CERCLA (Superfund) reauthorization. At this open session sponsored by the GSA Geology and Public Policy Committee, Hitzman will report about his experiences on the Hill and discuss some means by which earth scientists may become more effective in the public policy sphere.

Symposium:
Where Geology Matters: Past, Present, and Future (1:00–5:00 p.m.)

The speakers will explore the interface between geologists and officials who determine public policy on behalf of their governmental units:

- *Maxey Flats, Kentucky, Low-Level Nuclear Waste Repository*
  Donald C. Haney, Kentucky Geological Survey
- *Mount Rainier: Volcano Hazards and Emerging Land-Use and Emergency-Response Plans in Pierce County and Orting, Washington*
  Steven R. Brantley, U.S. Geological Survey, Vancouver, Washington
- *Wise Public Policy: Learning from Experience*
  James F. Davis, California Division of Mines and Geology
- *Successful Mineral Exploration and Project Development in Ireland*
  Murray W. Hitzman, Washington, D.C.
- *Herbicides in the Lower Kansas River Basin–Policy-relevant Findings*
  P. Patrick Leahy, U.S. Geological Survey, Reston, Virginia
- *Role of the Illinois State Geological Survey in the 1993 Historic Flooding in Illinois*
  Michael J. Chrzastowski, Illinois State Geological Survey
- *Conveying Information about Earthquake, Flood, and Landslide Hazards in San Mateo County, California*
  Earl E. Brabb, International Landslide Research Group
- *Implementing Public Policy in Los Angeles County, California, through the Regulatory Review of Geology Reports*
  Robert A. Larson, Los Angeles County Department of Public Works

The Geological Society of America

Congressional Science Fellowship 1995–1996

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

Criteria

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

Award

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

To Apply

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

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

Agents *continued from p. 217*

between oceans and continents or, in interior basins, the boundary between erosional and depositional regions.

In all such unidirectional processes, however, there are intermediate steps in which a particle that is moved is soon thereafter replaced by another, as, for example, the transfer of a sand grain from one point bar to the next downstream and its replacement by a grain from upstream. To the extent that such internal sediment transfers have no long-term geomorphic effect, I have disregarded them. Some internal transfers are not completely balanced, however, and thus do have a lasting effect. The migration of river meanders is an example.

Sediment transfers resulting from human activities are also internal in the sense that there is no well-defined line or plane across which material is moved. Furthermore, they are decidedly unbalanced, because much of the material removed is not replaced.

HUMAN ACTIVITIES

To quantify the geomorphic impact of *Homo sapiens*, I have chosen to consider three types of earth-moving activity: excavations for houses, mineral production, and road building. One can make a reasonable estimate of the quantities of earth moved in each of these three activities in the United States, as follows:

1. Housing starts average ~1.3 x 10^6/yr (*New York Times*, 1/23/92). If the average house measures 10 x 20 m and half of them require foundation holes 3 m deep, or an equivalent amount of regrading of the landscape, 300 m^3 of earth is moved per house. At a mean density of 2 t/m^3, house building involves moving ~0.8 Gt/yr (1 Gt = 10^9 t or 10^{12} kg).

2. Mineral production in 1988 totaled 3.2 Gt (U.S. Bureau of the Census, 1991, p. 694). Of this, the three largest products were stone (1.1 Gt), sand and gravel (0.86 Gt), and coal (0.86 Gt). Making an adjustment for the mass of ore moved to yield a unit mass of mineral product increases this to ~3.8 Gt. In making this adjustment, I conservatively estimated that mining of stone and of sand and gravel did not involve movement of material other than that produced, and that in producing coal, the mass of overburden removed was about one-third that of coal produced. For metals, figures on the concentrations required to yield an economically viable deposit were obtained from texts such as Dennen (1989).

3. There are ~6.23 x 10^6 km of highways in the United States (U.S. Bureau of the Census, 1991, p. 605). Assume that the principal period of construction of these was during the past 80 years, and that the construction (and reconstruction) rate in the past decade or so has been double the mean. Assume further that ~10 m^3 of earth with a density of 2 t/m^3 is moved per meter of road. This does not include gravel that is mined and hauled to the construction site, as that is included in the mineral production above. Then road construction may involve movement of ~3 Gt/yr.

To extrapolate these figures to worldwide activity, let us assume that the geomorphic activity of humans scales with the gross national product. The GNP of the world as a whole is about four times that of the United States (U.S. Bureau of the Census, 1991, p. 840–841), and so my estimate of the worldwide geomorphic activity of *Homo sapiens* becomes ~30 Gt/yr. Alternatively, one might scale human geomorphic activity with energy consumption. As energy consumption in the United States is 21.7% of the world total (Holdren, 1991), the estimate then rises to 35 Gt/yr.

TABLE 1. SUMMARY OF RATES OF GEOMORPHIC ACTIVITY

Agent	Mass moved (Gt/yr)
Humans	
GNP scaling	30
Energy use scaling	35
Energy use scaling and including effect on river sediment load	45
Rivers	
Long-distance sediment transfer	
At present	24
In the absence of human disturbance	14
River meandering	
Starting on 4th order streams	39
Starting on 5th order streams	23
Glaciers	
At present	4.3
Pleistocene	10
Slope processes	0.6
Wave action	
Sediment flux	1
Erosion	0.24
Wind	1
Mountain building	
Continental	14
Oceanic	30
Deep ocean sedimentation rates	7

RIVERS

Long-distance Sediment Transfer

Milliman and Meade (1983) estimated that the worldwide flux of clastic sediment to the oceans in rivers is ~16 Gt/yr, a figure that is generally consistent with other estimates (see Judson, 1968, Table 3). Dissolved load contributes an additional 2 to 4 Gt/yr (Judson, 1968; Lisitzin, 1972, p. 36), making a total of ~19 Gt/yr.

Judson (1968) estimated that in the absence of human disturbance, the combined clastic and dissolved load of rivers would be only ~9 Gt/yr. Thus human activities, particularly agriculture, may be responsible for as much as ~10 Gt/yr. In Table 1, the last estimate of the human impact on the landscape includes this contribution.

To the estimates of Milliman and Meade (1983) and Judson (1968) should be added the flux of river sediment to interior basins. On the basis of Judson's calculations, this is ~4.6 Gt/yr. Thus, in round numbers, we take the total sediment flux in rivers prior to human intervention to be ~14 Gt/yr, and thereafter ~24 Gt/yr.

Meandering

To estimate the amount of sediment moved in the process of river meandering, we must first estimate the total length of meandering streams in the world. Assume that the average drainage density is 1.5 km of stream channel per square kilometer of land. Assume further that streams of low order do not meander. Then, using relations developed by Horton (1945), calculate the total length of streams of order greater than this limit. In this calculation, I used a bifurcation ratio of 3.6 and a length ratio of 2.1, both of which are reasonable mean values. Finally, assume that the density of the eroded sediment is 2 t/m^3, the mean migration rate is 0.2 m/yr (Rohrer, 1982), and the mean stream depth is 1.5 m. Then, if streams of order 4 and higher are assumed to migrate by meandering, ~39 Gt/yr of sediment are moved by this process (Table 1).

GLACIERS

Rates of erosion by valley glaciers can be as high as 5 to 10 mm/yr, but more typically they are closer to 1 mm/yr, and for continental ice sheets they are an order of magnitude less (Embleton and King, 1975, p. 309–313, 320–321; Andrews, 1972). Glaciers, principally continental ice sheets, now cover about 15.86 x 10^6 km^2 of Earth's surface (Haeberli et al., 1989). Assuming a density of 2.7 t/m^3 for the rock eroded, the total annual erosion rate is ~4.3 Gt/yr. During the late Pleistocene glacial maximum, ice covered ~38.6 x 10^6 km^2 (Embleton and King, 1975, p. 14); this figure suggests a potential erosion rate of ~10 Gt/yr.

SLOPE PROCESSES

The land area of Earth is ~1.5 x 10^{14} m^2. Of this, probably one-third is so flat that slope processes are negligible. Then, if the length of a typical slope, top to bottom, is ~100 m, the total width, parallel to the contour, would be ~1 x 10^{12} m. Creep and slope wash can deliver ~3 x 10^{-4} m^3 of soil per year to the base of a typical slope of unit width (Kirkby, 1967; and unpublished data). Assuming a soil density of 2 t/m^3, the total mass of soil moved to the bottoms of slopes worldwide may be on the order of 0.6 Gt/yr.

WAVE ACTION

Typical rates of littoral drift range from 80 000 to 380 000 m^3/yr (Herbich and Haney, 1982). Let us assume that the primary sinks for this sediment are submarine canyons that have eroded headward across the continental shelf. The average spacing of submarine canyons along the Atlantic and Pacific coasts of the United States is ~200 km (Kennish, 1989). Thus, along the 0.5

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x 10^6 km of coastline in the world (Bird and Schwartz, 1985, p. vii) there may be ~2500 canyons. If each receives ~200 000 m^3/yr of sediment with a density of 2 t/m^3, the total thus discharged is 1 Gt/yr.

Of course, much of that sediment is delivered to the coast by rivers. Herbich and Haney (1982) suggested that actual erosion of beaches and beach cliffs along the coastlines of the world may be only ~1.2 x 10^8 m^3/yr, or ~0.24 Gt/yr.

WIND

G. Arnason (cited by Peterson and Junge, 1971, p. 312) estimated that wind may export ~0.5 Gt/yr of dust from the continents. This dust is believed to originate "primarily from arid regions, particularly the Sahara." This estimate is thus broadly consistent with a numerical model developed by Schütz et al. (1981) that predicted a dust transport from the Sahara of 0.26 Gt/yr.

Wind also moves sand, but sand dunes occupy only a small fraction of Earth's surface, so the geomorphic work done must be small compared with many other geomorphic processes. Furthermore, in many cases sand is simply moved back and forth as storm and prevailing winds alternate (Sharp, 1966). The total unidirectional transport of clastic sediment by the wind is thus estimated, very roughly, to be ~1 Gt/yr.

MOUNTAIN BUILDING

Because rather different processes are involved, it is convenient to consider orogenic movements on land separately from "mountain building" at midocean ridges. Rates of orogenic uplift of land areas vary widely, so rather than attempt to estimate a global average rate, I assume that this uplift is roughly balanced by river erosion. Thus, the estimate above for the rate of sediment delivery to the oceans and interior basins in the absence of human activities suggests an addition to the continental land mass above sea level of ~14 Gt/yr.

At midocean ridges, it is the geomorphic relief of the ridges themselves, and not the total production of lithosphere, that is relevant to the present comparisons. The ridges rise an average of ~2 km above the surrounding ocean floor (Sawkins et al., 1974, p. 119), and their total length is ~84 000 km (Hamblin, 1985, p. 404). The mean spreading rate is ~0.06 m/yr (Sawkins et al., 1974, p. 125). Assuming a density of 3 t/m^3 for the rock formed, the rate of midocean ridge formation is 30 Gt/yr.

DEEP-OCEAN SEDIMENTATION RATES

The ocean basins occupy about 3.55 x 10^{14} m^2, and typical sedimentation rates are of the order of 1 x 10^{-5} m/yr. Assuming a density of 2 t/m^3 yields a rate of ~7 Gt/yr. Of this, 2 to 3 Gt/yr may be biogenous sedimentation (Lisitzin, 1972, p. 135), and most of the rest is presumably fine clastic river sediment, together with a small eolian contribution, mentioned above, that is carried far from the continents before being deposited. The geomorphic effect of this sediment is to bury the irregular volcanic landforms originating at midocean ridges and elsewhere, and thus to smooth the abyssal plains of the ocean.

THE PREMIER GEOMORPHIC AGENT

Perhaps I have underestimated the role of some traditional geomorphic agents. More weight could be given to the impact of moving tens of millions of separate 1 g parcels of sediment each 1 km in a river, or of moving tens of billions of sand grains back and forth on beaches.

However, an equally strong case can be made to the contrary. Most geomorphic processes move sediment in a predictable direction, and the ultimate driving force is gravity. Humans, however, move soil or rock hither and yon, often in defiance of gravity, and governed by no apparent physical rules. Consequently, the visual impact of human geomorphic activity is vastly greater than that of most traditional geomorphic agents such as, for example, a river redistributing a similar amount of sediment in a floodplain or depositing it below sea level in a delta.

In conclusion, by the measures developed herein, however imperfect, *Homo sapiens* has become an impressive geomorphic agent. Coupling our earth-moving prowess with our inadvertent augmentation of the sediment load of rivers and the visual impact of our activities on the landscape, one is compelled to acknowledge that, for better or for worse, this biogeomorphic agent may be the premier geomorphic agent of our time.

ACKNOWLEDGMENTS

I am indebted to my colleague, E. C. Alexander, for his enthusiastic encouragement in this undertaking. Both Alexander and H. E. Wright, Jr., offered comments on an early draft of the paper.

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GSA Committee Awards Research Grants

June Forstrom, Research Grants Administrator

The GSA Committee on Research Grants met in Boulder, Colorado, on April 7–8, 1994, and awarded $303,073 to 238 student applicants. Two postdoctoral applicants for the Gladys W. Cole and W. Storrs Cole Awards received$14,000. Committee members for 1994 are Raymond V. Ingersoll (chairman), Mary L. Droser, Peter C. Patton, Darryll T. Pederson, Sheila J. Seaman, Ben A. van der Pluijm, and Thomas O. Wright (National Science Foundation conferee).

Of the 238 grant recipients, 98 were master's candidates and 140 were doctoral candidates. The size of the average award was $1273. Proposal requests totaled $1,070,304 from 583 students.

The committee's budget included $156,600 from the Penrose Endowment; $100,000 from the National Science Foundation; $6000 from the Harold T. Stearns Award Fund, the Sedimentary Geology Division, and the Structural Geology and Tectonics Division; $2854 of funds returned too late in 1993 to be reawarded; and $11,000 from the Second Century Fund. It also included $26,400 from the GSA Foundation, which included $12,000 from the Research Fund, $6800 from Unrestricted GEOSTAR funds and $7600 from various restricted special funds and Geophysics Division and Hydrogeology Division funds. The Gladys W. Cole and W. Storrs Cole Awards were funded by $14,000 income from the two Cole Award Funds of the GSA Foundation.

Cole Awards for Postdoctoral Research

The Gladys W. Cole Memorial Research Award for 1994 went to Ellen Eva Wohl of Colorado State University, Fort Collins, to support her project titled "Energy Expenditure in Deep, Narrow Bedrock Canyons of the Colorado Plateau." This award, established in 1980, is restricted to support research for the investigation of the geomorphology of semiarid and arid terrains in the United States and Mexico.

The W. Storrs Cole Memorial Research Award for research in invertebrate micropaleontology was established in 1989. It was presented this year to Pamela Hallock Muller of the University of South Florida, St. Petersburg, for her project titled "Evolutionary Implications of Environmental Stress on Adult *Amphistegina*."

Eligibility for both Cole awards is restricted to GSA Members and Fellows between 30 and 65 years of age.

Student Awards

Gretchen L. Blechschmidt Research Award. The family and friends of Gretchen Louise Blechschmidt established a fund in her memory in 1990 to support research for women in the geological sciences. The award was presented this year to Katharina Billups of the University of California, Santa Cruz, for her project titled "Early to Late Pliocene Paleoceanography: Reconstructing Seasonal Sea Surface Temperatures from the Stable Isotopic Composition of Individual Planktonic Foraminifera."

John T. Dillon Alaska Research Award. John Dillon was particularly noted for his radiometric dating work in the Brooks Range, the results of which have had a major impact on the geologic understanding of this mountain range. The 1994 recipient is Tracy Marie Siebert of Miami University (Ohio), for "Petrologic Significance of Mafic to Intermediate Volcanism at the Skookum Creek Volcanic Complex, Wrangell Volcanic Field, Alaska."

Robert K. Fahnestock Award. This award is given to honor the memory of Ken Fahnestock, who was a member of the Committee on Research Grants. It is awarded to the applicant with the best proposal in sediment transport or related aspects of fluvial geomorphology. The 1994 recipient is Laurence C. Smith, Cornell University, for "A New Method of Discharge Estimation for Braided Outwash Streams."

Lipman Research Award. The Lipman Research Fund was established in 1993 and is supported by gifts from the Howard and Jean Lipman Foundation to promote and support student research grants in volcanology and petrology in the western United States and Alaska. This year the fund supported the research of two students: Julia G. Bryce,

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Grants *continued from p. 225*

University of California, Santa Barbara, for "A Window into Magma Extrusion Mechanisms in Caldera-Forming Eruptions: The Boulder City Cauldron, Eldorado Mountains, Southeastern Nevada," and Kristin T. Huysken, Michigan State University, for "Time Constraints on the Origin and Evolution of the Timber Mountain Magmatic System: An Early History Recorded in the Pre–Caldera-Collapse Tephra."

Bruce L. "Biff" Reed Scholarship Award. The Bruce L. "Biff" Reed Scholarship Award was established in 1993 to provide research grants to graduate students pursuing studies in the tectonic and magmatic evolution of Alaska and its mineral deposits, but also can fund other geologic work in Alaska. The recipient of the first Reed Research Grant is Anne R. Poole, Rice University, for "Implications of Triple-Junction Migration on the Petrology of the Chugach Metamorphic Complex, Southeastern Alaska."

Harold T. Stearns Fellowship Award. The three recipients of this award, for research on aspects of the geology of the Pacific Islands and the circum-Pacific region, are: Samantha Goldfarb, University of Southern California, for "Linked Pluton–Wall Rock Systems: An Integrated Approach to Pluton Emplacement, Calamajue, Baja California, Mexico"; Peter W. Reiners, University of Washington, Seattle, for "Stratigraphic, Paleomagnetic, and Isotopic Test of the Single-Volcano Hypothesis for the Island of Kauai, Hawaii"; and Peter D. Weiler, University of California, Santa Cruz, for "Paleomagnetic Study of an Active Arc-Continent Collision."

Industrial Donations and Awards. Industrial donations this year are $5000 from Drummond Company, Inc., $2000 from Mobil Oil Corporation, and $5000 from Unocal Corporation. This is the 25th year of support from Mobil Oil for the grants program. The 1994 recipients are: John Corey Cram, Pennsylvania State University, "Diversion Well Treatment of Acid Mine Drainage"; Brian S. Currie, University of Arizona, 'Back-bulge' to Foredeep Evolution of the Late Jurassic– Early Cretaceous Cordilleran Foreland Basin"; Jennifer Joyce, University of Utah, "Methane Flux, Aqueous Geochemistry, and Hydrodynamic Relationships in Lago Loiza Reservoir, Puerto Rico"; Debra S. Laudermilch, University of Texas at Dallas, "Depositional Processes of Event Beds at the Cretaceous/Tertiary Boundary at Brazos River, Texas, and Arroyo el Mimbral, Northeast Mexico"; MaryAnn L. Malinconico, Columbia University, "Thermal Maturation and Organic Petrology of the Newark Basin, New Jersey/Pennsylvania"; Danielle Montague-Judd, University of Arizona, "Application of Paleontological and Sedimentological Criteria for Upwelling to the Luning Formation (Tr) and the Sharon Springs Member of the Pierre Shale (K)"; Julie Selway, University of Manitoba, "Surface Interactions on Sulfide Minerals"; and William Alexander Webster, Auburn University, "Evaluation of Pre- and Post-Industrialization of Wetlands: Heavy Metal Accumulations in Aquatic Plant Communities."

Outstanding Mention. The committee on Research Grants specially recognized 36 of the proposals as being of exceptionally high merit in conception and presentation:

Andy Crossland, University of Southern California, "Three-Dimensional Control of Space-Making Processes During Pluton Emplacement: A Study of the Hall Canyon Pluton"; Brian S. Currie, University of Arizona, "'Back-Bulge' to Foredeep Evolution of the Late Jurassic–Early Cretaceous Cordilleran Foreland Basin"; Genet Ide Duke, South Dakota School of Mines & Technology, "Geochronology and Geochemistry of Tertiary Intrusives in the Northern Black Hills, South Dakota and Wyoming"; Jeffrey Charles Fischer, Miami University, "Grenville History of the Adirondack Lowlands: The Significance of the Hyde School Gneiss"; Samantha Goldfarb, University of Southern California, "Linked Pluton–Wall Rock Systems: An Integrated Approach to Pluton Emplacement, Calamajue, Baja California, Mexico"; Andrea Groves, Bowling Green State University, "The Origin of Fluids Associated with Silica Boxwork"; Joel T. Harper, University of Wyoming, "Direct Measurement of Vertical Strain in an Active Valley Glacier"; Stephen T. Hasiotis, University of Colorado, "Partitioning of the *Scoyenia* Ichnofacies: A Model Synthesized from Ichnofossil-Bearing Mesozoic and Cenozoic Continental Deposits"; Christopher A. Hedlund, Colorado State University, "Geometry, Kinematics, and Mechanics of Decollement Folding in the Canadian Rockies"; Jan T. Heine, University of Washington, "Late Glacial Climate Change in the Western United States—A Glacial Chronology of Mount Ranier Volcano, Washington"; David M. Hirsch, University of Texas, Austin, "Using Quantitative Textural Analysis to Explain Porphyroblast Textures in Metamorphic Rocks in Terms of the Physical Parameters of Recrystallization"; Annika Karen Johansson, Columbia University, "The Global Miocene Silica Event in Grasses and Diatoms"; Stephen Curtis Knowles, University of North Carolina, Chapel Hill, "In Situ Analysis of Coastal Suspended Sediment Aggregates: Size, Shape, Orientation, Composition and Fall Velocity"; Christopher F. Kopf, University of Massachusetts, Amherst, "Metamorphic History of Mafic Granulites from the Snowbird Tectonic Zone in Northern Saskatchewan and Their Implications for the Nature of the Lower Continental Crust"; Stephen C. Kuehn, Washington State University, "The Nature of the Olympic-Wallowa Lineament and Hite Fault System, Northeast Oregon"; Debra S. Laudermilch, University of Texas, Dallas, "Depositional Processes of Event Beds at the Cretaceous/Tertiary Boundary at Brazos River, Texas, and Arroyo el Mimbral, Northeast Mexico"; Jonathan C. Lewis, University of Connecticut, "The Effect of Changing Plate Motions on the Structure of Accretionary Prisms: The Tertiary Shimanto Belt, Japan"; MaryAnn L. Malinconico, Columbia University, "Thermal Maturation and Organic Petrology of the Newark Basin, New Jersey/Pennsylvania"; Natalia Malyk-Selivanova, Rutgers University, "Determination of Chert Sources of Prehistoric Artifacts, Northwestern Alaska"; William F. Manley, University of Colorado, "Late Quaternary Ice-Sheet Interactions in the Eastern Canadian Arctic: Coherent Climate Changes?"; L. Lynn Marquez, Northwestern University, "Time-Dependent Hydrothermal Circulation: Crustal Architecture and Fault Systems at Active Spreading Centers"; Danielle Montague-Judd, University of Arizona, "Application of Paleontological and Sedimentological Criteria for Upwelling to the Luning Formation (Tr) and the Sharon Springs Member of the Pierre Shale (K)"; Jed Leigh Mosenfelder, Stanford University, "Kinetics of the Gabbro-Eclogite Transformation"; Oleg V. Pinous, Ohio State University, "Field and Laboratory Investigation of Mesozoic and Paleogene Stratigraphy and Sedimentology of West Siberia and Russian Platform: Application to Improvement of Quantified Eustatic Sea Level Curves"; Michael A. Poage, University of Montana, "The Petrology of the Plains Sill, Western Montana"; Robert M. Reed, University of Texas, Austin, "Emplacement and Deformation of the Wolf Mountain Pluton, Llano Uplift, Central Texas"; Peter W. Reiners, University of Washington, "Stratigraphic, Paleomagnetic, and Isotopic Test of the Single-Volcano Hypothesis for the Island of Kauai, Hawaii"; Peter E. Sauer, University of Colorado, "Calibration of the Meteoric Water Isotope–Submergent Aquatic Plant Cellulose Isotope Paleoenvironmental Indicator"; Kenneth M. Schopf, Harvard University, "Ecosystem Dynamics and Evolution in the Upper Cretaceous (Pierre Shale, U.S. Western Interior)"; Linda Elisabeth Sohl, Columbia University, "A New Approach for Improving Time Resolution in the Late Proterozoic"; Carol M. Tang, University of Southern California, "Evolution of Jurassic Marine Benthic Invertebrate Paleocommunities in the Western Interior of the U.S."; Robert Joseph Viens, University of Washington, "The Dynamic Response of Tidewater and Freshwater Calving Glaciers to Millennial-Scale Climatic Change"; Gina von Damm, University of California, Davis, "Microseismicity and Hydrothermal Circulation at Long Valley, California"; Peter D. Weiler, University of California, Santa Cruz, "Paleomagnetic Study of an Active Arc-Continent Collision"; Darrell Todd Woodford, Rice University, "Micro-Instrumental Neutron Activation Analysis, a New Technique for Chemical Analyses of Fluid Inclusions: Application to Fluid Evolution and Boron Metasomatism Studies of the Alta Stock Contact Aureole, Utah"; and Andrew H. Wulff, University of Massachusetts, Amherst, "Evaluating Common Petrogenetic Process Sequences Operative in the Southern Volcanic Zone, Chile, with a Chemo-Stratigraphic Template."

Other Successful Applicants.

Other applicants recommended for funding are the following:

Brian G. Anderson, Kirk Anderson, Scott Douglas Anderson, Dyke Andreasen, Robert Asher, David H. Backus, Rahul Bahadur, Suzanne E. Bailey, Sanjay Banerjee, Rachel J. Beane, Bryan E. Bemis, Margaret G. Bickmore, Baerbel G. Bischof, Pamela F. Borne, Julie L. Boyd, Brian W. Boyer, Kevin J. Bradford, Mary Anne Brown, Celeste Eva Burns, Isac Burstein, Erin A. Campbell, Danielle L. Carpenter, Tracey E. Cascadden, Yu-Chang Chan, Beth Anne Christensen, William C. Clyde, Jonathan Cole, Nancy E. Collins, Robert Allen Cooper, Maria-Merce Corbella, Kathleen J. Counter, Erich Cowgill, David M. Cox, Peter A. Craig, John L. Crocco, Scott L. Cross, James Cureton, Christopher Daniel, Joel Davidow, Cynta de Narvaez, Hilary Lee Dervin, Michael DeSantis, Pauline Deutz, Kathleen M. Duggan, Thomas R. Dwyer, Todd Alan Ehlers, David Aspinwall Evans, Timothy Fagan, Claudia Falkner, Remi N.R. Farvacque, James Wilson Fatherree, Daniel L. Feuerbach, Timothy R. Filley, Dagmar Gnieser, Paul W. Grover, David M. Haasl, Jeffrey R. Hale, Andrew D. Hanson, James Joseph Hardy, Jr., Catherine M. Helm, Frances A. Herlihy, Roberta Jean Hicks, Margaret M. Hiza, Kimberly S. Holland, Erin Holman, Erin F. Holmstad, Brian K. Horton, Victoria C. Hover, Richard G. Hoy, Shaosong Huang, Christopher Charles Humphrey, Hiram Jackson, Beth Lynn Johnson, Ian C. Jones, Merren Jones, Carlos F. Jove Colon, Thomas J. Kalakay, Richard A. Kayser, Alexander W.A. Kellner, Katherine J. Kendrick, Suvrat Kher, Eric Kirby, Robert T. Klein, Kurt M. Knesel, Marilyn D. Kressel, Douglas W. LaFarge, Holly Langrock, Patrick Luther Larsen, Amy C. Larson, Phillip C. Larson, Alexis Lavine, Robert S. Leighty, Robin Z. Levron, Richard H. Levy, Li Li, Johan Liebens, Jonathan K. Linn, Ghislaine Llewellyn, David B. Lowe, William Robert Lozier, Ernest Jan Luikart, Leta A. Magendanz, Kerry A. Mammone, Anna M. Martini, Andrew Lee Maxwell, Jason D. Mayfield, Scott M. McDaniel, Xiangying Meng, Andrew L. Moore, Andrew Joseph Mughannam, Hope E. Mullally, Jeffrey Alan Myers, Philip Norlund, Jodi Renee Norris, Edward Oldenburg, Anton Oleinik, Amalia Olivera, Jennifer A. Olson, William David Orndorff, Mary A. Parke, Cheryl Hapke Petrina, Michael Joseph Quinn, Joan M. Ramage, Troy Rasbury, Christine Reese, Trent Alan Rehill, Lynn Remkus-Catlin, Alexis Richardson, Matthew J. Robinson, P. Charles Robnett, Jeanette Roelofsen, Pavel A. Romashkin, J. G. Hector Romero-Espejel, Bruce F. Rueger, Janet L. Saltzman, Matthew R. Saltzman, Eric T. Schleicher, Tim Schroeder, Marcia K. Schulmeister, Brendan Shane, Russell Scott Shapiro, Brian T. Sheldon, Graham Simpson, Chad A. Smith, Jennifer S. Smith, Langhorne B. Smith, Jr., Matthew Paul Spizuco, Aradhna Srivastav, Piyush Srivastav, Sharon Stern, Karen B. Stilwell, Erik R. Stokstad, Luther M. Strayer, Eric C. Straffin, James R. Struthers, Aviva Joy Sussman, Robert John Swartz, Vikas Tandon, Glenn David Thackray, Wendi R. Thompson, Charles C. Tiller, Gustavo Tolson, Jeffrey M. Trop, Peter Tropper, Marlene F. Tuesink, Elizabeth C. Turner, Maria Uhle, Kenneth E. Valentine, Sytze van Heteren, James Raymond Waits, Cong Wang, Liping Wang, Andrew C. Warnock, Blaine A. Watson, Richard R. Weihe, Thomas E. West, Jr., Kathleen S. White, Peter D. Wilf, Tanja Nicole Williamson, Andrew John Willis, Richmond Wolf, David J. Wood, Julie Woodward, Zhangming Wu, Adam Wayne Wygant, Wan Yang, Qiucheng Ye, Xinping Yin, Samuel Allen Zebelman, Jijun Zhang, Pinglao Zhao, and Da Zhou. ■

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Registration and housing information appeared in the June issue of *GSA Today*
1994 Technical Program Schedule is in this issue, beginning this page
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Join Us in Seattle

Science. Communicating. Enjoying a new city. These thoughts always come to mind when I contemplate attending a GSA Annual Meeting.

Science: As this year's theme implies, the foremost goal of our Annual Meeting Committee has been to facilitate a technical and field-trip program that will define where our science is and where it is headed. If the program in my own field of structural geology and tectonics is at all representative, the topics that will be addressed during the Seattle meeting will educate and provoke us, and will influence our teaching, research, and applications for years to come.

Communicating: All kinds, at all levels. From the presidential address and the alumni parties to follow, to exhibits and special demonstrations, to the chance encounter in a hallway, an annual meeting is a forum for exchanging ideas and data or for just saying hello. I've lost count of the times I've been racing to hear a talk and then spent the time in valuable conversation with a colleague instead. Most of you will come to Seattle because you have something to tell others or because you want to listen. The Convention Center is a terrific venue for doing both.

1994 Annual Meeting Committee: Mark Ghiorso, Technical Program Chairman; Don Swanson, Field Trip Chairman; and Darrel S. Cowan, General Chairman.

Enjoying a new city: This year, it is our pleasure to introduce or re-introduce you to Seattle. It is the unusual registrant who will want to spend every waking minute in talks, poster sessions, meetings, and exhibits. Take a short break and walk to the Pike Place Market or embark on a bracing ferry ride across Puget Sound. Join one of the daily events chosen by our Guest Committee to convey what we find distinctive and enjoyable about Seattle and the Pacific Northwest. Seattle is an easy city to explore on one's own. If the October weather lives up to its (in my view, unjustifiably) infamous reputation, you'll find an espresso stand at every turn to warm your journey.

Darrel S. Cowan, General Chairman
1994 Annual Meeting Committee

Overview of the 1994 GSA Annual Meeting Program

October 24–27, 1994; Washington State Convention and Trade Center

There will be 197 technical sessions presented during the course of the meeting. Of these, symposia (invited papers) and theme sessions (volunteered papers submitted to a specific topic) are referred to by a number that precedes the title. All other sessions are referred to by disciplines, such as Geochemistry I, II. Sessions are oral unless poster is indicated.

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CF	Cushman Foundation
GS	Geochemical Society
GIS	Geoscience Information Society
IEE	Institute for Environmental Education
MSA	Mineralogical Society of America
NAGT	National Association of Geology Teachers
PS	Paleontological Society
SEG	Society of Economic Geologists
SEPM	Society of Sedimentary Geology
SGE	Sigma Gamma Epsilon

SYMPOSIA

S1. Keynote Symposium: Birth and Death of a Plate. 1994 GSA Annual Meeting Committee. Oct. 24 a.m.

S2. Plate Motion and Displacement Partitioning in the Circum-Pacific Orogenic Belts. International Division. Oct. 24 p.m.

S3. New Frontiers in Active Tectonics Science. Structural Geology and Tectonics Division and Geophysics Division. Oct. 26 a.m./p.m.

S4. Tectonic Geomorphology, Depositional Processes, and the Depositional Record. Sedimentary Geology Division. Oct. 25 p.m.

S5. Geology and the Postindustrial Society. 1994 GSA Annual Meeting Committee. Oct. 25 a.m.

S6. Meyer Symposium: Maintaining Compatibility of Mining and the Environment. SEG and 1994 GSA Annual Meeting Committee. Oct. 25 a.m./p.m.

S7. Advances in Silica Geochemistry. MSA. Oct. 24 p.m.

S8. Mineralogical Society of America 75th Anniversary Symposium. MSA and 1994 GSA Annual Meeting Committee. Oct. 26 p.m.

S9. Frontiers of Mineral Surface Geochemistry: A Symposium in Memory of Andrew J. Gratz (1962-1993). MSA and GS. Oct. 26 a.m.

S10. The Dreiss Symposium: Recent Trends in Studies of Coupled Hydrodynamic, Tectonic, and Thermal Processes. Hydrogeology Division. Oct. 24 p.m.

S11. Hydrology and Active Volcanism: At the Leading Edge. Quaternary Geology and Geomorphology Division. Oct. 26 p.m.

S12. Regional Economic Geology of the Northern Cordillera. SEG. Oct. 23 a.m./p.m.

S13. Historical Investigations of Extraterrestrial Events and Causes in Earth History. History of Geology Division. Oct. 26 a.m.

S14. Cataclysms and Catastrophes: The Planetary Perspective. Planetary Geology Division. Oct. 25 a.m.

S15. Evolutionary Paleobiology. PS. Oct. 25 a.m.

S16. Military Geology in War and Peace. Engineering Geology Division. Oct. 26 a.m./p.m.

S17. Pyrolysis Techniques for Source Rock Evaluation—Twenty Years Later. Organic Geochemistry Division of the GS. Oct. 23 p.m.

S18. Origin of Compositional Characteristics in Tertiary Coals: Paleoecology, Paleobotany, and Palynology. Coal Geology Division. Oct. 24 a.m.

S19. The Late Cretaceous Marine and Continental Record of Global Climate Change. CF. Oct. 24 p.m.

S20. Use of Archaeology for Dating Geologic Events. Archaeological Geology Division. Oct. 25 a.m.

S21. Changing Gateways: The Impact of Technology on Geoscience Information Exchange. GIS. Oct. 25 a.m.

S22. Recent Advances in Geoscience Education—The Leading Edge of Undergraduate Instruction and Research. NAGT and National Science Foundation. Oct. 25 a.m.

S23. Marine Trace-Element Biogeochemistry and the Sedimentary Record. GS. Oct. 23 a.m./p.m.

continued on p. 228

S24. The Geological Profession's Response to National Priorities in Science Education. Geoscience Education Division. Oct. 26 p.m.

S25. Annual Environmental Forum: Crucial Environmental Issues: Fear and Loathing at the Leading Edge. IEE and GSA Committee on Geology and Public Policy. Oct. 23 p.m.

S26. Student Research. SGE. Oct. 25 p.m. (Poster)

S27. Where Geology Matters: Past, Present, and Future. GSA Committee on Geology and Public Policy. Oct. 24 p.m.

THEME SESSIONS

T1. Liquefaction Hazard Mapping and Mitigation. Oct. 25 p.m.

T2. Speciation, Mobility, and Bioavailability of Metals in Mining Wastes. MSA. Oct. 27 a.m.

T3. The Role of Geology in Characterization, Contaminant Transport, and Remediation of Hazardous Waste Sites. IEE. Oct. 27 a.m./p.m.

T5. The Geological Basis of Wild Salmon Ecology. IEE. Oct. 27 a.m./p.m.

T6. Environmental Geology: The Voice of Warning. IEE. Oct. 26 a.m.

T7. Environmental Geology: The Voice of Reason. IEE. Oct. 26 a.m./p.m.

T8. Geochemistry of Contaminant Transport. Oct. 25 a.m.

T9. Urban, Suburban, and Rural—Environmental Geology at the Leading Edge. Quaternary Geology and Geomorphology Division and IEE. Oct. 24 a.m.

T10. The Management of Contaminated Sites in Near-shore Marine and Estuary Environments. Oct. 25 a.m.

T11. Stable Environmental Isotope Application in Ground-water Systems. Hydrogeology Division. Oct. 26 a.m.

T13. Relation of Depositional Environments to Chemical and Physical Heterogeneity within Sedimentary Aquifers. Hydrogeology Division and SEPM. Oct. 25 a.m.

T14. Geologic Significance of Microbial Processes. Hydrogeology Division. Oct. 27 p.m.

T15. Computational Hydrology and Data Visualization and Animation. Hydrogeology Division. Oct. 24 a.m.

T16. Leading Edge Applications of Earth Science Modeling and Visualization. COGEOINFO (Commission on the Management and Application of Geoscience Information). Oct. 24 a.m.

T17. Integration of Hydraulic and Geochemical Approaches in Vadose Zone Transport Studies. Hydrogeology Division and IEE. Oct. 26 p.m.

T18. Methods for Quantifying Unsaturated Permeability, Retardation, and Other Transport Properties in Rock, Soil, and Sediment. (Poster) Oct. 27 a.m.

T20. Records of Glaciation and Climate Change Along the Leading Edge During the Last Glacial Maximum and the Pleistocene-Holocene Transition (20-8 ka). Oct. 27 a.m./p.m.

T21. The Last Interglacial: Timing and Environment. Oct. 27 p.m.

T22. Paleoclimate Records from Arctic Lakes and Estuaries. Oct. 26 a.m.

T23. Correlation of the Marine and Terrestrial Paleoclimatic Record of the Eastern North Pacific and Western United States. (Poster) Oct. 25 p.m.

T24. Tectonics and Landforms Around the Pacific Rim. Oct. 25 a.m.

T26. Quaternary Dating Methods. Oct. 25 p.m.

T27. Late Quaternary Evolution of the Eastern Aleutian Arc: Volcanoes, Earthquakes, Glaciers, and Shorelines. Oct. 24 p.m.

T28. Learning in Small Groups: Using Collaborative Activities To Teach Geology. NAGT. Oct. 26 a.m./p.m.

T29. Advances in the Geology and Metallogeny of Gold Deposits. MSA and SEG. Oct. 24 a.m./p.m.

T30. Boron: Mineralogy, Petrology, and Geochemistry in Earth's Crust. MSA. Oct. 27 a.m./p.m.

T32. Phase Transformations: Mechanisms and Kinetics of Mineral Reactions. MSA. Oct. 25 p.m.

T33. Magmatic Evolution of Circum-Pacific Arc Systems. MSA. Oct. 26 a.m.

T34. Volcanic Hazards and Disasters in Human History. Archaeological Geology Division. Oct. 25 p.m.

T35. Volatiles and Volcanoes. MSA. Oct. 27 a.m./p.m.

Program by Scientific Disciplines

KEY: I, II, ... X = Discipline session number in a series; P = Poster; S = Symposium; SP = Symposium Poster; T = Theme Session (listed under disciplines having the majority of the abstracts); TP = Theme Poster Session.

DISCIPLINE	SUN, OCT. 23 8:00 a.m.–12:00 N 1:00–5:00 p.m.		MON, OCT. 24 8:00 a.m.–12:00 N 1:00–5:00 p.m.		TUES, OCT. 25 8:00 a.m.–12:00 N 1:30–5:30 p.m.		WED, OCT. 26 8:00 a.m.–12:00 N 1:30–5:30 p.m.		THURS, OCT. 27 8:00 a.m.–12:00 N 1:00–5:00 p.m.	
	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM
ARCHAEOLOGY				P	S20	T34		I		
COAL			S18	I		P				
COMPUTERS			T16							
ECONOMIC	S12	S12	I, T29	T29	S6	S6	II	III		P
EDUCATION			P	I	S22		T28	S24, T28	II	III
ENGINEERING						I, TI	S16	S16		
ENVIRONMENTAL		S25	I, T9	P	TI0		T6, T7	T7	II, T2, T3, T5	III, T3, T5
GEOCHEMISTRY, AQUEOUS			I		T8					T14
GEOCHEMISTRY, OTHER	S23	S17, S23			PI	I, T32	II, S9, T44	III, PII, T44, TP45		
GEOPHYSICS/ TECTONOPHYSICS				TP54		I	S3, T44	S3, T44		P
GEOSCIENCE INFORMATION				I	S21			P		
HISTORY							S13		I	
HYDROGEOLOGY			TI5	SI0	TI3		I, II, TII	III, TI7	P, TP18	
MARINE								P	T49	I
MICROPALEONTOLOGY				S19	I			P		
MINERALOGY/ CRYSTALLOGRAPHY				S7	I			S8	II, T30	P, T30
PALEOCEANOGRAPHY/ PALEOCLIMATOLOGY			T66	TP43	I	II, TP23			P	T39
PALEONTOLOGY/ PALEOBOTANY			I, P, TP41	II	SI5		III, T37	IV, T37	V, T38	VI, T38
PETROLEUM						I		P		
PETROLOGY, EXPERIMENTAL						I	P			
PETROLOGY, IGNEOUS			I				P, T33	II		III
PETROLOGY, METAMORPHIC			I			P				II
PLANETARY/ REMOTE SENSING			T65	I, T65	S14	T36			II, P	
PRECAMBRIAN			I			P	T62	T63		
QUATERNARY/ GEOMORPHOLOGY			I	II, T27	III, T24	IV, V, T26	VI, P, T22	SII	T5, T20	T20, T21
SEDIMENTS, CARBONATE			I	II						
SEDIMENTS, CLASTIC			I	T55		II, S4			TP64	P
STRATIGRAPHY				T68	I	P			II	III, T67
STRUCTURE			I	II, S2	P, T47	T47	III, S3	S3	T61	T60, T61
TECTONICS				I	II, P, T57	III, T57, T58	IV		T51, T59	V, T48
VOLCANOLOGY				I, P		T34			T35	II, T35
MISCELLANEOUS			SI	S27	S5	SP26				

T36. Geological Mapping of Terrestrial Planets: Use (and Abuse?) of Remotely Sensed Data. Planetary Geology Division. Oct. 25 p.m.

T37. Impacts and Extinctions. PS. Oct. 26 a.m./p.m.

T38. New Perspectives on Faunal Stability in the Fossil Record. PS. Oct. 27 a.m./p.m.

T39. Tectonic and Climatic Influences on the Neogene Paleobiology of West-Central Nevada. Oct. 27 p.m.

T41. Teaching Paleontology. PS and NAGT. (Poster) Oct. 24 a.m.

T43. Pliocene Climates—Sea Levels and Ice Volumes. (Poster) Oct. 24 p.m.

T44. Scientific Results of the Continental Drilling Program: Creede Caldera, Newark Rift Basin, Manson Impact Structure—Parts I and II. Oct. 26 a.m/p.m.

T45. Scientific Results of the Continental Drilling Program: Creede Caldera, Newark Rift Basin, Manson Impact Structure—Part III. (Poster). Oct. 26 p.m.

T47. Quantitative Analysis of Joints and Faults: New Approaches to Field, Laboratory, and Modeling Studies of Rock Fracture. Oct. 25 a.m./p.m.

T48. Cascadia Subduction Zone. Oct. 27 p.m.

T49. Cascadia Convergent Margin: Forearc Tectonics. Oct. 27 a.m.

T51. Baja British Columbia: Evaluation of Large-scale Northward Transport of the Northern Cordillera in Late Cretaceous to Early Tertiary Time. Oct. 27 a.m.

T54. Geophysical Studies of the Continental Margin, Western North America. (Poster) Oct. 24 p.m.

T55. Late Mesozoic Basins in the North American Cordillera: Constraints on Terrane Accretion and Translation. Sedimentary Geology Division. Oct. 24 p.m.

T57. Birth and Life of an Island Arc at a Leading Edge—The Geologic Development of Japan. International and Structural Geology and Tectonics Divisions, and Geological Society of Japan. Oct. 25 a.m./p.m.

T58. Active Arc-Continent Collision in Taiwan. Structural Geology and Tectonics Division. Oct. 25 p.m.

T59. Geologic Evolution of the Tian Shan Orogenic System, Central Asia. Oct. 27 a.m.

T60. Rheological and Structural Evolution of Contractional Orogenic Belts. Oct. 27 p.m.

T61. Dating Deformation. Oct. 27 a.m./p.m.

T62. Precambrian and Phanerozoic Terrane Accretion: Contrasts and Similarities. Oct. 26 a.m.

T63. Precambrian Orogens: Tectonic Setting and Crustal Architecture. Oct. 26 p.m.

T64. Relations Between Diagenesis and Deformation. Sedimentary Geology Division. (Poster) Oct. 27 a.m.

T65. Perspectives on Desert Surface Processes. Planetary Geology Division. Oct. 24 a.m./p.m.

T66. Cenozoic Sequences on Passive Margins: A Triad of Processes. Sedimentary Geology Division. Oct. 24 a.m.

T67. West Coast Salt Marshes: Stratigraphy, Sea-Level Change, and Seismic Events. Oct. 27 p.m.

T68. Evolution of the Atlantic Coastal Plain—Sedimentology, Stratigraphy, and Hydrogeology. Oct. 24 p.m.

Note:

T4. Withdrawn

T52. Combined with T51

The following Theme Sessions were canceled due to receiving less than the minimum number of papers:.

T12. Hydrothermal Systems Evolution in the Cascade Range.

T19. Description and Measurement of Constitutive Relations Governing Fluid in Variably Saturated Media.

T25. The Juneau Icefield: A Half Century of Geoscience Education, Research, and Professional Training in the Alpine and Glacial Environment.

T31. Advances in Silica Geochemistry.

T40. Evolution of Reef Biotas Along Active Plate Margins.

T42. Educating Paleontologists for the Next Millenium: Evolution and Revolution.

T46. Teaching Structural Geology.

T50. Puget Sound-Georgia Strait: 140 Million Years of Tectonics.

T53. Convergent and Transform Processes at the Leading Edge of the Northern Pacific Rim.

T56. Geology of the Coast Ranges of Oregon and Washington: New Discoveries.

T69. Geologic Hazards Education for K–12 Students.

Seattle at the leading edge

Session Program Calendar

Sunday, October 23, AM

Session 1, 09:00 AM, WSCTC:615-617
GS Symposium (S23): Marine Trace-Element Biogeochemistry and the Sedimentary Record (Part I)

Session 2, 08:00 AM, WSCTC:611-612
SEG Symposium (S12): Regional Economic Geology of the Northern Cordillera (Part I)

Sunday, October 23, PM

Session 3, 01:30 PM, WSCTC:615-617
GS Symposium (S23): Marine Trace-Element Biogeochemistry and the Sedimentary Record (Part II)

Session 4, 01:00 PM, WSCTC:605-606
IEE and GSA Committee on Geology and Public Policy Symposium (S25): Annual Environmental Forum: Crucial Environmental Issues: Fear and Loathing at the Leading Edge

Session 5, 01:00 PM, WSCTC:618-620
Organic Geochemistry Division of the GS Symposium (S17): Pyrolysis Techniques for Source Rock Evaluation—Twenty Years Later

Session 6, 01:00 PM, WSCTC:611-612
SEG Symposium (S12): Regional Economic Geology of the Northern Cordillera (Part II)

Monday, October 24, AM

Session 7, 08:00 AM, WSCTC:6E
1994 GSA Annual Meeting Committee (S1): Keynote Symposium: Birth and Death of a Plate

Session 8, 08:00 AM, WSCTC:201
Coal Geology Division Symposium (S18): Origin of Compositional Characteristics in Tertiary Coals: Paleoecology, Paleobotany and Palynology

Session 9, 08:00 AM, WSCTC:6B
Environmental Geology I: Environmental Geochemistry

Session 10, 08:00 AM, WSCTC:609-610
GS—Geochemistry: Aqueous and Biogeochemistry

Session 11, 08:00 AM, WSCTC:611-612
MSA—Igneous Petrology I

Session 12, 08:00 AM, WSCTC:608
MSA—Metamorphic Petrology I

Session 13, 08:00 AM, WSCTC:Hall 4C
NAGT—Geology Education (Posters)

Session 14, 08:00 AM, WSCTC:402-403
Precambrian Geology

Session 15, 08:00 AM, WSCTC:613-614
PS—Paleontology/Paleobotany I

Session 16, 08:00 AM, WSCTC:Hall 4C
PS—Paleontology/Paleobotany (Posters)

Session 17, 08:00 AM, WSCTC:607
Quaternary Geology/Geomorphology I: Landscape and Climate Change

Session 18, 08:00 AM, WSCTC:206
Sedimentology, Carbonates I: Sedimentation, Diagenesis, and Dolomitization

Session 19, 08:00 AM, WSCTC:204
Sedimentology, Clastic I: Process Sedimentology

Session 20, 08:00 AM, WSCTC:6C
SEG—Economic Geology I: Gold Exploration and Deposits

Session 21, 08:00 AM, WSCTC:618-620
Structural Geology I: Vertical Structures; Rock Fabrics

Session 22, 08:00 AM, WSCTC:602-604
T 9. Quaternary Geology and Geomorphology Division and IEE: Urban, Suburban, and Rural—Environmental Geology at the Leading Edge

Session 23, 08:00 AM, WSCTC:605-606
T15. Hydrogeology Division: Computational Hydrology and Data Visualization and Animation

Session 24, 08:00 AM, WSCTC:307-308
T16. COGEOINFO (Commission on the Management and Application of Geoscience Information): Leading Edge Applications of Earth Science Modeling and Visualization

Session 25, 10:00 AM, WSCTC:6C
T29. MSA and SEG: Advances in the Geology and Metallogeny of Gold Deposits (Part I)

Session 26, 08:00 AM, WSCTC:Hall 4C
T41. PS and NAGT: Teaching Paleontology (Posters)

Session 27, 08:00 AM, WSCTC:6A
T65. Planetary Geology Division: Perspectives on Desert Surface Processes (Part I)

Session 28, 08:00 AM, WSCTC:615-617
T66. Sedimentary Geology Division: Cenozoic Sequences on Passive Margins: A Triad of Processes

Monday, October 24, PM

Session 29, 01:00 PM, WSCTC:Hall 4C
Archaeology (Posters)

Session 30, 01:00 PM, WSCTC:402-403
CF Symposium (S19): The Late Cretaceous Marine and Continental Record of Global Climate Change

Session 31, 01:00 PM, WSCTC:201
Coal Geology

Session 32, 01:00 PM, WSCTC:Hall 4C
Environmental Geology (Posters)

Session 33, 01:00 PM, WSCTC:307-308
GIS—Geoscience Information

Session 34, 01:00 PM, WSCTC:608
GSA Committee on Geology and Public Policy Symposium (S27): Where Geology Matters: Past, Present, and Future

Session 35, 01:00 PM, WSCTC:605-606
Hydrogeology Division Symposium (S10): The Dreiss Symposium: Recent Trends in Studies of Coupled Hydrodynamic, Tectonic, and Thermal Processes

Session 36, 01:00 PM, WSCTC:6E
International Division Symposium (S2): Plate Motion and Displacement Partitioning in the Circum-Pacific Orogenic Belts

Session 37, 01:00 PM, WSCTC:611-612
MSA Symposium (S7): Advances in Silica Geochemistry

Session 38, 01:00 PM, WSCTC:6B
MSA—Volcanology I

Session 39, 01:00 PM, WSCTC:Hall 4C
MSA—Volcanology (Posters)

Session 40, 03:00 PM, WSCTC:307-308
NAGT—Geology Education I: Educators in Partnership with Related Professionals

Session 41, 01:00 PM, WSCTC:613-614
PS—Paleontology/Paleobotany II

Session 42, 01:00 PM, WSCTC:607
Quaternary Geology/Geomorphology II: Glaciers and Glaciation

Session 43, 03:00 PM, WSCTC:6A
Remote Sensing: New Results from SIR-C/X-SAR: Geology from Spaceborne Radar

Session 44, 01:00 PM, WSCTC:206
Sedimentology, Carbonates II: Precambrian and Phanerozoic Studies

Session 45, 01:00 PM, WSCTC:618-620
Structural Geology II: Extension Structures; Pluton Emplacement

Session 46, 01:00 PM, WSCTC:609-610
Tectonics I: Canadian Shield, Asia, and Other

Session 47, 01:00 PM, WSCTC:602-604
T27. Late Quaternary Evolution of the Eastern Aleutian Arc: Volcanoes, Earthquakes, Glaciers, and Shorelines

Session 48, 01:00 PM, WSCTC:6C
T29. MSA and SEG: Advances in the Geology and Metallogeny of Gold Deposits (Part II)

Session 49, 01:00 PM, WSCTC:Hall 4C
T43. Pliocene Climates—Sea Levels and Ice Volumes (Posters)

Session 50, 01:00 PM, WSCTC:Hall 4C
T54. Geophysical Studies of the Continental Margin, Western North America (Posters)

Session 51, 01:00 PM, WSCTC:615-617
T55. Sedimentary Geology Division: Late Mesozoic Basins in the North American Cordillera: Constraints on Terrane Accretion and Translation

Session 52, 01:00 PM, WSCTC:6A
T65. Planetary Geology Division: Perspectives on Desert Surface Processes (Part II)

Session 53, 01:00 PM, WSCTC:204
T68. Evolution of the Atlantic Coastal Plain—Sedimentology, Stratigraphy, and Hydrogeology

Tuesday, October 25, AM

Session 54, 08:00 AM, WSCTC:611-612
1994 GSA Annual Meeting Committee Symposium (S5): Geology and the Postindustrial Society (Part I)

Session 55, 08:00 AM, WSCTC:206
Archaeological Geology Division Symposium (S20): Use of Archaeology for Dating Geologic Events

Session 56, 08:00 AM, WSCTC:615-617
CF—Micropaleontology

Session 57, 08:00 AM, WSCTC:307-308
GIS Symposium (S21): Changing Gateways: The Impact of Technology on Geoscience Information Exchange

Session 58, 08:00 AM, WSCTC:Hall 4C
GS—Organic Geochemistry (Posters) I

Session 59, 08:00 AM, WSCTC:6A
MSA—Mineralogy/Crystallography I

Session 60, 08:00 AM, WSCTC:608
NAGT and National Science Foundation Symposium (S22): Recent Advances in Geoscience Education—The Leading Edge of Undergraduate Instruction and Research

Session 61, 08:00 AM, WSCTC:613-614
Paleoceanography/Paleoclimatology I

Session 62, 08:00 AM, WSCTC:6B
Planetary Geology Division Symposium (S14): Cataclysms and Catastrophes: The Planetary Perspective

Session 63, 08:00 AM, WSCTC:6C
PS Symposium (S15): Evolutionary Paleobiology

Session 64, 08:00 AM, WSCTC:607
Quaternary Geology/Geomorphology III: Glacial and Coastal Geomorphology

Session 65, 08:00 AM, WSCTC:6E
SEG and 1994 GSA Annual Meeting Committee Symposium (S6): Meyer Symposium: Maintaining Compatibility of Mining and the Environment (Part I)

Session 66, 10:00 AM, WSCTC:204
Stratigraphy I

Session 67, 08:00 AM, WSCTC:Hall 4C
Structural Geology (Posters)

Session 68, 08:00 AM, WSCTC:618-620
Tectonics II: Pacific Northwest

Session 69, 08:00 AM, WSCTC:Hall 4C
Tectonics (Posters)

Session 70, 08:00 AM, WSCTC:609-610
T 8. Geochemistry of Contaminant Transport

Session 71, 08:00 AM, WSCTC:204
T10. The Management of Contaminated Sites in Near-shore Marine and Estuary Environments

Session 72, 08:00 AM, WSCTC:605-606
T13. Hydrogeology Division and SEPM: Relation of Depositional Environments to Chemical and Physical Heterogeneity within Sedimentary Aquifers

Session 73, 08:00 AM, WSCTC:602-604
T24. Tectonics and Landforms Around the Pacific Rim

Session 74, 08:00 AM, WSCTC:201
T47. Quantitative Analysis of Joints and Faults: New Approaches to Field, Laboratory, and Modeling Studies of Rock Fracture (Part I)

Session 75, 08:00 AM, WSCTC:402-403
T57. International and Structural Geology and Tectonics Divisions, and Geological Society of Japan: Birth and Life of an Island Arc at a Leading Edge—The Geologic Development of Japan (Part I)

Tuesday, October 25, PM

Session 76, 01:30 PM, WSCTC:Hall 4C
Coal Geology (Posters)

Session 77, 01:30 PM, WSCTC:6B
Engineering Geology: Landslides, Debris Flows, and Subsidence

Session 78, 03:30 PM, WSCTC:402-403
Geophysics

Session 79, 01:30 PM, WSCTC:605-606
GS—Geochemistry I: Hydro, Isotopic, and Economic Geochemistry

Session 80, 03:30 PM, WSCTC:611-612
MSA—Experimental Petrology

Session 81, 01:30 PM, WSCTC:Hall 4C
MSA—Metamorphic Petrology (Posters)

Session 82, 01:30 PM, WSCTC:613-614
Paleoceanography/Paleoclimatology II

Session 83, 01:30 PM, WSCTC:608
Petroleum Geology

Session 84, 01:30 PM, WSCTC:Hall 4C
Precambrian Geology (Posters)

Session 85, 01:30 PM, WSCTC:607
Quaternary Geology/Geomorphology IV: Floods, Sediment Transport, and River Channel Development—A Memorial to Marie Morisawa

Session 86, 03:30 PM, WSCTC:608
Quaternary Geology/Geomorphology V: Records Through the Last Interglacial

Session 87, 01:30 PM, WSCTC:615-617
Sedimentary Geology Division Symposium (S4): Tectonic Geomorphology, Depositional Processes, and the Depositional Record

Session 88, 01:30 PM, WSCTC:206
Sedimentology, Clastic II: Sedimentation and Tectonics

Session 89, 01:30 PM, WSCTC:6E
SEG and 1994 GSA Annual Meeting Committee Symposium (S6): Meyer Symposium: Maintaining Compatibility of Mining and the Environment (Part II)

Session 90, 01:30 PM, WSCTC:Hall 4C
SGE Symposium (S26): Student Research (Posters)

Session 91, 01:30 PM, WSCTC:Hall 4C
Stratigraphy (Posters)

Session 92, 01:30 PM, WSCTC:618-620
Tectonics III: Cenozoic Tectonics: Southwestern North America, Central America, and Caribbean

Session 93, 01:30 PM, WSCTC:204
T 1. Liquefaction Hazard Mapping and Mitigation

Session 94, 01:30 PM, WSCTC:Hall 4C
T23. Correlation of the Marine and Terrestrial Paleoclimatic Record of the Eastern North Pacific and Western United States (Posters)

Session 95, 01:30 PM, WSCTC:602-604
T26. Quaternary Dating Methods

Session 96, 01:30 PM, WSCTC:609-610
T32. MSA: Phase Transformations: Mechanisms and Kinetics of Mineral Reactions

continued on p. 230

Session 97, 01:30 PM, WSCTC:307-308
T34. Archaeological Geology Division: Volcanic Hazards and Disasters in Human History

Session 98, 01:30 PM, WSCTC:6A
T36. Planetary Geology Division: Geological Mapping of Terrestrial Planets: Use (and Abuse?) of Remotely Sensed Data

Session 99, 01:30 PM, WSCTC:201
T47. Quantitative Analysis of Joints and Faults: New Approaches to Field, Laboratory, and Modeling Studies of Rock Fracture (Part II)

Session 100, 01:30 PM, WSCTC:402-403
T57. International and Structural Geology and Tectonics Divisions, and Geological Society of Japan: Birth and Life of an Island Arc at a Leading Edge—The Geologic Development of Japan (Part II)

Session 101, 01:30 PM, WSCTC:6C
T58. Structural Geology and Tectonics Division: Active Arc-Continent Collision in Taiwan

Wednesday, October 26, AM

Session 102, 08:00 AM, WSCTC:608
Engineering Geology Division Symposium (S16): Military Geology in War and Peace (Part I)

Session 103, 08:00 AM, WSCTC:609-610
GS—Geochemistry II: Fluids and Isotopes

Session 104, 08:00 AM, WSCTC:206
History of Geology Division Symposium (S13): Historical Investigations of Extraterrestrial Events and Causes in Earth History

Session 105, 08:00 AM, WSCTC:605-606
Hydrogeology I: Quantitative Groundwater Modeling

Session 106, 10:00 AM, WSCTC:607
Hydrogeology II: Near Surface Processes

Session 107, 08:00 AM, WSCTC:6A
MSA and GS Symposium (S9): Frontiers of Mineral Surface Geochemistry: A Symposium in Memory of Andrew J. Gratz (1962–1993)

Session 108, 08:00 AM, WSCTC:Hall 4C
MSA—Experimental Petrology (Posters)

Session 109, 08:00 AM, WSCTC:Hall 4C
MSA—Igneous Petrology (Posters)

Session 110, 08:00 AM, WSCTC:613-614
PS—Paleontology/Paleobotany III

Session 111, 08:00 AM, WSCTC:607
Quaternary Geology/Geomorphology VI

Session 112, 08:00 AM, WSCTC:Hall 4C
Quaternary Geology/Geomorphology (Posters)

Session 113, 08:00 AM, WSCTC:6C
SEG—Economic Geology II

Session 114, 08:00 AM, WSCTC:6E
Structural Geology and Tectonics Division and Geophysics Division Symposium (S3): New Frontiers in Active Tectonics Science (Part I)

Session 115, 08:00 AM, WSCTC:618-620
Structural Geology III: Contraction Structures

Session 116, 08:00 AM, WSCTC:201
T 6. GSA Geology and Public Policy Committee and IEE: Environmental Geology: The Voice of Warning

Session 117, 10:00 AM, WSCTC:201
T 7. GSA Geology and Public Policy Committee and IEE: Environmental Geology: The Voice of Reason (Part I)

Session 118, 08:00 AM, WSCTC:204
T11. Hydrogeology Division: Stable Environmental Isotope Application in Ground-water Systems

Session 119, 08:00 AM, WSCTC:602-604
T22. Paleoclimate Records from Arctic Lakes and Estuaries

Session 120, 08:00 AM, WSCTC:307-308
T28. NAGT: Learning in Small Groups: Using Collaborative Activities To Teach Geology (Part I)

Session 121, 08:00 AM, WSCTC:611-612
T33. MSA: Magmatic Evolution of Circum-Pacific Arc Systems

Session 122, 08:00 AM, WSCTC:6B
T37. PS: Impacts and Extinctions (Part I)

Session 123, 08:00 AM, WSCTC:402-403
T44. Scientific Results of the Continental Drilling Program: Creede Caldera, Newark Rift Basin, Manson Impact Structure—Part I

Session 124, 08:00 AM, WSCTC:615-617
T62. Precambrian and Phanerozoic Terrane Accretion: Contrasts and Similarities

Wednesday, October 26, PM

Session 125, 01:30 PM, WSCTC:204
Archaeological Geology

Session 126, 01:30 PM, WSCTC:Hall 4C
CF—Micropaleontology (Posters)

Session 127, 01:30 PM, WSCTC:608
Engineering Geology Division Symposium (S16): Military Geology in War and Peace (Part II)

Session 128, 01:30 PM, WSCTC:206
Geoscience Education Division Symposium (S24): The Geological Profession's Response to National Priorities in Science Education

Session 129, 01:30 PM, WSCTC:Hall 4C
GIS—Geoscience Information (Posters)

Session 130, 01:30 PM, WSCTC:609-610
GS—Geochemistry III: Reaction Rates and Soils

Session 131, 01:30 PM, WSCTC:Hall 4C
GS—Geochemistry (Posters) II

Session 132, 01:30 PM, WSCTC:607
Hydrogeology III: Aqueous Geochemistry

Session 133, 01:30 PM, WSCTC:Hall 4C
Marine Geology (Posters)

Session 134, 01:30 PM, WSCTC:6A
MSA and 1994 GSA Annual Meeting Committee Symposium (S8): Mineralogical Society of America 75th Anniversary Symposium

Session 135, 01:30 PM, WSCTC:611-612
MSA—Igneous Petrology II

Session 136, 01:30 PM, WSCTC:Hall 4C
Petroleum Geology (Posters)

Session 137, 01:30 PM, WSCTC:613-614
PS—Paleontology/Paleobotany IV

Session 138, 01:30 PM, WSCTC:602-604
Quaternary Geology and Geomorphology Division Symposium (S11): Hydrology and Active Volcanism: At the Leading Edge

Session 139, 01:30 PM, WSCTC:6C
SEG—Economic Geology III: Stratabound and Magnetite

Session 140, 01:30 PM, WSCTC:6E
Structural Geology and Tectonics Division and Geophysics Division Symposium (S3): New Frontiers in Active Tectonics Science (Part II)

Session 141, 01:30 PM, WSCTC:618-620
Tectonics IV: Paleozoic and Mesozoic, Western North America

Session 142, 01:30 PM, WSCTC:201
T 7. GSA Geology and Public Policy Committee and IEE: Environmental Geology: The Voice of Reason (Part II)

Session 143, 01:30 PM, WSCTC:605-606
T17. Hydrogeology Division and IEE: Integration of Hydraulic and Geochemical Approaches in Vadose Zone Transport Studies

Session 144, 01:30 PM, WSCTC:307-308
T28. NAGT: Learning in Small Groups: Using Collaborative Activities To Teach Geology (Part II)

Session 145, 01:30 PM, WSCTC:6B
T37. PS: Impacts and Extinctions (Part II)

Session 146, 01:30 PM, WSCTC:402-403
T44. Scientific Results of the Continental Drilling Program: Creede Caldera, Newark Rift Basin, Manson Impact Structure—Part II

Session 147, 01:30 PM, WSCTC:Hall 4C
T45. Scientific Results of the Continental Drilling Program: Creede Caldera, Newark Rift Basin, Manson Impact Structure—Part III (Posters)

Session 148, 01:30 PM, WSCTC:615-617
T63. Precambrian Orogens: Tectonic Setting and Crustal Architecture

Thursday, October 27, AM

Session 149, 08:00 AM, WSCTC:607
Environmental Geology II

Session 150, 10:00 AM, WSCTC:611-612
History of Geology

Session 151, 08:00 AM, WSCTC:Hall 4C
Hydrogeology (Posters)

Session 152, 08:00 AM, WSCTC:611-612
MSA—Mineralogy/Crystallography II

Session 153, 08:00 AM, WSCTC:307-308
NAGT—Geology Education II: Effective Approaches to Undergraduate Education

Session 154, 08:00 AM, WSCTC:Hall 4C
Paleoceanography/Paleoclimatology (Posters)

Session 155, 10:00 AM, WSCTC:607
Planetary Geology: Meteorites, Mars, Terrestrial Impact Structures and Lunar Orbital Evolution

Session 156, 08:00 AM, WSCTC:201
PS—Paleontology/Paleobotany V

Session 157, 08:00 AM, WSCTC:Hall 4C
Remote Sensing (Posters)

Session 158, 08:00 AM, WSCTC:206
Stratigraphy II: Sequence Stratigraphy and Related Topics

Session 159, 08:00 AM, WSCTC:609-610
T 2. MSA: Speciation, Mobility, and Bioavailability of Metals in Mining Wastes

Session 160, 08:00 AM, WSCTC:605-606
T 3. IEE: The Role of Geology in Characterization, Contaminant Transport, and Remediation of Hazardous Waste Sites (Part I)

Session 161, 08:00 AM, WSCTC:6B
T 5. IEE: The Geological Basis of Wild Salmon Ecology (Part I)

Session 162, 08:00 AM, WSCTC:Hall 4C
T18. Methods for Quantifying Unsaturated Permeability, Retardation, and Other Transport Properties in Rock, Soil, and Sediment (Posters)

Session 163, 08:00 AM, WSCTC:602-604
T20. Records of Glaciation and Climate Change Along the Leading Edge During the Last Glacial Maximum and the Pleistocene-Holocene Transition (20 - 8 ka) (Part I)

Session 164, 08:00 AM, WSCTC:608
T30. MSA: Boron: Mineralogy, Petrology, and Geochemistry in Earth's Crust (Part I)

Session 165, 08:00 AM, WSCTC:6C
T35. MSA: Volatiles and Volcanoes (Part I)

Session 166, 08:00 AM, WSCTC:613-614
T38. PS: New Perspectives on Faunal Stability in the Fossil Record (Part I)

Session 167, 08:00 AM, WSCTC:6E
T49. Cascadia Convergent Margin: Forearc Tectonics

Session 168, 08:00 AM, WSCTC:6A
T51. Baja British Columbia: Evaluation of Large-scale Northward Transport in the Cordillera in Late Cretaceous to Early Tertiary Time

Session 169, 08:00 AM, WSCTC:615-617
T59. Geologic Evolution of the Tian Shan Orogenic System, Central Asia

Session 170, 08:00 AM, WSCTC:618-620
T61. Dating Deformation (Part I)

Seattle
at the leading edge

Session 171, 08:00 AM, WSCTC:Hall 4C
T64. Sedimentary Geology Division: Relations Between Diagenesis and Deformation (Posters)

Thursday, October 27, PM

Session 172, 03:00 PM, WSCTC:6B
Environmental Geology III

Session 173, 01:00 PM, WSCTC:Hall 4C
Geophysics (Posters)

Session 174, 01:00 PM, WSCTC:402-403
Marine

Session 175, 03:00 PM, WSCTC:608
MSA—Igneous Petrology III

Session 176, 01:00 PM, WSCTC:611-612
MSA—Metamorphic Petrology II: Regional Studies

Session 177, 01:00 PM, WSCTC:Hall 4C
MSA—Mineralogy/Crystallography (Posters)

Session 178, 03:00 PM, WSCTC:6C
MSA—Volcanology II

Session 179, 01:00 PM, WSCTC:307-308
NAGT—Geology Education III: Instructional Issues and Suggested Responses

Session 180, 01:00 PM, WSCTC:201
PS—Paleontology/Paleobotany VI

Session 181, 01:00 PM, WSCTC:Hall 4C
Sedimentology, Carbonate and Clastic (Posters)

Session 182, 01:00 PM, WSCTC:Hall 4C
SEG—Economic Geology (Posters)

Session 183, 03:00 PM, WSCTC:204
Stratigraphy III

Session 184, 01:00 PM, WSCTC:618-620
Tectonics V: The Southern Continents

Session 185, 01:00 PM, WSCTC:605-606
T 3. IEE: The Role of Geology in Characterization, Contaminant Transport, and Remediation of Hazardous Waste Sites (Part II)

Session 186, 01:00 PM, WSCTC:6B
T 5. IEE: The Geological Basis of Wild Salmon Ecology (Part II)

Session 187, 01:00 PM, WSCTC:609-610
T14. Hydrogeology Division: Geologic Significance of Microbial Processes

Session 188, 01:00 PM, WSCTC:602-604
T20. Records of Glaciation and Climate Change Along the Leading Edge During the Last Glacial Maximum and the Pleistocene-Holocene Transition (20 - 8 ka) (Part II)

Session 189, 01:00 PM, WSCTC:607
T21. The Last Interglacial: Timing and Environment

Session 190, 01:00 PM, WSCTC:608
T30. MSA: Boron: Mineralogy, Petrology, and Geochemistry in Earth's Crust (Part II)

Session 191, 01:00 PM, WSCTC:6C
T35. MSA: Volatiles and Volcanoes (Part II)

Session 192, 01:00 PM, WSCTC:613-614
T38. PS: New Perspectives on Faunal Stability in the Fossil Record (Part II)

Session 193, 01:00 PM, WSCTC:206
T39. Tectonic and Climatic Influences on the Neogene Paleobiology of West-Central Nevada

Session 194, 01:00 PM, WSCTC:6E
T48. Cascadia Subduction Zone

Session 195, 01:00 PM, WSCTC:6A
T60. Rheological and Structural Evolution of Contractional Orogenic Belts

Session 196, 01:00 PM, WSCTC:204
T61. Dating Deformation (Part II)

Session 197, 01:00 PM, WSCTC:615-617
T67. West Coast Salt Marshes: Stratigraphy, Sea-Level Change, and Seismic Events

JUPITER—SPECIAL SESSION

Wednesday, October 26, 5:45 to 7:00 p.m.
Washington State Convention and Trade Center

Eugene Shoemaker, U.S. Geological Survey, Flagstaff, will review last July's spectacular collision between Jupiter and fragments of comet Shoemaker-Levy 9. He will present different images recording the impacts and discuss what we have learned from this event about our solar system—and what mysteries remain.

President's Student Forum

The Second Annual President's Student Forum will be held at the Seattle Annual Meeting on Wednesday, October 26, from 4:00 to 5:30 p.m. in Room 210 of the Washington State Convention and Trade Center. All students in attendance at the Annual Meeting are encouraged to attend the Forum to voice their opinions about GSA affairs directly to GSA officers. Especially welcome are ideas about enhanced student participation in GSA activities and how GSA can better serve student needs. For background, read the article by GSA President Bill Dickinson in the July 1994 issue of *GSA Today* (p. 183), reporting on the recent action by GSA Council to afford graduate students the opportunity to become full voting GSA members, beginning in 1995, without increase in dues or fees above the Student Associate level.

The Future of the Geosciences, Are We Ready for the 21st Century?

Wednesday, October 26, 5:30 to 7:30 p.m.; Sheraton Seattle Hotel

This AWG-sponsored forum will be moderated by Chris Mathewson, Texas A&M; Bonnie Brunkhorst, Californnia State University–San Bernardino; and Jane Willard, EnPro Assessment Corp. *(This forum missed the June GSA Today printing deadline.)*

Last Chance GSA Continuing Education Notes For Sale

Limited supplies of the following Continuing Eductaion manuals or notes remain available from the Cincinnati and Boston Annual Meetings. Through October, these may be ordered, while supplies last, through GSA Publication Sales 1-800-472-1988.

Note: In the future, Continuing Education Manuals will only be available for purchase on-site at the Annual Meeting.

1993

SCN020: *GIS and the Geosciences*, by Richard L. Bedell, Jr. ..... $16.50 net

SCN021: *Asia: A Continent Built and Assembled Over the Past 500 Million Years*, by Kevin Burke and A. M. Celal Şengör ..... $27.75 net

SCN022: *Contaminant Hydrogeology: Practical Monitoring, Protection, and Cleanup*, by Christopher M. Palmer and Jeffrey L. Peterson ..... $27.75 net

SCN023: *Fracture Mechanics of Rock*, by Terry Engelder, Michael R. Gross, and Mark P. Fischer ..... $22.75 net

SCN024: *Alternative Pedagogies in Geological Sciences: A Workshop*, by Ann Bykerk-Kauffman, Lauret E. Savoy, and Jill Schneiderman ..... $13.50 net

SCN026: *Computer Mapping at Your Desk that Really Works*, by Russell A. Ambroziak, Grant R. Woodwell, and Renee E. Wicks ..... $16.50 net

SCN027: *Environmental/Engineering Geology and Land-Use Planning—An Interface Between Science and Regulations*, by Charles W. Welby, Jerome V. DeGraff, and Rhea L. Graham ..... $16.50 net

Prices include shipping and handling; GSA Member discount does NOT apply on 1993 editions. Prepayment is required (check, major credit card, or money order in U.S. funds on U.S. bank).

1992

SCN002: *Paleosols for Sedimentologists*, by Greg H. Mack and Calvin James $18.75

SCN004: *Phase I Preliminary Site Assessments*, by Jeffrey L. Peterson $18.75

Prices include shipping and handling; GSA Members deduct member discount. Prepayment is required (check, major credit card, or money order in U.S. funds on U.S. bank).

Annual Meeting Sponsors

For the Seattle Annual Meeting, the following exhibitors have generously donated funds to support the meeting. GSA is most appreciative of this support and thanks these companies.

C. C. Filson Co.
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Are You Planning on Going to Graduate School?

Shortcut your search for the right graduate school. Come to the GSA Annual Meeting in Seattle and meet with representatives from universities across the nation without spending travel time and money to go to each school for interviews. The schools participating (at press time) are listed below.

Individual appointments are not necessary, although students are welcome to contact the schools in advance to schedule a meeting time. If you would like to receive a complete list of schools with the contact persons and telephone numbers contact Matt Ball, GSA Meetings Department, (303) 447-2020, ext. 141, fax 303-447-0648, E-mail: mball@geosociety.org

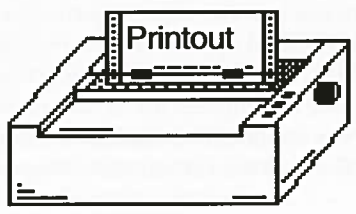
Graduate School Information Forum Schedule (at press time)

Washington State Trade and Convention Center, Level 4, Hall C
9:00 a.m. to 5:00 p.m.

Participating Schools	Mon. Oct. 24	Tues. Oct. 25	Wed. Oct. 26
BOISE STATE AND IDAHO STATE UNIVERSITIES	•	•	
CALIFORNIA INSTITUTE OF TECHNOLOGY	•	•	
CLEMSON UNIVERSITY		•	
CORNELL UNIVERSITY	•	•	•
GRADUATE SCHOOL AND BROOKLYN COLLEGE OF THE CITY UNIVERSITY OF NEW YORK	•	•	
INDIANA UNIVERSITY	•		•
LEHIGH UNIVERSITY		•	•
MONTANA STATE UNIVERSITY		•	
NEW MEXICO TECH		•	
NORTHERN ARIZONA UNIVERSITY	•		
NOTRE DAME	•	•	•
PENNSYLVANIA STATE UNIVERSITY		•	
RENSSELAER POLYTECHNIC INSTITUTE		•	
RICE UNIVERSITY	•	•	
SOUTHERN ILLINOIS UNIVERSITY AT CARBONDALE	•		
UNIVERSITY OF ALABAMA	•	•	
UNIVERSITY OF CALIFORNIA, RIVERSIDE	•	•	
UNIVERSITY OF DELAWARE		•	
UNIVERSITY OF FLORIDA	•	•	
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN		•	
UNIVERSITY OF KENTUCKY		•	
UNIVERSITY OF MARYLAND	•	•	
UNIVERSITY OF MASSACHUSETTS	•		
UNIVERSITY OF NEW MEXICO	•	•	
UNIVERSITY OF NORTH CAROLINA, CHAPEL HILL		•	
UNIVERSITY OF NORTH DAKOTA	•		
UNIVERSITY OF PENNSYLVANIA		•	
UNIVERSITY OF SOUTHERN MISSISSIPPI	•		
UNIVERSITY OF TEXAS AT DALLAS	•	•	
UNIVERSITY OF TEXAS AT EL PASO	•		
UNIVERSITY OF UTAH		•	
UNIVERSITY OF WASHINGTON	•	•	
UTAH STATE UNIVERSITY			•
VANDERBILT UNIVERSITY		•	
VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY	•	•	
YALE UNIVERSITY	•	•	•

GSA Program on Disk!

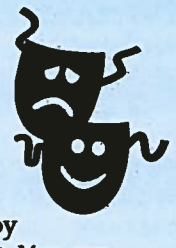
Preregister for the GSA Annual Meeting and receive a free meeting scheduling program. This DOS compatible program will allow you to create a customized program before you arrive at the meeting. Search menus will be available for the technical program sessions (authors and titles), events, field trips, exhibits and convenience information. Simply select the items you wish to attend and the program will create a chronological file to be printed. Disks will be mailed along with badges prior to the meeting for all those who preregister. GSA thanks Rockware Inc. for its support of this project, and Dwights Energy Data Inc. which developed the software.



Starting September 15, the program will be available on the World Wide Web, Universal Resource Locator
http://www.aescon.com/geosociety/index.html

ATTENTION
GSA's Internet Domain Has Changed!
It is now: name@geosociety.org

Latin Cuisine at La Gaviota and Seattle Repertory Theatre



Saturday, October 22, 6:00–10:30 p.m.

The Repertory Theatre fall schedule is out and we are in luck! ***London Suite,*** a world premiere by Neil Simon, takes us on four visits to the Connaught Hotel in London, where we witness four *intense* scenes of passion, sorrow, and laughter in the parade of life. Prior to the theater, enjoy Latin cuisine (paella!) at the nearby La Gaviota Restaurant. You can register for this event on the GSA Annual Meeting registration form found in the June *GSA Today*. You will receive further information after registering from Nancy Adams of *Travel to Music*. Transportation will not be provided; however, the theater is only a short cab ride. Seats will be assigned in the order received.

Cost: $65. Limit: 45.

GSA SECTION MEETINGS

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

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

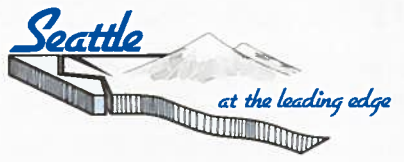
NORTH-CENTRAL/SOUTH-CENTRAL SECTIONS
University of Nebraska, Lincoln, Nebraska April 27–28, 1995. Submit completed abstracts to: David Loope, 332 Bessey Hall, University of Nebraska, Lincoln, NE 68588-0340, (402) 472-2647 *Abstract Deadline: January 6, 1995.*

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

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

GSA ANNUAL MEETINGS

■ 1994



Seattle, Washington
October 24–27

Washington State Convention and Trade Center, Sheraton Seattle Hotel

Preregistration Deadline: *September 16*
Technical Program Schedule: *Page 227*

For information call the GSA Meetings Department, 1-800-472-1988 or (303) 447-2020, ext. 113; fax 303-447-0648; E-mail: mball@geosociety.org

Registration Materials in JUNE *GSA Today*
Register Today!

■ 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

For general information call the GSA Meetings Department, 1-800-472-1988 or (303) 447-2020, ext. 141.

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

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

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

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

Theme for 1995 Annual Meeting in New Orleans

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

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

■ FUTURE

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

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

IEE Forum *continued from p. 221*

do not have to be obeyed. So-called creation scientists are an example. A group can label itself as "scientists" and take an anti-science position to get a lot of publicity, thereby obscuring an issue rather than helping to make it more understandable.

In the legal system, similar problems exist. It has become more of a game—whoever has the best lawyer wins. Is the acquittal of a confessed murderer a victory? The point here is that many aspects of today's society have become polarized. Understanding a situation appears not to be the objective. Geologists possibly could do much to change the present system. We can do this not by simply presenting our data and hypotheses, but by leading people through our style of thinking. Geologists incorporate new data and continually evaluate multiple hypotheses. We are used to constantly reevaluating, and taking new positions on the basis of new information. This is very different from the single-issue people who might take one position on one issue and argue it for an entire career without ever having to think another thought again.

Politicians essentially have to be generalists; they need to make decisions on many issues covering a broad range of topics in which they are supposed to have some expertise. This is in contrast to the great specialization of most scientists. Politicians, many of whom are former lawyers, are very much at ease in adversarial proceedings; they are accustomed to highly confrontational situations. Geologists, in contrast, might have lively debates, but these are better characterized as attempts to stress agreement, to find the facts that are most important, and to form hypotheses that account for all the facts. A politician needs facts "right now" to bear on a particular situation. A scientist wants to know the underlying principles, how to explain a class of phenomena. A politician needs to know the best answer now. Scientists want to follow a path that leads to a satisfactory answer no matter how long it takes.

Politicians tend to follow the path of least resistance, of compromise. An example is seen in the flood-control channels along the lower seven miles of the San Diego River. What made sense to the politicians, compromising as a result of pressures placed on them, has created an absurd situation in which a 49,000 cubic foot per second capacity channel feeds into a 10,000 cfs channel which, in turn, dumps into a 115,000 cfs channel! The idea of designing segments of a flood-control channel by bisecting a path between the loudest voices of a particular time does not lead to a solution of much value.

It is with community boards and community action groups that geologists can have a positive effect by leading a group through a complex situation using the geological thought process. We can help them to follow a path constrained by facts, to weigh various options while looking at consequences, and to defer decisions until they have evaluated priorities. An effective way to influence policy is to take politicians into the field. Avoid lobbying and shoving another opinion on them. Let them feel the pleasure and the joy of a field trip. Show them examples of relevant geologic principles—superposition, cross-cutting relationships, and others—to get them involved in discovery, in asking questions, as you would with any group of students. Politicians, planners, and others who develop their own knowledge of how things work will be better able to fend off lobbyists and shape reasonable policy.

Geological Reasoning for Understanding the Environment

Commenting that we live in a time of profound change, Vic Baker of the University of Arizona averred that geology has a central role to play in forging a new relationship between science and society. As important as information that geologists can provide about the planet inhabited by humankind might be, more important is the approach used by geologists to understand nature. Almost alone among disciplines, geology has preserved a pragmatic approach to science that derives its relevance from documentation of real experience of the natural world.

The real change of Earth's environments is the subject matter of geology, but the changing intellectual, cultural, and social environments are also real because of the consequences that they hold for geology. The traditional roles of geologists are in decline, but new opportunities have arisen in the areas of environmental geology, where concerns include natural hazards, the quality of water supplies, management of wastes, and global climate change. Inasmuch as these subjects are also worked on by environmental engineers and applied physicists, chemists, and biologists, we should examine what special insights geologists can bring to these concerns.

Another area of change involves the compact that has existed between science and society during most of this century through the Cold War, by which our industrial society has essentially trusted the scientific establishment to provide for its needs. This compact of trust resulted in both resources and freedom to pursue science as scientists deemed appropriate. Today, practical politicians are criticizing scientists as being insensitive to the needs of the society that sustains them, and are defining national goals for resolving key societal problems. Scientific research is being viewed as closely tied to those goals.

How does geology differ from other sciences in its approach to understanding the environment? As other sciences became more and more analytical, geology maintained a tradition in synthetic thinking—the continuous activity of comparing, connecting, and putting together thoughts and perceptions. The focus is on deriving hypotheses from nature rather than on applying elegant theories. The geologist uses analysis as well, but not to provide ultimate answers for intellectual puzzles predefined by limiting assumptions imposed on the real world. Analysis in geology allows the investigator to consider the consequential effects of hypotheses. In contrast, the analytical reasoning process of physics and allied sciences leads from assumed principles to consequences deduced from those principles according to a structured logic, often mathematical. This deduction is what physicists mean by a "prediction." But, for physics, the one contact with reality comes in the match of this deduced consequence ("prediction") with a measured property of nature.

Predictive analytical approaches to natural processes such as river flooding can lead to totally erroneous, sometimes disastrous, results. Analytical solutions can solve the problems as defined by the analysts, but the natural experience of a river must be *assumed* in order to make the necessary calculations. The approach involves the application of general principles (assumed to apply at all times to all rivers), the problem is defined in a limited manner (erosion at a particular point), and the practical solution is applied at the point of the problem. The geological approach does not directly involve universal principles. Rather than looking to immutable laws that are assumed to govern its behavior, the geologist looks to the natural behavior of the river—the geologist is viewing nature's habits. The habit of the river results in tendencies. Recognizing those tendencies does not permit the geologist to predict exactly where and when erosion will occur. However, such recognition does show what generally can be expected for the river. Moreover, this view must consider the whole river, not just its local problem spots.

The various sciences can productively be viewed as complementary. The strength of mathematical physics is in the power of its predictive capabilities, but this power is two-edged. Prediction can be powerfully wrong as well as powerfully right. Geology does not bring such predictive power to the understanding of nature. But it does bring a broad connection to reality, an experience of the past providing a vision that might be fuzzy—but is less likely to be blind. Thus, the role of the geologist is to understand the natural experience. This is an extremely critical role, and it is being neglected by many of today's environmental scientists for a whole host of environmental issues, ranging from flooding, to the movement of contaminants in subsurface water, to the planning of aggregate extraction for urban construction.

Lessons from the Landscape

Stephen Wells, University of California, Riverside, pointed out that knowledge of geomorphology and Quaternary geology has become increasingly important as it applies to many aspects of engineering and environmental geology, hydrology, paleoclimatology, and neotectonics. Applications abound in the analysis and solution of problems related to land-use planning, resource exploitation and stewardship, environmental management, and hazard evaluation. Perspectives reflecting long time spans and differing scales of area provide geomorphologists and Quaternary geologists with awareness of the complexity and the potential for landscape change over time and space.

Because natural systems are complex and interconnected, the role of geoscience is critical in the arena of environmental policy that directs the management and stewardship of natural resources. Environmental decisions are typically controversial, however, and geoscientists often avoid becoming involved with related topics and questions in order to escape political and funding implications. Nevertheless, many projects can contribute to basic science as well as contribute to the resolution of environmental problems.

In resolving complex environmental problems, geomorphologists and Quaternary geologists might use two different approaches, depending on the situation in need of resolution. One is to place short-term human activity as a catalyst for adverse environmental change into the context of the long-term history of natural processes. In this instance, one determines the rates and magnitudes of processes in order to establish a background against which to compare the rates and magnitudes of the effects of human activities. The second approach views Earth as a natural laboratory and a source of discovery and creativity regarding events and processes that have relevance to environmental problems. Here, one might undertake volcanic hazards studies in an area considered for radioactive waste isolation. This would require a detailed record of Quaternary volcanism in order that one might attempt to forecast the nature and rates of volcanic processes over tens of thousands of years into the future.

Geomorphologists and Quaternary geologists, by the nature of their training, approach problems with the understanding that the types, magnitude, and frequency of surficial processes vary at differing temporal and spatial scales, and that geomorphic processes operate in an interconnected system. This approach guards against severing and studying piecemeal complex environmental problems, and challenges the validity of an explanatory panacea or solitary mechanism as an explanation for environmental degradation.

Reducing Uncertainty in the Characterization of Subsurface Geology

Previous speakers had referred to the spatial variability of geologic features and to problems associated with a purely analytical approach. Perhaps in no other situation do these two aspects come into play as frequently as in problems of ground-water contamination. The last speaker in the symposium, Carol Creasey of the University of California, Santa Cruz, described the use of geostatistics to reduce uncertainty and aid in the cleanup design at ground-water contamination sites.

To clean up contaminated sites effectively, the directions and rates of ground-water flow and of solute or pollutant transport must be determined. The subsurface geology and its heterogeneity are among the dominant factors controlling these directions and rates. The location and geometry of geologic heterogeneity must be accurately described in order to define flow boundaries and preferential pathways for flow and solute transport. At contaminated sites considerable information is often available from boreholes, and the geology is typically inferred

IEE Forum *continued on p. 234*

GSAF UPDATE

Robert L. Fuchs

Bromery Foyer Greets Boulder Visitors

Randolph W. "Bill" Bromery and his wife Cecile have pledged a gift to GSA's Second Century Fund for Earth • Education • Environment, which they have requested be used to support the costs of the addition to the Boulder headquarters. In honor of this contribution, GSA's main entrance and reception area—a greeting place for visitors, often a gathering site for employees, and home of the famous "Big Al" glacial erratic from Colorado's Big Thompson canyon plus other fine rock specimens—has been named the Bromery Foyer.

Cecile and Bill Bromery

Bill Bromery is the President of Springfield College, a 109-year-old private college in Springfield, Massachusetts. Perhaps best known as the "birthplace of basketball," Springfield has 3200 graduate and undergraduate students studying physical education, allied health sciences, liberal arts, business, and human services. Bromery was planning to retire in 1992 when the Springfield trustees asked him to take on the president's job on a temporary basis. That supposedly short assignment has become a fully involved position, capping a successful career as scientist, educator, and business leader.

Bill Bromery was born in Cumberland, Maryland, and received degrees from Howard University, American University, and Johns Hopkins University in geology, geophysics, mathematics, and physics. He served in the U.S. Air Force as a Tuskegee airman during World War II and spent 19 years in exploration geophysics with the USGS. During this period he was project chief for numerous geophysical programs throughout the United States and Puerto Rico, and in addition was assigned to US/AID to work on surveys in Liberia. His career in education began in 1967 when he joined the faculty of the University of Massachusetts at Amherst. Bromery was not only professor of geophysics but at various times held administrative posts, including department chairman, vice chancellor, and chancellor. He was acting president of Westfield State College from 1988 to 1990 and then served as interim chancellor of the Board of Regents of Higher Education for the State of Massachusetts, before accepting his present post in Springfield.

Throughout his busy career Bill Bromery has maintained close ties with industry, often serving as consultant to natural resource companies. At present he is a director of four major U.S. companies—Exxon, NYNEX, Chemical Bank, and John Hancock Insurance. The demands of teaching and consulting have not prevented active involvement in public service. Bromery has a long record of participation as a trustee, director, or committee member in such organizations as Woods Hole, Johns Hopkins, Mount Holyoke, Fairfield University, Hampshire College, the Educational Testing Service, and the National Academy of Sciences. He has served on international commissions to Zaire and South Africa, and has been very active in groups dealing with social improvement and the problems of minorities. Bromery holds honorary degrees from nine colleges and universities in this country, Korea, and Japan and is a frequent lecturer on educational and social topics.

GSA has not been neglected in this attention to a multitude of organizations and causes. The work Bill Bromery has done for the Society over a 20-year period is extensive. In addition to chairing the Audit and Nominations committees, he was a member of the Committee on Committees and has played a leading role in the recognition and advancement of minorities in geology. Bromery was GSA's 101st president, and his was a pivotal term as the Society moved into its second century and new programs such as SAGE and IEE came into being. His capacity for being more than fully occupied remains undiminished—he now chairs the Society's major capital campaign, the Second Century Fund for Earth • Education • Environment.

Bill and Cecile Bromery were married in 1947, and they have raised five children. The children now have careers of their own, and the Bromerys continue to live in Amherst, where they located when Bill joined the University of Massachusetts faculty. A home and boat in Hilton Head, South Carolina, have a strong attraction, provided Bill Bromery can avoid the call of yet another college in need of his considerable talents. GSA President Bill Dickinson noted, "I have followed Bill Bromery's career with interest and admiration since he and I were Councilors together in the late 1970s. It is entirely fitting that the Bromery name will be attached permanently to a prominent part of the GSA building."

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Don't Get Left Out

The GSA Foundation's booth at the annual meeting will be one of the places you will want to visit in Seattle this October. In addition to the usual information about GSA activities and the Foundation's financing efforts, those contributors who are listed in the Century Plus Roster will be presented with a gift of appreciation from the Foundation. How does one become listed in the Century Plus Roster? It's easy—just make a contribution of at least $150 to the Foundation between now and October 15. A gift will be yours when you arrive at the Foundation booth in Seattle. ■

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from descriptions of the materials encountered. This method, however, tends to underutilize the available information, for it does not utilize the detail and spatial correlation of these qualitative data. Moreover, it provides no means to represent the uncertainties in the stratigraphic interpretation.

In the use of geostatistical techniques to interpret the hydrostratigraphy at two different sites, the approach was threefold: (1) transformation of qualitative or descriptive data into quantitative indicator values, designated binary indicators; (2) geostatistical representation of the three-dimensional geometries and depositional patterns characteristic of the environment, designated variograms; and (3) use of a linear interpolation method that allows the estimate of the uncertainty in the hydrostratigraphic interpretation, known as kriging.

The binary indicator function is used simply to distinguish between relatively high (sands and gravels = 1) and relatively low (silts and clays = 0) permeability. By using a formalized relationship that represents the expected squared difference between pairs of values separated by a distance, one can obtain a direct measurement of the probability that two data points belong to different permeability categories. This information is represented in variograms that provide a 3-D geostatistical representation of the environment. Finally, the technique of kriging provides estimates where no data exist. Moreover, it describes the site hydrostratigraphy and associated uncertainty, and estimates the probabilities of inferred high-permeability zones.

The results can provide useful guidance when designing cleanup strategies. If pump and treat is being considered, it would be prudent to place an extraction well where there is the highest probability of encountering a high-permeability zone so as to be better able to flush out the contaminant. In contrast, consideration of the use of flow barriers would dictate that drilling should be done where there is the lowest probability of encountering an inferred high-permeability zone. The results are also useful in identifying where the greatest uncertainty in the hydrostratigraphy exists, and therefore where additional data might be needed.

Leadership Opportunities

One hopes that the San Bernardino symposium, and similar efforts to heighten awareness of the role of geoscience in environmental issues, will help geoscientists to recognize the opportunities that exist for them to demonstrate leadership in solving the complex issues of today and the future. ■

NORTHEASTERN SECTION, GSA 30th Annual Meeting

Cromwell, Connecticut
March 20–22, 1995

The University of Connecticut, Wesleyan University, and the Geological and Natural History Survey of Connecticut will host the Northeastern Section of the Geological Society of America meeting at the Radisson Hotel and Conference Center in Cromwell, Connecticut. The Eastern Section of SEPM, the Northeastern Section of the Paleontological Society (NE-PS), the New England Section of the National Association of Geology Teachers (NAGT), and the Association for Women Geoscientists will be meeting with GSA's Northeastern Section. The meeting will be conducted from 8:00 a.m., Monday, March 20, to 5:00 p.m., Wednesday, March 22. Field trips and short courses will be held on Saturday, March 18, Sunday, March 19, and Wednesday, March 22.

DETAILED INFORMATION

Information concerning registration, travel, accommodations, and activities will appear in the December 1994 issue of *GSA Today* and as part of the GSA Northeastern Section *Abstracts with Programs* for 1995. Requests for additional information or suggestions should be addressed to either the General Chair, Norman H. Gray, or the Abstracts Coordinator, Raymond L. Joesten, at

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and Geophysics
University of Connecticut
Storrs, CT 06269-2045
(203) 486-4435 or
fax 203-486-1383
E-mail: gray@uconnvm.uconn.edu

or to the Technical Sessions Chair, J. Gregory McHone at:

Graduate Liberal Studies Program
Wesleyan University
255 High St.
Middletown, CT 06459-0519
(203) 344-7930 or
fax 203-344-7957
E-mail: jmchone@willet.
wesleyan.edu

LOCATION

Cromwell is in the Connecticut River Valley, 10 miles south of Hartford and 5 miles north of Middletown. The area is serviced by interstate routes 91 and 84, which intersect in Hartford and provide convenient and easy highway access from any site in the Northeast. New York and Boston are each less than a 2 hour drive away. I-91 runs north from New Haven through the states of Connecticut, Massachusetts, and Vermont to the Canadian border. It intersects the Massachusetts Turnpike near Springfield, which runs west to New York State and east to Boston. I-84 diagonally bisects the state and connects New York and Boston. Bradley International Airport, 22 miles north of Cromwell, is served by 18 commercial carriers offering "same plane" service from 65 U.S. and Canadian cities. Scheduled shuttle service is available to the meeting site at the Cromwell Radisson. Temperatures during March range from the 30s to the 60s (°F); rain, snow, or sunshine can be expected.

CALL FOR PAPERS

Papers are invited from students and professionals for presentation at oral and poster theme sessions and in general sessions. The format for the oral sessions will include 15 minutes for presentation and five minutes for discussion. Two projectors and two screens will be provided in each of the oral sessions. All slides must fit into a standard 35 mm carousel tray. The format for the poster sessions will include three hours of display time, with two hours specified during which the authors should be present for discussion. Each poster booth will include three 4' by 8' tack boards. Electrical outlets for poster sessions will not be available unless specifically requested in advance. Papers of regional interest to geologists in northeastern North America, as well as those of general interest to professionals, teachers, and the general public will be considered for oral or poster presentation.

SYMPOSIA AND THEME SESSIONS

The following symposia and theme sessions have been proposed for the meeting. Symposia generally include invited papers and selected volunteered papers; theme sessions are generally composed entirely of volunteered papers. Additional symposia or theme sessions may be added. If insufficient papers are received for a proposed symposium or theme session, submitted papers will be considered for regular oral or poster sessions.

Symposia

1. **The Newark Supergroup: New Results from Old Rifts.** (*Sponsored by the Eastern Section of SEPM)* Elizabeth Gierlowski-Kordesch and Bruce M. Simonson. c/o Elizabeth Gierlowski-Kordesch, Department of Geological Sciences, Ohio University, Athens, OH 45701, (614) 593-1101, fax 614-593-0486, or E-mail: Gierlowski@ouvaxa.cats.ohiou.edu.
2. **Investigative Techniques for Contaminated Site Characterization.** (*Sponsored by the Connecticut Groundwater Association)* Dennis Waslenchuk, Haley & Aldrich, Inc. 110 National Drive, Glastonbury, CT 06033, (203) 659-4248.
3. **The Petrology and Geochemistry of Archaeological Materials.** Barbara L. A. Calogero, Department of Anthropology, University of Connecticut, Storrs, CT 06269-2179, (203) 486-3851, or fax 203-486-1383.
4. **Biotic Responses to Tectonic-Environmental Events.** (*Sponsored by the Northeastern Section of the Paleontological Society)* Constance M. Soja, Department of Geology, Colgate University, Hamilton, NY 13346, (315) 824-7200, or fax 315-824-7187, E-mail: csoja@center.colgate.edu.
5. **Chronology and Paleoenvironmental Record of the Last Deglaciation of New England.** Janet Radway Stone and Gail M. Ashley, c/o Janet Radway Stone, U.S. Geological Survey (Hartford), Room 525, 450 Main Street, Hartford, CT 06103-3013, (203) 240-3060 or fax 203-240-3783.
6. **Mesozoic Paleontology and Ecology.** Nicholas G. McDonald, Department of Earth and Environmental Sciences, Wesleyan University, Middletown, CT 06459-0139, (203) 658-4444.

Theme Sessions

1. **Magmatism Associated with Mesozoic Rifting in Eastern North America.** Anthony R. Philpotts and J. Gregory McHone, c/o J. Gregory McHone, Graduate Liberal Studies Program, Wesleyan University, 255 High St., Middletown, CT 06459-0519, (203) 344-7930, or E-mail: jmchone@willet.wesleyan.edu.
2. **Geology of the Central Appalachian Piedmont: Tenth Annual Workshop.** Mary Louise Hill, Department of Geology, Temple University, Philadelphia, PA 19122, (215) 204-8226, or fax 215-204-1532.
3. **Lithotectonic Terranes in the Northern Appalachians: Evidence from Structure, Petrology, Geochemistry, Geophysics, and Paleontology.** Robert P. Wintsch, Department of Geological Sciences, Indiana University, Bloomington, IN 47401, (812) 855-4018, or E-mail: wintsch@ucs.indiana.edu.
4. **New or Innovative Applications of Geophysical Data to Environmental Studies.** S. Peter Haeni and John Williams, c/o S. Peter Haeni, U.S. Geological Survey (Hartford), Room 525, 450 Main Street, Hartford, CT 06103-3013, (203) 240-3299, or fax 203-240-3783.
5. **Hydrogeology of Sedimentary Rocks in the Northeast.** Robert Melvin, U. S. Geological Survey (Hartford), Room 525, 450 Main Street, Hartford, CT 06103-3013, (203) 240-3060, or fax 203-240-3783.
6. **Rock and Mineral Deposits in the Northeast.** Robert Altamura, Department of Geosciences, Pennsylvania State University, University Park, PA 16802, (814) 863-1665, fax 814-863-2001, or E-mail: boba@gaia.essc.psu.edu.
7. **Holocene Sea-Level Changes and Coastal Evolution Along the Northern Atlantic Seaboard.** Orson van de Plassche, Free University of Amsterdam. Mail c/o Department of Earth and Environmental Sciences, Wesleyan University, Middletown, CT 06459-0139, phone 31-20-444-7380, or fax 31-20-646-2457, or E-mail: plao@geo.cvu.nl.
8. **The Impact of GIS, GPS, Computer Aided Mapping, and Electronic Surveying on Traditional Geologic Field Work.** Mary Digiacomo-Cohen and Norman H. Gray, c/o Norman H. Gray, Department of Geology and Geophysics, University of Connecticut, Storrs, CT 06269-2045, (203) 486-4434, fax 203-486-1383, or E-mail: gray@uconnvm.uconn.edu.
9. **The Usefulness of the Field Experience in K–12 Science Curricula.** Randolph P. Steinen, Department of Geology and Geophysics, University of Connecticut, Storrs, CT 06269-2045, (203) 486-1390, or fax 203-486-1383.
10. **The Hydrodynamics of New England Estuaries.** Peter C. Patton, Department of Earth and Environmental Sciences, Wesleyan University, Middletown, CT 06459-0139, (203) 347-9411 ext. 2819.

Poster Theme Sessions

1. **Undergraduate Research.** *(Sponsored by the Geology Division, Council on Undergraduate Research)* Larry Malinconico, Office of the Provost, Lafayette College, Easton, PA 18042, (610) 250-5070, or E-mail: malincol@lafvax.lafayette.edu.
2. **Side Scan Images of Coastal New England and New York.** Suzanne O'Connell and Ralph Lewis, c/o Suzanne O'Connell, Department of Earth and Environmental Sciences, Wesleyan University, Middletown, CT 06459-0139, (203) 347-9411, ext. 2044, or E-mail: soconnell@eagle.wesleyan.edu.

Panel Discussion and Public Forum

Remediating Groundwater Contamination: Have We Been Wasting Our Time or Is There Hope? Gary A. Robbins, Department of Geology and Geophysics, University of Connecticut, Storrs, CT 06269-2045, (203) 486-1392, or fax 203-486-1383.

Evening Discussion (Keg) and Poster Session

Toward New State Surficial and Bedrock Maps. *(Sponsored by the Geological and Natural History Survey of Connecticut)* Ralph Lewis, Connecticut Geological Survey, and O. Don Hermes, University of Rhode Island, c/o Ralph Lewis, Long Island Sound Resource Center, 1084 Shennecossett Road, UConn, Avery Point, Groton, CT 06340, (203) 445-3473.

ABSTRACTS

Abstracts are limited to about 250 words and must be submitted on the official 1995 GSA abstract form, available from Abstracts Coordinator, Geological Society of America, P.O. Box 9140, Boulder, CO 80301, (303) 447-2020, or E-mail: ncarlson@geosociety.org.

Send one original and eight copies of abstracts to be considered to: Norman H. Gray, Department of Geology and Geophysics, University of Connecticut, Storrs, CT 06269-2045. Authors who think that a paper might be suitable for inclusion in a symposium or theme session should send an extra copy of the abstract to the appropriate contact person.

Abstracts will be reviewed for content, originality, and format. Only one volunteered paper may be presented by each individual, although a person may also be a coauthor on papers presented by others. Additional papers may be presented by an individual if they are invited for a symposium.

ABSTRACTS ARE DUE BY NOVEMBER 21, 1994.

SHORT COURSES

Two short courses have been proposed for the Connecticut meeting. The courses are scheduled for Sunday, March 19, and Wednesday afternoon, March 22. Preregistration is required.

March 19. **Digital Geologic Mapping Using Caris, MS Windows and GEMM.** Henk W. Van De Poll and Paul F. Williams, Department of Geology, University of New Brunswick, Fredericton, NB E3B 5A3, Canada, (506) 453-4803, or fax 506-453-5055.

March 22. **The Electronic Total Station—A Versatile Revolutionary New Geological Mapping Tool.** Norman H. Gray, Anthony R. Philpotts, and Randolph P. Steinen, Department of Geology and Geophysics, University of Connecticut, Storrs, CT 06269-2045, (203) 486-4435, or fax 203-486-1383.

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FIELD TRIPS

Proposed field trips for the meeting are listed below. Additional trips may be added at a later date. The actual trips run will depend on weather and enrollment. All trips will depart from and return to the Radisson Hotel and Conference Center in Cromwell, Connecticut.

1. **Lithotectonic Terranes in Eastern Connecticut.** Sunday, March 19. Leader: Robert P. Wintsch, Department of Geological Sciences, Indiana University, Bloomington, IN 47401, (812) 855-4018, or E-mail: wintsch@ucs.indiana.edu.
2. **The Long Tidal River: Quaternary History and Geology of the Connecticut River.** Sunday, March 19, Leaders: Suzanne O'Connell and Janet Radway Stone, c/o Suzanne O'Connell, Department of Earth and Environmental Sciences, Wesleyan University, Middletown, CT 06459-0139, (203) 347-9411, ext. 2044, or E-mail: soconnell@eagle.wesleyan.edu.
3. **Lake Sequences in the Central Hartford Basin, Connecticut.** (*Sponsored by the Eastern Section of SEPM)* Sunday, March 19. Leader: Elizabeth Gierlowski-Kordesch, Department of Geological Sciences, Ohio University, Athens, OH 45701 (614) 593-1101, fax 614-593-0486, or E-mail: gierlowski@ouvaxa.cats.ohiou.edu.
4. **Window into the Holyoke: The Tilcon Traprock Quarry, North Branford, Connecticut.** Sunday, March 19. Leaders: Brian J. Skinner and Anthony R. Philpotts, c/o Brian J. Skinner, Department of Geology and Geophysics, Yale University, 210 Whitney Avenue, P.O. Box 6666, New Haven, CT 06511, (203) 432-3114, or fax 203-432-3134.
5. **Paleoenvironmental Traverse Across the Early Mesozoic Hartford Rift Basin.** Saturday, March 18. Leaders: Nicholas G. McDonald, Peter LeTourneau, and Gregory S. Horne, c/o Nicholas G. McDonald, Department of Earth and Environmental Sciences, Wesleyan University, Middletown, CT 06459-0139, (203) 658-4444.

EXHIBITS

Exhibit space will be available at the Radisson Hotel, and snacks and refreshments will be available for exhibit visitors. Exhibit booths (8' by 10'), framed with drapes and containing a table and chairs, will be available for exhibitors during the entire meeting, from 8:00 a.m., Monday, March 20, to noon Wednesday, March 22. Reduced rates will be available for educational or nonprofit groups or institutions. For further information and space reservations, contact: Department of Geology and Geophysics, University of Connecticut, Storrs, CT 06269-2045, (203) 486-4435, fax 203-486-1383, or E-mail: gray@uconnvm.uconn.edu.

SPECIAL EVENTS

Breakfast
- Association for Women Geoscientists

Luncheons
- Paleontological Society NE Section
- NAGT Business Meeting

Receptions
- Welcome Reception and shuttle to the Rocky Hill Dinosaur State Park trackway, 6–10 p.m., Sunday, March 19
- GSA Northeastern Section Reception and Banquet, Tuesday, March 21

Other Events
- GSA Northeastern Section Management and Board Meeting

GUEST ACTIVITIES

The Hartford-Middletown area offers a wide variety of activities that may be of interest to guests, including the Mark Twain House and the Wadsworth Athenaeum Museum. A large number of additional museums and attractions are within a 1–2 hour drive of Cromwell, including the Peabody Museum of Natural History, Mystic Seaport, and Sturbridge Village. Gamblers may appreciate the huge new casino at Mashantucket. Brochures and printed information will be available at the registration desk to assist guests with sightseeing plans.

EARTH SCIENCE EDUCATION

Special activities are contemplated for K–12 and college earth science educators. The Connecticut Earth Science Teachers Association (CESTA) will staff a "classroom" in which new videos and educational software will be demonstrated and available for previewing. A late afternoon symposium, "Usefulness of a Field Experience in the K–12 Science Curricula," and a series of evening workshops at the Dinosaur State Park facility at Rocky Hill are planned. To encourage attendance of precollege earth science teachers, on-site registration fees for these events will be reduced for K–12 teachers in public and private schools.

REGISTRATION

Anyone wishing to attend oral sessions, poster sessions, or exhibits must register for the meeting. Please check the December 1994 issue of *GSA Today* and GSA Northeastern Section *Abstracts with Programs* for 1995 for student and professional registration fees and for registration forms. A reduced one-day registration fee will be available for those unable to attend more than one day of the conference. To encourage attendance of precollege earth science teachers, on-site registration fees will be reduced for K–12 school teachers in public and private schools. Guests who wish to attend only luncheons, dinners, receptions, and guest activities may register at a greatly reduced fee.

Preregistration deadline: February 28, 1995

HOUSING

A large block of rooms has been reserved for meeting participants and their guests at the Radisson Hotel and Conference Center in Cromwell, Connecticut. The hotel has ample free parking for all participants and is conveniently located just east of Exit 21 off I-91. All of the meeting exhibits will be located within the hotel building. For conference planning and to take advantage of attractive conference room rates, it is important to reserve your room before February 28, 1995. Guaranteed rates, which include applicable taxes, are $80.64 single, $80.64 double, $91.84 triple, or $103.04 for four persons. For reservations call (203) 635-2000, or (800) 333-3333. ■

MEETINGS

1994 Meetings

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, September 10–15, 1994. Lunteren, The Netherlands. 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. Information: Theola Evans, Kentucky Geological Survey, 228 MMRB, University of Kentucky, Lexington, KY 40506, (606) 257-5500, E-mail: theola@kgs.uky.edu.

Meetings *continued on p. 237*

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.

Global Gas Resources Workshop, September 19–21, 1994, Vail, Colorado. Information: Carol Ruthven, Bureau of Economic Geology, University of Texas, University Station, Box X, Austin, TX 78713-7508, (512) 471-1534; fax 512-471-0140, E-mail: ruthvenc@begv.beg.utexas.edu.

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.

Pennsylvania Geologists 59th Annual Field Conference: Some Aspects of Piedmont Geology in Lancaster and Chester Counties, Pennsylvania, September 30–October 1, 1994, Lancaster, Pennsylvania. Information: Field Conference of PA Geologists, P.O. Box 5871, Harrisburg, PA 17110-0871, (717) 787-2379.

October

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

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

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

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

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

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

■ **Association of Earth Science Editors Annual Meeting,** October 15–18, 1994, Oak Ridge, Tennessee. Information:

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Robert D. Hatcher, Jr., Dept. of Geological Sciences, University of Tennessee, Knoxville, TN 37996-1410, (615) 974-6565, fax 615-974-2368, E-mail: bobmap@utkvx.utcc.utk.edu.

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

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

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

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

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

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

November

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

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

December

■ **American Geophysical Union Fall Meeting,** December 5–9, 1994, San Fransisco, California. Information: AGU Meetings Dept., 1994 Fall Meeting, 2000 Florida Ave., N.W., Washington, DC 20009, (202) 462-6900, fax 202-328-0566, E-mail: meetinginfo@kosmas.agu.org. *(Abstract deadline: September 7, 1994.)*

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

Investigations of Lithosphere Architecture and Development (ILIAD)

Lithospheric Science Workshop

A workshop on the continental lithosphere will be held in Taos, New Mexico from November 5–9, 1994. The workshop is designed to encourage scientific exchange between seismologists and other Earth scientists engaged in fundamental research on the structure and evolution of the continental lithosphere. We will emphasize both integrated Earth science approaches and integrated multi-scale seismic experiments for understanding lithospheric structure and processes. The workshop will include three half day sessions of invited and contributed talks, followed by poster sessions and working group meetings on science planning, experiment design, instrumentation needs, and community organization.

The workshop is intended to assess the technical and organization resources necessary to undertake the scientific investigations described in the report "A National Program for Research in Continental Dynamics CD/2020" and to develop community-wide scientific consensus on instrumentation needs for lithospheric seismology. Workshop attendees will develop a science plan to complement and support the technical plan for seismic instrumentation developed by IRIS.

The workshop is open to all lithospheric scientists; travel support is available for 40 participants. Limited funds available for graduate students and postdoctoral participants. We particularly encourage scientists involved in active tectonics and continental margin studies to apply. *Interested parties should send by email a letter of application to Liz McDowell (liz@iris.edu).*

The workshop is sponsored by the National Science Foundation, Geophysics and Continental Dynamics Programs, and the Mathematics and Geophysics Directorate of the Air Force Office of Scientific Research.

Workshop Organizing Committee: Alan Levander (Rice University), Larry Brown (Cornell University), Walter Mooney (USGS), Gene Humphreys (University of Oregon).***Workshop Advisory Committee:*** Nik Christensen (Purdue University), Ron Clowes (UBC, Lithoprobe liaison), Kevin Furlong (Penn State University), Bob Hatcher (University of Tennessee), Steve Hickman (USGS, Deep Continental Drilling liaison), Art Lerner-Lam (Lamont-Doherty, CSEDI liaison), Jill McCarthy (USGS), Anne Meltzer (Lehigh University), Jinny Sisson (Rice University), George Zandt (Lawrence Livermore)

September *BULLETIN* and *GEOLOGY* Contents

The Geological Society of America
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Forum

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Positions Open

DEAN, SCHOOL OF SCIENCE

California State University, Hayward, invites applications and nominations for the position of Dean, School of Science, effective Fall, 1995. The School, one of four at CSU Hayward has nine departments: Biology, Chemistry, Geology, Health Sciences, Math/Computer Science, Nursing, Physics, Psycology, and Statistics and has 125 faculty, 40 staff, 2400 majors, and offers bachelor's, master's, and certificate programs. The Dean, assisted by the Associate Dean, is the administrative officer of the School and reports directly to the Provost. Qualifications include: eligibility for appointment in one of the School's departments; a record of significant achievement in university teaching, research, and administration, including a record of successful fiscal and resource management; experience in advanced technologies; a commitment to increasing the diversity of faculty, students, and staff; effective participation in university governance; and excellent communication and interpersonal skills. The Dean is expected to take a strong leadership role in the University and the School and continue to foster excellence in teaching, student and faculty research, School development, and the recruitment and generation of new resources. Letters of application should be accompanied by a curriculum vitae and the names of five references. Review of applications will begin 1 November 1994. Please direct all correspondence to: Search Committee for the Dean, School of Science, c/o Office of the Provost, California State University, Hayward CA 94542. CSUH is an Equal Opportunity/Affirmative Action Employer.

ASSISTANT PROFESSOR / REMOTE SENSING

The Department of Geography and Earth Science invites applications for a full-time (9 months), tenure-track position at the Assistant Professor level, to begin January 1995, in the area of remote sensing, with application to GIS and other areas of interest within the Department. In addition, the candidate will be expected to teach Physical Geology, Environmental Issues, or other introductory-level courses offered by the Department. Applicants should have a Ph.D. and must have a strong commitment to excellence in teaching at the undergraduate level. Salary commensurate with education and experience. Send letter of application with statement of teaching interests, complete resume, transcripts, and 3 letters of recommendation to: Dr. Dale A. Springer, Chairperson, Search and Screen Committee, Dept. Geography & Earth Science, Bloomsburg University, Bloomsburg, PA 17815. Application deadline is November 1, 1994. (See also Jobs Notice Board at Seattle GSA). Bloomsburg University is an equal-opportunity, affirmative action employer. Minorities, women, and all other protected class members are especially urged to apply. Bloomsburg University, State System of Higher Education, Comonwealth of Pennsylvania.

WATERSHED HYDROLOGIST
UNIVERSITY OF CALIFORNIA, DAVIS

The Hydrologic Science Program of the Department of Land, Air and Water Resources seeks applicants for a nine-month tenure-track position, with probability of extension to eleven-month employment, at the Assistant Professor level. The appointee will develop a quantitative field-experimental research program in Watershed Hydrology emphasizing processes that may include land-atmosphere interactions, precipitation and runoff, surface water and groundwater interaction, surface water detention, wetlands hydrology, snow hydrology, and chemical cycling in watersheds. The appointee is required to teach an undergraduate summer field course in hydrology, an integral part of the new Hydrologic Science major and a graduate level course in field-experimental hydrology methods, and an undergraduate general education course in watershed management. We seek a strong scientist with a Ph.D. in hydrology, engineering, earth science or closely related field with demonstrated experience in experimental watershed hydrology including the ability to conduct measurements of surface and subsurface flows as well as surface energy budgets. A quantitative background in mathematical modeling and teaching experience is desirable. The position is available July 1, 1995. Applicants should submit resume, transcripts, research and teaching statements with background in each, copies of relevant publications and manuscripts and the names and addresses of at least four references to: Professor Wesley W. Wallender, Watershed Hydrology Search Committee Chair, Hydrologic Science, University of Caliifornia, Davis, CA 95616, telephone (916) 752-0688/1719, email wwwallender@ucdavis.edu. Applications should be postmarked by 10/31/94. A more detailed job description can be obtained from the above address or via ftp at enthusiasm.ucdavis.edu.

The University of California is an affirmative action, equal opportunity employer.

ARCHEOLOGICAL CONSULTING FIRM seeks full-part-time geologist/geomorphologist with graduate degree. Position requires outstanding writing skills, knowledge of southeast U.S. coastal and fluvial sedimentology, and ability to characterize and identify soils. Archeological experience helpful. R. Christopher Goodwin & Assoc., Inc., 5824 Plauche St., New Orleans, LA 70123, Attn: Tracie H. Eiserloh, Personnel Manager. Equal Opportunity Employer.

SEDIMENTARY GEOLOGY

The School of Geology and Geophysics at the University of Oklahoma invites applications for a tenure-track faculty appointment at the rank of assistant professor in the field of sedimentary geology. The starting date is open but we expect to fill the position by September, 1995. The Ph.D. is required at the time of appointment. Preference will be given to multidisciplinary scientists in the areas of sedimentology and/or stratigraphy, paleoclimatology, sedimentary geochemistry, and basin evolution. The successful candidate must have commitment to both undergraduate and graduate (M.S. and Ph.D.) education, and equally develop an externally-funded research program. In addition to graduate level courses in the research specialty, the candidate will be expected to teach undergraduate and graduate courses in sedimentology, stratigraphy, sedimentary petrology, and participate appropriately in the Summer Field Camp. It is also expected that the candidate will contribute expertise toward strengthening the School's environmental program, and its general education mission. Facilities include an organic geochemistry lab with several mass spectrometers, electron microprobe, SEM, XRD/XRF lab, fluid inclusion lab, luminoscope, rock mechanics lab, paleomagnetic lab, and hardware and software for seismic processing and basin modeling. Opportunities also exist for interaction in the Energy Center's Center for Reservoir Characterization and its field laboratory. Applicants should send a resume, description of teaching and research interest, copies of relevant publications, and the names of three references to Chair, Sedimentary Geology Search, School of Geology and Geophysics, The University of Oklahoma, 100 E. Boyd, Suite 810, Norman, OK 73019. Applcations will be reviewed beginning September 1, 1994, and continue until the position is filled. The University of Oklahoma is an equal-opportunity, affirmative action employer. Women and minorities are encouraged to apply. OU has a policy of being responsive to the needs of dual-career couples.

GROUND WATER & SITE REMEDIATION
WRIGHT STATE UNIVERSITY

The Department of Geological Sciences invites applications for a tenure-track faculty position at the assistant professor level starting January 1995. Ph.D. or equivalent is required at the itme of appointment. A background in site remediation and organic contaminant fate and transport is desirable, as are degrees in both geosciences and engineering. The successful candidate will join a 12-member faculty in a department with strong M.S. programs in hydrogeology, environmental geology, and applied geophysics (63 grad students, 47 hydrogeology). He/she will teach and develop externally funded research in areas that complement departmental strengths in hydrogeochemistry, hydrological modeling, and applied field studies. Opportunities exist for interaction with other administrative units including the Center for Ground Water Management and the Institute for Environmental Quality, as well as for participation in the development of a Ph.D. and an Environmental Engineering program.

Related departmental facilities/equipment, supported by a field service engineer and a technician, include a hydrogeochemistry laboratory with AA and graphite furnace, IC, a stable isotope processing lab, scintillation counter, state-of-the-art computing facilities, X-ray spectrographic and fluorescence equip., soil mech. equip., ground penetrating radar and resistivity systems, truck-mounted drill rigs, truck-mounted seismic reflection systems, 19 field vehicles, an experimental watershed and a wetlands field area both w/dedicated pumping, observation, and monitor wells.

Inquires are welcome. Applicants are requested to send their curriculum vitae, transcripts, a statement of research and teaching interests, and the names and addresses of three references to Dr. Robert W. Ritzi, Department of Geological Sciences, Wright State University, Dayton OH 45435, (513) 873-3455. Review of applications will begin October 1, 1994 and continue until the position is filled. Wright State University is an equal opportunity/affirmative action employer.

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

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

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

RESEARCH GEOLOGISTS

State Geological Survey, Albany, NY seeks applicants for two permanent research positions: 1. Paleozoic Stratigrapher. Specialties: lithic and Paleozoic biostratigraphic correlations; high resolution depositional environment analysis; subsurface study techniques. Duties: independent geologic mapping, subsurface interpretations, and related stratigraphic research and synthesis in NY Paleozoic sedimentary rock;management of large file of oil and gas well logs. 2. Structural Geologist-Metamorphic Petrology. Specialities: appropriate modern field and laboratory techniques; experience in geologic mapping of deformed sedimentary and metamorphic terrains. Duties: independent geologic mapping and related tectonic and stratigraphic research in metamorphic and deformed rock of eastern NY. Both posiitions require Ph.D. in Geology with specialties; three years professional experience including nine months of bedrock field mapping. Starting salary $40,907. Positions requirea a Civil Service training and experience examination. Send requests for exam application, resume and names of three references to: Mr. Charles J. Byrne, Director of Personnel, Room 528EB, Box SC-59, 89 Washington Avenue, Albany, NY 12234. AA/EOE.

GEOLOGIST. 40hr/wk. 8-5pm. $700/wk. Perform phase I, II & III envir. site & subsurface investigations, soil & groundwater remediation sys. design; conduct geo. background, soil & sediment mineralogical study using sequential extraction proc, groundwater modeling using MODFLOW, QUICKFLOW, VENTING, SPILLFLOW, AQTESOLV & Excel; hydrogeo. study such as slug test, pumping & pilot test. Req: M.S. in Geo., 1 yr exp. in geo. research & investigation as shown by M.S. paper & grad. courses in each: directed study (groundwater modeling), statistics & comp. method, & groundwater. Employer-paid ad. Send resumes to 7310 Woodward Ave., Rm 415, Detroit, MI 48202. Ref#81194.

DEAN
COLLEGE OF SCIENCE

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

THE COLORADO COLLEGE
Technical Director — Geology

The Geology Department invites applications for a newly created position of Technical Director. Founded in 1874, CC is a private, four-year, independent coeducational liberal arts and sciences college of 1,890 undergraduate students. It is located in a spectacular geological setting at the foot of Pikes Peak. The Geology Department has a field-oriented geology program in which most of the senior majors do original research. The College is committed to increasing the diversity of the college community and curriculum and candidates who can advance this goal are particularly encouraged to apply. Responsibilities include routine maintenance of instruments and their suport labs (XRD, XRF, ICP, field geophysical equipment,rock saws and crushers, rock deformation apparatus, sedimentology lab); computer support (IBM and Apple systems) for software applicaitons in data analysis and graphics and in software for teaching geology; working closely with senior majors on research, including training and supervision of use of major instruments and support for using software in data reduction and plotting. Graduate degree in Earth Science required plus experience in laboratory instrumentation and computer support applications, mechanical aptitude, supervision and leadership ability; strong organization and interpersonal skills, commitment to diversity, plus the ability to work effectively with students and faculty in a college environment. Salary is $30,000; excellent benefits; position begins on or about January 1, 1995. For full consideration, apply by November 1, 1994. Submit letter of application, resume, and three letters of recommendation to Technical Director, Geology Search Committee, The Colorado College, Human Resources Office, 14 East Cache la Poudre, Colorado Springs, CO 80903. Equal Opportunity Employer. The Colorado College welcomes members of all groups and reaffirms its commitment not to discriminate on the basis of race, color, age, religion, sex, national origin, sexual orientation or disability in its educational programs, activities, and employment practices.

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Opportunities for Students

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

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

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

GSA ANNUAL MEETING

Seattle — at the leading edge

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- **TECHNICAL INFORMATION**
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  September 16
- **LODGING DEADLINE:**
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- **FOR REGISTRATION, HOUSING, AND PROGRAM INFORMATION**
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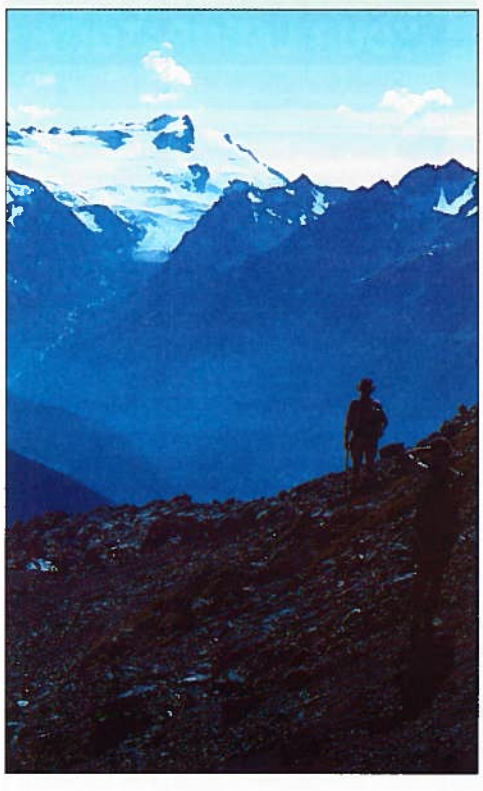

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